

- c. Seal air-handling unit casing penetrations.
- d. Install duct smoke detector components in accordance with written instructions furnished by supplier.
 - 1) Sampling tubes shall extend the full width of airstream.
 - 2) Sampling tubes greater than **36 inches (900 mm)** long shall be supported on both ends.
- e. Photograph installation and transmit photos to fire-alarm system Installer before air-handling unit shipment to ensure proper installation. Fire-alarm system Installer shall review photos and provide written acceptance of installation to air-handling unit manufacturer before air-handling unit shipment.
 - 1) Document date of photos and approval for record purposes.
 - 2) Make corrective measures required by fire-alarm system Installer as required for acceptance.
- f. Coordinate work schedule of air-handling unit manufacturer and fire-alarm system supplier to meet requirements of Project schedule.
- g. See **[Section 284600 "Fire Detection and Alarm"]****[and]****[Section 284614 "Single- and Multiple-Station Alarms"]****<Insert Section>** for additional requirements.

OO. Catwalks, Handrails, and Ladders:

- 1. General:
 - a. Provide elevated air-handling units and top levels of multilevel stacked units with catwalks, handrails, and ladders to provide service access.
 - b. Factory-fabricate catwalks, handrails, and ladders to ensure proper alignment and attachment.
 - c. Catwalks, handrails, and ladders may be disassembled and shipped separate from the air-handling unit for field installation.
 - d. Design and fabricate catwalk to be completely self-supported from air-handling unit frame without need for any type of field-installed supports.
 - e. Comply with OSHA requirements where requirements are more stringent than requirements indicated.
 - f. Install catwalk, handrails, and ladders level and plumb.
- 2. Catwalks:
 - a. Extend catwalks to service elevated portions of air-handling unit.
 - b. Catwalk width shall be of sufficient size to properly access and service equipment and maintain code-required clearances to electrical devices. Width shall be at least **[60 inches (1500 mm)]****<Insert dimension>** clear between the exterior casing and handrail.
 - c. Cantilever catwalk base frame from the air-handling unit base frame. Removable catwalks shall be bolted to the air-handling unit base frame at multiple points to ensure a rigid and firm attachment.
 - d. Catwalk base frame material and finish shall match air-handling unit frame.
 - e. Catwalk floor material shall match air-handling unit floor material.
 - f. Catwalk walking surface elevation shall match floor surface inside air-handling unit.
- 3. Handrails:
 - a. Provide catwalk with handrail, kneerail, toeboard, and vertical supports along entire length of catwalk. Comply with 29 CFR 1910.23.
 - b. Handrail shall be a minimum of **[42 inches (1050 mm)]****<Insert dimension>** high and

- comply with OSHA requirements. Vertical supports shall be spaced not more than [96 inches (2400 mm)]<Insert dimension> o.c.
- c. Construct handrail, kneerail, and vertical supports from not less than nominal [1-1/2-inch-(38-mm-)]<Insert dimension> diameter tube.
 - d. Handrail shall be capable of withstanding a live load force of not less than [100 lb./ft. (450 N/300 mm)] and a [200-lb (900-N)]<Insert value> concentrated force in any direction.
 - e. Provide lift-out sections of handrail to facilitate removal of air-handling unit internal components from the top-level to grade.
 - f. Provide self-closing gate at ends of catwalk accessible by ladders to provide fall protection.
 - g. Construct handrails, kneerails, toeboards, and vertical supports of [aluminum][fiberglass][galvanized-steel][or][stainless steel] materials.
- 1) Finish: Hot-dip galvanize assemblies constructed of steel after fabrication.
4. Ladders with Safety Cages:
- a. Provide a permanently attached ladder at [one][each] end of catwalk.
 - b. Ladder shall rise from building structural floor to the top of handrail.
 - c. Provide for construction tolerance and adjustable means to fasten the ladder at its base to the building structural floor.
 - d. Fabricate ladders with dimensions, spacing, details, and anchorages as required.
 - e. Comply with requirements of ALI A14.3 and 29 CFR 1910.27.
 - f. Support each ladder at top and bottom. Use welded or bolted brackets, designed for adequate support and anchorage, and to hold ladder [7 inches (175 mm)]<Insert dimension> clear from catwalk walking surface.
 - g. Extend rails at least [42 inches (1050 mm)]<Insert dimension> above top rung, and return rails with secure handholds fastened to handrail.
 - h. Construct ladders of [aluminum][fiberglass][galvanized-steel][or][stainless steel] materials.
- 1) Finish: Hot-dip galvanize ladders, brackets, and fasteners constructed of steel after fabrication.
- i. Provide non-slip surface on top of each rung, either by coating rung with aluminum-oxide granules set in epoxy-resin adhesive or by using a type of manufactured rung that has a non-slip top surface.

PP. Hardware:

1. Screws:
 - a. For Galvanized-Steel Materials: Self-tapping, hex-head, [zinc-plate steel][or][300 series stainless steel] screws with a neoprene gasket encapsulated by a [zinc-plate steel][or][300 series stainless steel] washer.
 - b. For Aluminum and Stainless Steel Materials: Self-tapping, hex-head, 300 series stainless steel screws with a neoprene gasket encapsulated by a 300 series stainless steel washer.
 - c. Provide protective covers on exposed screws to prevent personnel injury.
2. Bolts, Nuts, and Washers:
 - a. For Joining Galvanized and Painted Carbon Steel Materials: Hex-head, high-strength, [galvanized steel][or][300 series stainless steel].
 - b. For Joining Aluminum and Stainless Steel Materials: Hex-head, high-strength, 300 series stainless steel.

- c. Use washers and lock washers at each bolted connection.
- d. Select bolt size and spacing sufficient for load and application.

QQ. Welding:

- 1. Welding Filler Metals: Comply with AWS welding codes for welding materials appropriate for thickness and chemical analysis of material being welded.
 - a. Use welding materials with corrosion properties equal to material being welded.
- 2. Use welders that are certified to weld at least **[twice]** the thickness of the material to be welded. Certification shall be within **[three][six]<Insert number>** months of work being performed.
- 3. Welds shall be continuous, full-penetration welds unless otherwise indicated. Intermittent welds, stitch welds, and tack welds are permitted only in specific applications indicated.
- 4. Use welders and welding procedures complying with the following:
 - a. Piping Systems: Section IX of the ASME Boiler and Pressure Vessel Code and Section V of ASME B31.1.
 - b. Structural Aluminum: AWS D1.2/D1.2M.
 - c. Structural Carbon Steel: AWS D1.1/D1.1M.
 - d. Structural Stainless Steel: AWS D1.6/D1.6M.
 - e. Sheetmetal: AWS D9.1/D9.1M.

RR. Painting:

- 1. General:
 - a. Painted OEM components do not require additional coating other than touchup to damaged areas. Match the touchup coating to surrounding undamaged surfaces.
 - b. Finish miscellaneous surfaces to match continuous surfaces.
 - c. Protect mill galvanized surfaces that are exposed to view, such as raw steel cuts and damage by welding, with multiple coats of matching galvanized paint.
 - d. Protect mill galvanized surfaces that are concealed, such as raw steel cuts and damage by welding, with multiple coats of zinc-rich paint or matching galvanized paint.
 - e. Touch up or entirely repaint surface finishes, damaged during shipment and installation, to the original condition, using original materials and methods.
- 2. Preparation:
 - a. Submit proposed manufacturer's written preparation and application instructions for information.
 - b. If paint manufacturer's recommended preparation requirements differ from those indicated, use the more stringent requirements.
 - c. Structural carbon steel to be painted shall be deburred, ground smooth, cleaned, and blasted in accordance with **[SSPC-SP 6/NACE No. 3][or][SSPC-SP 10/NACE No. 5]**.
 - d. Before applying a primer and a finish coat, remove oil and grease from surfaces to be coated using clean rags soaked in thinner in accordance with SSPC-SP 1.
 - e. Treat surfaces to be painted to ensure that paint adheres.
- 3. Primer:
 - a. Rust-inhibiting type, with a minimum dry film thickness of **[1][2]<Insert value>** mil(s) per coat.
 - b. Apply at least **[two]<Insert number>** coats of primer to unfinished carbon steel surfaces and at least one coat of primer to other surfaces.
 - c. Use primer that is compatible with substrate and finish coat.

4. Finish Coat:
 - a. Finish coat painting system shall be **[alkyd-enamel][epoxy][polyurethane]<Insert coating>**.
 - b. Use dry film thickness recommended by paint manufacturer for each coat. Total dry film thickness of all finish coats not less than **[3][5]<Insert value>** mils.
 - c. Painted Surfaces Minimum Properties:
 - 1) Salt Spray ASTM B117: 5 percent salt solution fog at **95 deg F (35 deg C)** for **[500][1000][2000]** hours with no deterioration.
 - 2) Adhesion ASTM D3359: When the coating is cut into **0.0625-inch (1.6-mm)** squares and 3M No. 600 tape is suddenly removed, there is no loss of adhesion.
 - 3) Acid Resistance ASTM D3260: 15-minute exposure to 10 percent hydrochloric acid at room temperature with no effect.
 - 4) Alkali Resistance ASTM D1647: 15-minute exposure to 10 percent sodium hydroxide at room temperature with no effect.
 - 5) Humidity Resistance ASTM D2247: 850-hour exposure to **100 deg F (38 deg C)** and at least 95 percent relative humidity with no effect.
 - 6) Pencil Hardness ASTM D3363: A hardness of 1H.
 - d. Finish coat color shall be selected by Architect and not be limited to manufacturer's standard offering.
 - 1) Submit a written request for color selection and indicate in the request the date color selection must be returned without impacting schedule.
5. Application: Paint the following surfaces with primer and finish coat indicated:
 - a. Unfinished carbon steel surfaces.
 - b. Exposed mill galvanized-steel surfaces of air-handling unit casing exterior.
 - c. Exposed aluminum surfaces of air-handling unit casing exterior.
 - d. Exposed stainless steel surfaces of air-handling unit casing exterior.

SS. Cleanliness Requirements:

1. General:
 - a. Provide equipment that has been manufactured, shipped, stored, and installed maintaining highest degree of cleanliness possible.
 - b. Owner Cleanliness Inspection: Air-handling unit(s) cleanliness is subject to Owner cleanliness inspection **[and must pass a white glove test]** before packaging for shipment.
 - c. **<Insert requirements>**.
2. During Manufacturing:
 - a. Clean materials to be free of mill grease, oxidation, dirt, dust, and other impurities before manufacturing and assembly.
 - b. Protect casing materials from contamination during manufacturing and assembly.
 - c. Use sealing materials that do not outgas.
 - d. Provide OEM components and equipment from their respective manufacturers free of grease, oxidation, and dirt. Store OEM components and equipment indoors. Cover and protect OEM components and equipment to maintain cleanliness. Follow OEM instructions for equipment storage.
3. After Manufacturing:

- a. Before shipment, after unit is completely assembled, clean unit inside and out.
 - 1) Vacuum entire inside to remove dirt, dust, and debris using HEPA-filtered vacuum equipment.
 - 2) Purge hard to reach surfaces with dry, oil-free, compressed or bottled nitrogen.
 - 3) Wipe down all surfaces, inside and out, with a residue-free cleaning agent.
 - b. Protect unit to maintain cleanliness.
4. Shipping:
- a. Protect interior and exterior of air-handling unit from exposure to weather dirt, dust, and debris during shipment and rigging.
 - b. Cover openings with puncture-resistant durable coverings to ensure that cleanliness is maintained inside unit while providing an air- and watertight seal.
5. On-Site Storage:
- a. If air-handling unit is to be stored before installation, Installer shall work closely with air-handling unit manufacturer for air-handling unit manufacturer to provide adequate protection at the factory to ensure that cleanliness for both unit interior and unit exterior is maintained. This protection shall remain in place until unit startup is performed.
 - b. For extended periods of storage, provide a means to rotate fan and motor assemblies on a periodic basis (as recommended by manufacturer) without compromising unit cleanliness.

TT. Accessories:

1. Tool Kit:
 - a. Manufacturer shall assemble a tool kit specially designed for use in servicing air-handling units furnished.
 - b. Include only special tools required to service air-handling unit components not readily available for purchase by Owner service personnel in performing routine maintenance.
 - c. Place tools in a lockable case with hinged cover.
 - d. Mark case cover with large and permanent text to indicate special purpose of tool kit, such as "Air-Handling Unit Tool Kit." Text size shall be at least [1 inch (25 mm)]<Insert dimension> high.
 - e. Provide a list of each tool furnished and permanently attach the list to underside of case cover. Text size shall be at least [1 inch (25 mm)]<Insert dimension> high.

2.5 SOURCE QUALITY CONTROL

A. AHRI Compliance:

1. AHRI 260 (I-P): Air-handling unit sound ratings shall be in accordance with AHRI 260 (I-P), "Sound Rating of Ducted Air Moving and Conditioning Equipment."
2. AHRI 261 (SI): Air-handling unit sound ratings shall be in accordance with AHRI 261 (SI), "Sound Rating of Ducted Air Moving and Conditioning Equipment."
3. AHRI 410: Air-handling unit coils shall be rated in accordance with AHRI 410 and shall be listed by AHRI[and labeled in accordance with AHRI].
4. AHRI 1060 (I-P) Certification: Air-handling units that include [energy wheels][fixed plate heat exchangers][and][heat pipe heat exchangers] shall be rated in accordance with AHRI 1060 (I-P) and shall be listed by AHRI[and labeled in accordance with AHRI].
5. AHRI 1061 (SI) Certification: Air-handling units that include [energy wheels][fixed plate heat exchangers][and][heat pipe heat exchangers] shall be rated in accordance with AHRI 1061 (SI)

and shall be listed by AHRI[**and labeled in accordance with AHRI**].

B. AMCA Compliance:

1. AMCA 201: Air-handling unit manufacturer shall evaluate fan's performance within the air-handling unit in accordance with AMCA 201, "Fans and Systems" and account for conditions within the air-handling unit that could be detrimental to fan's performance by adjusting the fan performance indicated on Drawings.
2. AMCA 205 Certification: Air-handling unit fan's fan efficiency grade (FEG) shall be rated in accordance with AMCA 205, "Energy Efficiency Classifications for Fans"[**and shall bear the AMCA-certified FEG seal**].
3. AMCA 210 Certification: Air-handling unit fan's air performance shall be rated in accordance with AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating"[**and shall bear the AMCA-certified air ratings seal**].
4. AMCA 300: Air-handling unit fan's sound performance shall be rated in accordance with AMCA 300, "Reverberant Room Method for Sound Testing of Fans."
5. AMCA 301 Certification: Air-handling unit fan's sound performance shall be rated in accordance with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data"[**and shall bear the AMCA-certified sound ratings seal**].
6. AMCA 500-D: Air-handling unit damper's performance shall be rated in accordance with AMCA 500-D, "Laboratory Methods of Testing Dampers for Rating"[**and shall bear the AMCA-certified air ratings seal**].

C. NFPA Compliance:

1. NFPA 70: Electrical components, devices, and accessories shall be listed and labeled by a qualified testing agency, and marked for intended location and application.
2. NFPA 90A: Design, fabrication, and installation of air-handling units and components shall comply with NFPA 90A.

D. UL Compliance:

1. UL 1598 Certification: Air-handling unit UVGI shall be NRTL listed and labeled in accordance with UL 1598, "Luminaires."
2. UL 1995 Certification: Where indicated, air-handling unit components shall be NRTL listed and labeled in accordance with UL 1995, "Standard for Safety Heating and Cooling Equipment."

2.6 SOURCE QUALITY CONTROL - INDEPENDENT LABORATORY TESTING

A. General:

1. Project-specific testing by an independent laboratory is not required if air-handling unit manufacturer has written independent laboratory test results of past tests performed on same casing construction proposed for use on this Project.
2. If Project-specific testing is required, testing shall be performed in ample time to include test reports with submittals and before manufacturing of air-handling units. Include sufficient lead time for unit delivery, installation, and testing required by construction schedule.

B. Casing Structural Deflection Test:

1. Include service of an independent testing laboratory to verify casing structural deflection requirements indicated.
 - a. In lieu of independent laboratory testing, manufacturer may perform factory deflection

testing of proposed construction to prove compliance if witnessed by **[Architect][and][Owner]**. Manufacturer shall bear cost of labor and travel expenses to witness testing.

2. Test casing construction to performance criteria indicated.
3. Test casing construction proposed for use on Project. Include, at a minimum, particulars such as metal materials and thickness, internal support and reinforcing, and insulation material and thickness.
4. Test largest full-size casing panel proposed for use on Project.
5. Test proposed construction of walls, floor, and roof. Include a separate test for each unique casing construction proposed.
6. Submit test reports for each test to show compliance with performance indicated.

C. Casing Airborne Sound Transmission Test:

1. Include services of an independent testing laboratory to test proposed casing construction for sound transmission. Include a separate test for each unique casing construction proposed.
2. Conduct tests in accordance with ASTM E90.
3. Determine sound transmission class by using ASTM E413.
4. Test proposed construction of walls and roof.
5. Test proposed construction of floor assembly only if air-handling unit is not installed on a concrete housekeeping pad or building structural floor.
6. Submit test reports for each test to show compliance with performance indicated.

D. Casing Sound Absorption Test:

1. Include services of an independent testing laboratory to verify casing sound absorption coefficients for perforated casing panels. Provide a separate test for each unique casing construction proposed.
2. Conduct tests in accordance with ASTM C423 and ASTM E795.
3. Test proposed construction of walls and roof.
4. Submit test reports to show compliance with performance indicated.

2.7 SOURCE QUALITY CONTROL - AIR-HANDLING UNIT FACTORY TESTS

A. Witness of Testing: Allow **[Architect][Commissioning Agent][Construction Manager][and][Owner]<Insert entity>** access to place where air-handling units are being tested for witness testing.

1. Submit written notification at least **[30][20]<Insert number>** days in advance of testing.
2. Schedule testing at mutually agreeable dates and times.

B. Witness Testing Travel Expenses:

1. Include in bid, the cost of travel expenses to witness factory testing. Total cost for travel expenses shall be clearly indicated separately in bid.
2. Expenses shall include roundtrip **[coach][or][first]** class airfare, out-of-town hotel accommodations, out-of-town meals (breakfast, lunch, and dinner), out-of-town ground transportation and parking, and all associated taxes and fees.
3. Exclude other incidental expenses not indicated.
4. Include travel expenses for **[one][two]<Insert number>** representative(s) with origin of **<Insert city and state>**.

C. Casing Leakage Test:



1. Perform a leak test for **[each assembled air-handling unit][each assembled air-handling unit of unique size and arrangement]<Insert requirement>**.
2. Follow testing procedures in accordance with ASHRAE 111.
3. Perform leak test before shipping first air-handling unit **[of unique size and arrangement]**.
4. Test results shall indicate that units comply with leakage requirements indicated. Make changes to noncompliant air-handling units and retest until units comply with requirements.
5. Prepare test reports in accordance with ASHRAE 111.
6. Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single air-handling unit, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

D. Casing Structural Deflection Test:

1. Perform a structural deflection test for **[each assembled air-handling unit][each assembled air-handling unit of unique size and arrangement][only one air-handling unit with the worst-case condition]<Insert requirement>**.
2. Pressurize and load air-handling units to the performance criteria indicated for structural deflection. Test air-handling unit **[floors][walls and roofs]**.
3. Test results shall indicate that units comply with deflection requirements indicated. Make changes to noncompliant air-handling units and retest until units comply with requirements.
4. Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single air-handling unit, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

E. Functional Run Test:

1. Run test each unit before shipment.
2. Test and balance fans to comply with vibration requirements indicated.
3. Energize each electrical device to ensure that it is operational.
 - a. Take meter readings for volts, amperes, and kVA_r on each phase leg of each motor.
 - b. Take meter readings for volts, amperes, and kVA_r on each single-phase power connection to field power.
4. Exercise each damper to ensure proper operation.
5. Exercise each access door to ensure proper fit.
6. Exercise each valve to ensure proper operation.
7. Submit a written report for each unit tested. Written report shall include, at a minimum, full name of each person witnessing test, detailed list of each unit component tested, condition observed, and corrective action required. Each line item shall have full name of the person doing the checkout and date and time the checkout was performed.

F. Fan Vibration Test:

1. Perform a fan vibration test for **[each assembled air-handling unit][each assembled air-handling unit of unique size and performance]<Insert requirement>**.
2. Energize each fan within the air-handling unit after air-handling unit final assembly and perform a vibration analysis with fan operating at design speed **[and at all speeds throughout the range from design to minimum speed]**.

3. Three vibration measurements shall be taken for each bearing in horizontal, vertical, and axial directions. Vibration measurements shall be recorded and consist of vibration amplitude verses frequency[**with filter-in**].
4. Fan bearing measurement points shall be marked or scribed on bearings for permanent record.
5. Test results shall indicate that units comply with vibration requirements indicated. Make changes to noncompliant air-handling units and retest until units comply with requirements.
6. Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single air-handling unit, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

G. Acoustical Performance Test:

1. Perform an acoustical performance test for **[each assembled air-handling unit][each assembled air-handling unit of unique size and performance]<Insert requirement>**.
2. Air-handling unit acoustic performance shall be verified by factory test in accordance with AHRI 260 (I-P) and AHRI 261 (SI).
3. Air-handling unit supply-air discharge, return-air inlet, and casing radiated sound components shall be measured with air-handling unit operating at design conditions.
4. Testing Location: Perform testing in a location complying with AHRI 220, "Reverberation Room Qualification and Testing Procedures for Determining Sound Power of HVAC Equipment."
 - a. Test location shall be broadband qualified in accordance with AHRI 220 Section 5.1 and discrete frequency qualified in accordance with Section 5.2.
5. Operating conditions used in acoustic testing shall be verified by test in accordance with AMCA 210[**in an AMCA-accredited facility**].
6. Test results shall indicate that units comply with acoustical requirements indicated. Make changes to noncompliant air-handling units and retest until units comply with requirements.
7. Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single air-handling unit, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

H. Airflow Capacity Performance Test:

1. Perform an airflow capacity performance test for **[each assembled air-handling unit][each assembled air-handling unit of unique size and performance]<Insert requirement>**.
2. Operating conditions shall be verified by test in accordance with AMCA 210[**in an AMCA-accredited facility**].
3. Test results shall indicate that units comply with design airflow requirements indicated. Make changes to noncompliant air-handling units and retest until units comply with requirements.
4. Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single air-handling unit, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

2.8 SOURCE QUALITY CONTROL - OEM COMPONENT FACTORY TESTS

A. Air Mixer Testing:

1. Owner-witnessed performance test to demonstrate compliance with performance requirements indicated.

B. Coil Testing:

1. Hydronic Coils: Factory tested with air while coil is completely submerged underwater to design pressure indicated, but not less than **[300-psig (2070-kPa)]<Insert pressure>** internal pressure.
2. Refrigerant Coils: Factory tested with air while coil is completely submerged underwater to design pressure indicated, but not less than **[300-psig (2070-kPa)]<Insert pressure>** internal pressure.
3. Steam Coils: Factory tested with air while coil is completely submerged underwater to design pressure indicated, but not less than to **[300-psig (2070-kPa)]<Insert pressure>** internal pressure.
4. Coils to display a tag with inspector's identification as proof of testing.

C. Fan Vibration Testing:

1. Perform a fan vibration test for **[each fan]<Insert requirement>**.
2. Energize each fan after final assembly and perform a vibration analysis with fan operating at design speed **[and at all speeds throughout the range from design to minimum speed]**.
3. Three vibration measurements shall be taken for each bearing in horizontal, vertical, and axial directions. Vibration measurements shall be recorded and consist of vibration amplitude verses frequency **[with filter-in]**.
4. Fan bearing measurement points shall be marked or scribed on bearings for permanent record.
5. Test results shall indicate that units comply with vibration requirements indicated. Make changes to noncompliant fans and retest until fans comply with requirements.
6. Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single fan, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine air-handling units before installation. Reject units with physical damage, and air-handling unit components that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for the following before installation of air-handling units:
 1. Structural substrate mounting and anchorage to verify actual sizes, types, and locations.
 2. Piping systems to verify actual sizes, types, and locations of connections.
 3. Ductwork and plenums to verify actual sizes, types, and locations of connections.
 4. Electrical services and controls to verify actual sizes, types, and locations of connections.

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

3.2 INSTALLATION OF INDOOR, CUSTOM AIR-HANDLING UNITS

- A. Equipment Mounting: Install air-handling units at locations indicated on Drawings. Unless, otherwise indicated on Drawings, install air-handling units on concrete equipment bases.
1. Units Mounted on Concrete Bases:
 - a. Install air-handling units on cast-in-place concrete equipment bases. Coordinate sizes and locations of concrete bases with actual equipment provided. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - b. Level air-handling unit bases using aluminum or stainless steel shims compatible with air-handling unit base material.
 - c. Fill voids between air-handling unit bases and concrete bases using high-strength non-shrink grout.
 - d. Continuously seal between concrete bases and perimeter of air-handling unit bases with nonhardening sealant.
 2. Units Mounted to Structural-Steel Supports: Level unit air-handling bases using aluminum or stainless steel shims compatible with air-handling unit base material. Continuously seal between structural supports and air-handling unit bases with nonhardening sealant.
 3. Units Mounted Directly to Finished Floors: Level air-handling unit bases using aluminum or stainless steel shims compatible with air-handling unit base material. Continuously seal between floor and perimeter of air-handling unit bases with nonhardening sealant.
 4. Suspended Units: Suspend and laterally brace air-handling units from building structure by attaching to only air-handling unit bases at manufacturer-designated locations.
 5. Comply with requirements for seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
- B. Equipment Clearances and Access:
1. Arrange installation of air-handling units to provide access space around air-handling units for service and maintenance and for removal and replacement of internal components.
 2. Provide clearance and access required by governing codes and NFPA 70.
 3. At a minimum, comply with requirements indicated on Drawings and air-handling unit manufacturer's written instructions.

3.3 PROTECTION DURING CONSTRUCTION

- A. Exterior Covers: Cover air-handling units during construction with sealed covers to protect air-handling unit casing and externally mounted components from physical damage, dirt, dust and debris, paint splatter, and any other construction materials.
1. Minor physical damage, as determined by Owner, shall be repaired by air-handling unit factory service personnel to factory-finished condition.
 2. Replace air-handling units with damage that in any way compromises the performance indicated.
- B. Internal Access: Keep access doors locked to maximum extent possible and restrict access to only authorized personnel.
1. Open access doors only during periods authorized work inside air-handling units is required.
 2. Coordinate and monitor work inside air-handling units on a shift basis. Lock access doors once work is complete or at the end of each shift.

3. Immediately report unauthorized access and any observed damage to Owner.

3.4 DUCT CONNECTIONS

- A. Connect ducts and plenums to air-handling unit connections. Comply with requirements in Section 233113 "Metal Ducts."
- B. Connect ducts and plenums to air-handling unit connections with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."
- C. Provide duct transitions required to make field connections to air-handling units.
- D. Arrange ducts and plenums to provide unobstructed access to inside of air-handling units.

3.5 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to air-handling unit, provide unobstructed access to inside of air-handling units for service and maintenance.
- C. Connect piping to air-handling units with flexible connectors.
- D. Drain Pan Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping."
 1. Make connections to air-handling unit connections with **[flanges or]**unions.
 2. Extend **[dedicated]**drain piping from each air-handling unit connection to nearest equipment or floor drain and arrange piping to maintain clear service aisle paths free of potential tripping hazards.
 3. Construct traps near air-handling unit connections to seal airflow from escaping within air-handling unit. Locate traps in a serviceable location that is away from access doors.
 4. Install threaded cleanouts at changes in direction.
 5. Secure drain piping to structure.
- E. Air-Handling Unit Floor Drains: Do not require installation of permanent drain piping.
- F. Air-Handling Unit Floor Drain Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping."
 1. Make connections to air-handling unit connections with **[flanges or]**unions.
 2. Extend **[dedicated]**drain piping from each air-handling unit connection to nearest equipment or floor drain and arrange piping to maintain clear service aisle paths free of potential tripping hazards.
 3. Construct traps near air-handling unit connections to seal airflow from escaping within air-handling unit. Locate traps in a serviceable location that is away from access doors.
 4. Install threaded cleanouts at changes in direction.
 5. Secure drain piping to structure.
- G. Chilled-Water Coil Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."

1. Comply with requirements indicated on Drawings.
 2. Make connections to coils with a [flange][or][union].
 3. Connect to each coil inlet with shutoff valve, test plug, [pressure gauge][and][thermometer].
 4. Connect to each coil outlet with balancing valve, test plug, [pressure gauge][thermometer][flow meter][and][shutoff valve].
 5. Connect each coil drain connection with a drain valve, which is full size of drain connection.[
Connect drain pipe to drain valve with union, and extend drain pipe to terminate over floor drain.]
 6. Connect each coil vent connection with [automatic][or][manual] vent, which is full size of vent connection.
- H. Hot-Water Coil Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
1. Comply with requirements indicated on Drawings.
 2. Make connections to coils with a [flange][or][union].
 3. Connect to each coil inlet with shutoff valve, test plug, [pressure gauge][and][thermometer].
 4. Connect to each coil outlet with balancing valve, test plug, [pressure gauge][thermometer][flow meter][and][shutoff valve].
 5. Connect each coil drain connection with a drain valve, which is full size of drain connection.[
Connect drain pipe to drain valve with union, and extend drain pipe to terminate over floor drain.]
 6. Connect each coil vent connection with [automatic][or][manual] vent, which is full size of vent connection.
- I. Steam and Condensate Coil Piping: Comply with applicable requirements in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties." Install shutoff valve at steam supply connections, float and thermostatic trap assembly, and union or flange at each coil return connection.
- J. Refrigerant Coil Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Install shutoff valve at each supply and return connection.
- K. Steam Humidifier Piping: Comply with applicable requirements in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties." Install gate valve and inlet strainer at supply connection of steam humidifiers and steam trap assemblies to condensate return connection.
- 3.6 ELECTRICAL CONNECTIONS
- A. Install field power to each air-handling unit electrical power connection. Coordinate with air-handling unit manufacturer and installers.
 - B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
 - C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
 - D. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
 - E. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553

"Identification for Electrical Systems."

2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least [1/2 inch (13 mm)]<Insert dimension> high.

3.7 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."
- C. Install nameplate for each control connection, indicating field control panel designation and I/O control designation feeding connection.

3.8 STARTUP SERVICE

- A. Engage an air-handling unit factory[-**authorized**] service representative to perform startup service.
 1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 2. Verify that shipping, blocking, and bracing are removed.
 3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, controls, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
 4. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
 5. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
 6. Verify that face-and-bypass dampers provide full face flow.
 7. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
 8. Comb coil fins for parallel orientation.
 9. Verify that proper thermal-overload protection is installed for electric heaters.
 10. Install new, clean filters.
 11. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.
 12. <Insert requirement>.
- B. Starting procedures for air-handling units include the following:
 1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. [**Replace fan and motor pulleys as required to achieve design conditions.**]
 2. Measure and record motor electrical values for voltage and amperage.
 3. Manually operate dampers from fully closed to fully open position and record fan performance.
 4. <Insert requirement>.
- C. Heat Wheel Startup Service:
 1. After field installation is complete, a final checkout and startup shall be completed to ensure proper purge adjustment, seal adjustment, control settings, and other key operational functions.
 2. Service shall be completed by trained factory service personnel employed by heat wheel manufacturer.
 3. Submit a report summarizing findings, adjustments made, and final settings.

3.9 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.
- C. Before turning equipment over to Owner for use, adjust air-handling unit components that require further adjustment for proper operation. Consult air-handling unit manufacturer for instruction.
- D. Occupancy Adjustments: When requested within [12]<Insert number> months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to [two]<Insert number> visits to Project during other-than-normal occupancy hours for this purpose.
- E. Seasonal Adjustments: Make seasonal visits during warranty period to inspect and review operation of equipment. Make necessary adjustments for components observed to require adjustments for proper operation. Prepare and submit a report to Owner documenting each visit, observations, and any adjustments made.

3.10 CLEANING

- A. Cleaning Schedule: After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems, and after completing startup service, and immediately before Owner use, clean air-handling units to remove foreign material and construction dirt and dust.
- B. Unit Interior: Clean air-handling units internally to factory clean condition. Remove foreign material and construction debris, dirt, and dust.
 - 1. Vacuum clean with HEPA-filtered vacuum and then wipe down with cleaning solution.
 - 2. Clean casing floors, roofs, wall surfaces, access doors, and panels.
 - 3. Clean all internal components, such as, coils, dampers, filter frames, fans, and motors.
 - 4. Clean light fixtures and control devices.
- C. Unit Exterior: Clean external surfaces of air-handling units to factory clean condition. Remove foreign material and construction debris, dirt, and dust. Vacuum clean with HEPA-filtered vacuum and then wipe down all surfaces with cleaning solution.
- D. Cleaning Materials: Use cleaning materials and products recommended in writing by air-handling unit manufacturer.
- E. Acceptance: Following unit cleaning, submit a written request for review and [Owner] acceptance. Acceptance for cleaning of air-handling units [**with absolute filters**] must pass a white glove test.

3.11 FIELD QUALITY CONTROL

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

authorized service representative]:

1. After field piping connections are complete, test **[hydronic][and][steam]** coils and connections for leaks.
2. Charge refrigerant coils with refrigerant and test for leaks.
3. Field-Assembly Supervision: Instruct Installer and supervise field installation of **[first]<Insert quantity>** air-handling unit(s) shipped in multiple pieces for field assembly.
4. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Field Casing Leakage Test:

1. Perform leak testing of air-handling units that include field assembly of multiple sections. Air-handling units that are shipped and installed as a single piece do not require field testing.
2. Leak test **[one]<Insert value>** air-handling unit(s) of each unique size and arrangement randomly selected by **[Architect][Commissioning Agent][Owner]**.
3. Follow procedures complying with ASHRAE 111.
4. Assembled air-handling units shall satisfy leakage criteria indicated. Modify air-handling units that fail to satisfy criteria and retest. For every air-handling unit that fails test, another air-handling unit shall be tested until all air-handling units tested pass leakage criteria on first attempt.
5. Submit a test report for each test indicating test equipment, procedures, results, date and time, and full name of personnel performing tests and witnesses.
6. Test report shall be in accordance with ASHRAE 111.
7. Witness Testing:
 - a. Provide written notification at least **[30][20]<Insert number>** business days in advance of testing.
 - b. Testing shall be conducted in presence of testing and balancing agent.
 - c. Other parties such as Architect, Commissioning Agent, and Owner shall be invited to witness testing with attendance being optional.

E. Field Fan Vibration Test:

1. Perform fan vibration testing for every one out of **[10]<Insert number>** air-handling unit fans randomly selected by **[Architect][Commissioning Agent][Owner]**.
2. Test after air-handling unit installation is complete.
3. Three vibration readings shall be taken for each bearing in horizontal, vertical, and axial directions. Record each reading including vibration amplitude verses frequency.
4. Modify fans that fail to satisfy performance criteria and retest. For every fan that fails test, another fan shall be tested until all fans tested pass criteria on first attempt.
5. Submit a report for each fan tested indicating air-handling unit designation, fan designation, test equipment, procedures, results, date and time, and full name of personnel performing tests and witnesses.
6. Witness Testing:
 - a. Provide written notification at least **[30][20]<Insert number>** business days in advance of testing.
 - b. Testing shall be conducted in presence of testing and balancing agent.
 - c. Other parties such as Commissioning Agent, Architect, and Owner shall be invited to witness testing with attendance being optional.

- F. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.**

- G. Prepare test and inspection reports.

3.12 OPERATION DURING CONSTRUCTION

- A. Operation of air-handling units for temporary cooling, heating, and ventilation is not allowed without Owner authorization.
1. Submit written request for Owner approval by signature with detailed description of operating procedures to be followed including, but not limited to, the following:
 - a. Description of construction activities while units are operating.
 - b. Operation:
 - 1) Beginning and ending calendar dates.
 - 2) List each day during week.
 - 3) List start and stop time and hours for each day.
 - c. Startup procedures and shut-down procedures.
 - d. Provisions for routine monitoring of unit operation.
 - e. Provisions to prevent and protect against damage to equipment due to adverse operation such as, low temperature, high temperature, over pressure, fire, smoke, electrical over- and undervoltage, and current and electrical fault.
 - f. Provisions and safeguards for filtration to keep inside of units from getting dirty.
 - g. Record keeping.
 2. If approved by Owner, units used for temporary cooling, heating, and ventilation during and before interior finish work is complete shall include an unconditional complete unit labor and parts warranty to extend at least **[two]<Insert number>** years after the warranty indicated expires.
 3. Interior and exterior of air-handling units shall be cleaned to a factory-cleaned condition and clean condition must be accepted by Owner.
- B. Filtration during Temporary Use:
1. Protect air-handling system ducts (exhaust air, outdoor air, and return air) with temporary filters installed and supported to prevent filter media from collapse and bypass of unfiltered air. Temporary media shall be installed at each inlet and shall have a published filtration efficiency of MERV **[8][11][13]<Insert MERV>** in accordance with ASHRAE 52.2.
 2. Protect air-handling units with open inlets that are not ducted with temporary filters installed and supported to prevent filter media from collapse and bypass of unfiltered air. Temporary media shall be installed at each inlet and shall have a published filtration efficiency of MERV **[8][11][13]<Insert MERV>** in accordance with ASHRAE 52.2.
 3. Do not operate air-handling units until both temporary and scheduled permanent air-handling unit particulate filters are in place. Temporary filters must be installed upstream of permanent filters while units are operating.
 4. Replace temporary and permanent filters used during construction when dirty. After end of temporary use, replace permanent filters with new, clean filters before beginning testing, adjusting, and balancing.
- C. Comply with SMACNA 008, "IAQ Guidelines for Occupied Buildings under Construction," for procedures to protect HVAC system.

3.13 DEMONSTRATION

- A. Engage air-handling unit manufacturer **[employed training instructor][or][factory-authorized service**

representative] to train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

- B. Training shall include, but not be limited to, procedures and schedules related to performance, safety, startup and shut down, troubleshooting, servicing, preventive maintenance, and how to obtain replacement parts.
1. Access Doors: Adjustment, gasket removal and replacement, handle removal and replacement, and spare parts.
 2. Access Panels: Removal and replacement, adjustment, gasket removal and replacement, and spare parts.
 3. Air Blenders: Cleaning, operation, removal, and replacement.
 4. Coils: Cleaning, combing fins, draining, venting, removal, and replacement.
 5. Controls: Calibration, cleaning, operation, service, removal and replacement, and spare parts.
 6. Damper Assemblies: Cleaning, operation, service, removal and replacement, and spare parts.
 7. Drain Pans: Cleaning, removal, and replacement.
 8. Duct Silencers: Cleaning, removal, and replacement.
 9. Electric Heaters: Cleaning, operation, service, removal and replacement, and spare parts.
 10. Heat Wheels: Cleaning, operation, service, removal and replacement, and spare parts.
 11. Fan and Motor Assemblies: Cleaning, operation, removal and replacement, service, and spare parts.
 12. Filters: Operation, removal and replacement, frame gasket removal and replacement, clip removal and replacement, and spare parts.
 13. Fixed Plate heat Exchangers: Cleaning, removal, and replacement.
 14. Heat Pipe Heat Exchangers: Cleaning, combing fins, removal, and replacement.
 15. Humidifiers: Cleaning, operation, service, removal and replacement, and spare parts.
 16. UV-C Lamp Systems: Cleaning, operation, service, removal and replacement, and spare parts.
 17. Lights, Receptacles, and Switches: Cleaning, operation, service, removal and replacement, and spare parts.
 18. **<Insert requirement>**.
- C. Instructor:
1. Instructor shall be factory trained and certified by air-handling unit manufacturer with current training on equipment installed.
 2. Instructor's credentials shall be submitted for review by **[Architect][Commissioning Agent][Owner]** before scheduling training.
 3. Instructor(s) **[primary][sole]** job responsibility shall be Owner training.
 4. Instructor(s) shall have not less than **[three]<Insert number>** years of training experience with air-handling unit manufacturer and past training experience on at least **[three]<Insert number>** projects of comparable size and complexity.
- D. Schedule and Duration:
1. Schedule training with Owner at least **[20]<Insert number>** business days before first training session.
 2. Training shall occur before Owner occupancy.
 3. Training shall be held at mutually agreed date and time during normal business hours.
 4. Each training day shall not exceed **[eight]<Insert number>** hours of training. Daily training schedule shall allow time for a **[one]<Insert number>**-hour lunch period and **[15]<Insert number>**-minute break after every **[two]<Insert number>** hours of training.
 5. Perform not less than **[eight][16][24]<Insert number>** hours of training.
- E. Location: Owner to provide a suitable on-site location to host classroom training.



- F. Training Attendees: Assume [three]<Insert number> people.
- G. Training Attendance Records: For record purposes, document training attendees at start of each new training session. Record date, time, brief description of training covered during the session, attendee's name, signature, phone number, and e-mail address. Submit scanned copy of sign-in sheet to Owner for each training session.
- H. Training Format: Individual training modules to include classroom training followed by hands-on field demonstration and training.
- I. Training Materials: Provide training materials in electronic format to each attendee.
 - 1. Include instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
- J. Training Video Recording: Video record each classroom training session and submit an electronic copy to Owner before requesting Owner acceptance of training.
- K. Written Acceptance: Obtain [Architect][Commissioning Agent][or][Owner] written acceptance that training is complete and requirements indicated have been satisfied.

END OF SECTION 23 73 13 00B



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23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 73 13 00	07 72 00 00	Roof Accessories
23 73 13 00	23 73 00 00	Indoor, Indirect, Gas-Fired Heating and Ventilating Units
23 73 13 00	23 73 00 00a	Indoor, Direct-Fired Heating and Ventilating Units



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SECTION 23 74 00 00 - OUTDOOR, SEMI-CUSTOM AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Outdoor, semi-custom air-handling units.

1.2 ACTION SUBMITTALS

A. Product Data: For each air-handling unit.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Include unit dimensions and weight.
4. Include cabinet material, metal thickness, finishes, insulation, and accessories.
5. Fans:
 - a. Include certified fan-performance curves with system operating conditions indicated.
 - b. Include certified fan-sound power ratings.
 - c. Include fan construction and accessories.
 - d. Include motor ratings, electrical characteristics, and motor accessories.
6. Include certified coil-performance ratings with system operating conditions indicated.
7. Include dampers, including housings, linkages, and operators.

B. Sustainable Design Submittals:

1. Product data showing compliance with ASHRAE 62.1.
2. Product Data: For air filtration performance.
3. Product Data: For adhesives, mastics, and sealants, indicating VOC content.
4. Laboratory Test Reports: For adhesives, mastics, and sealants, indicating compliance with requirements for low-emitting materials.

C. Shop Drawings: For each outdoor, semi-custom air-handling unit.

1. Include plans, elevations, sections, and **[mounting][attachment]** details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of outdoor, semi-custom air-handling units, as well as procedure and diagrams.
4. Include diagrams for power, signal, and control wiring.

D. Delegated Design Submittal: For vibration isolation[, **supports**],[and **seismic restraints**] indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.



1. Design Calculations: Calculate requirements for selecting vibration isolators[, **supports**,][and **seismic restraints**,] and for designing vibration isolation bases.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
- B. Sample Warranty: For manufacturer's warranty.
- C. Seismic Qualification Data: Certificates for air-handling units, accessories, and components, from manufacturer.
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
 4. Restraint of internal components.
- D. Wind Qualification Data: Certificates for air-handling units, accessories, and components, from manufacturer.
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of wind force and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- E. Source quality-control reports.
- F. Startup service reports.
- G. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air-handling units to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Filters: **[One]<Insert number>** set(s) for each air-handling unit.
 2. Gaskets: **[One]<Insert number>** set(s) for each access door.
 3. Fan Belts: **[One]<Insert number>** set(s) for each air-handling unit fan.

1.6 WARRANTY

- A. Warranty: Manufacturer agrees to repair or replace components of outdoor, semi-custom, air-handling unit that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Entire Unit: Manufacturer's standard but not less than **[one]<Insert number>** year(s) from date of Substantial Completion.
 - 2. Warranty Period for Heat Wheels: Not less than **[five]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.
- C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- E. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation[, **supports**], and **seismic restraints**, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- F. Structural Performance:
 - 1. Casing Panels: Self-supporting and capable of withstanding positive/negative **[8-inch wg (2000-Pa)]<Insert value>** internal static pressure, without exceeding a midpoint deflection of **[0.0042 inch/inch (0.0042 mm/mm)]<Insert dimensions>** of panel span.
 - 2. Floor and Roof Panels: Self-supporting and capable of withstanding **300-lb (136-kg)** static load at midspan, without exceeding a midpoint deflection of **[0.0042 inch/inch (0.0042 mm/mm)]<Insert dimensions>**.
 - 3. Roof Panels: Self-supporting and capable of withstanding a static snow load of **30 lb/sq. ft. (146 kg/sq. m)**, without exceeding a midpoint deflection of **[0.0042 inch/inch (0.0042 mm/mm)]<Insert dimensions>**.
- G. Casing Leakage Performance: ASHRAE 111, **[Class 6 leakage]<Insert leakage class>** or better at **[plus or minus 8-inch wg (2000 Pa)]<Insert pressure>**.
- H. Seismic Performance: Air-handling units shall withstand the effects of earthquake motions determined according to **[ASCE/SEI 7]<Insert requirement>**. See Section 230548 "Vibration and Seismic Controls for HVAC."
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."
 - 2. Component Importance Factor: **[1.5][1.0]**.

3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>.**

- I. Wind Performance: Air-handling units are to withstand the effects of wind determined in accordance with [ASCE/SEI 7] <Insert requirement>. See [Section 230548 "Vibration and Seismic Controls for HVAC."][Section 230548.13 "Vibration Controls for HVAC."]

2.2 CAPACITIES AND CHARACTERISTICS

A. Supply Fan:

1. Type: [DWDI, backward-inclined centrifugal fan][DWDI, forward-curved centrifugal fan][DWDI, airfoil centrifugal fan][SWSI, airfoil unhooused centrifugal fan] <Insert fan type>.
2. Class: AMCA 99, Section 14, [Class I][Class II][Class III].
3. Drive: [V-belt][Direct].
4. Number of Fan Wheels: <Insert number>.
5. Fan Diameter: <Insert value> inches (mm).
6. Airflow: <Insert value> cfm (L/s).
7. Total Static Pressure: <Insert value> inches wg (kPa).
8. External Static Pressure: <Insert value> inches wg (kPa).
9. Speed: <Insert rpm>.
10. Maximum Outlet Velocity: <Insert value> fpm (m/s).
11. Motor:

- a. Size: <Insert horsepower>.
- b. Speed: <Insert rpm>.
- c. Volts: [208][230][460] <Insert value> V.
- d. Phase: [Three] <Insert value>.
- e. Hertz: [60] <Insert number> Hz.
- f. Full-Load Amperes: <Insert value> A.
- g. Minimum Circuit Ampacity: <Insert value> A.
- h. Maximum Overcurrent Protection: <Insert amperage> A.

12. Fan Discharge Sound Power, dB:

- a. 1st Octave: <Insert value>.
- b. 2nd Octave: <Insert value>.
- c. 3rd Octave: <Insert value>.
- d. 4th Octave: <Insert value>.
- e. 5th Octave: <Insert value>.
- f. 6th Octave: <Insert value>.
- g. 7th Octave: <Insert value>.
- h. 8th Octave: <Insert value>.

B. Fan: [Return][Exhaust].

1. Type: [DWDI, backward-inclined centrifugal fan][DWDI, forward-curved centrifugal fan][DWDI, airfoil centrifugal fan][SWSI, airfoil unhooused centrifugal plenum fan] <Insert fan type>.
2. Class: AMCA 99, Section 14, [Class I][Class II][Class III].
3. Drive: [V-belt][Direct].
4. Number of Fan Wheels: <Insert value>.
5. Fan Diameter: <Insert value> inches (mm).
6. Airflow: <Insert value> cfm (L/s).

7. Total Static Pressure: **<Insert value> inches wg (kPa).**
8. External Static Pressure: **<Insert value> inches wg (kPa).**
9. Speed: **<Insert rpm>.**
10. Maximum Outlet Velocity: **<Insert value> fpm (m/s).**
11. Motor:
 - a. Size: **<Insert value> hp.**
 - b. Speed: **<Insert value> rpm.**
 - c. Volts: **[208][230][460]<Insert value> V.**
 - d. Phase: **[Three]<Insert number>.**
 - e. Hertz: **[60]<Insert number> Hz.**
 - f. Full-Load Amperes: **<Insert value> A.**
 - g. Minimum Circuit Ampacity: **<Insert value> A.**
 - h. Maximum Overcurrent Protection: **<Insert amperage> A.**
12. Fan Inlet Sound Power, dB:
 - a. 1st Octave: **<Insert value>.**
 - b. 2nd Octave: **<Insert value>.**
 - c. 3rd Octave: **<Insert value>.**
 - d. 4th Octave: **<Insert value>.**
 - e. 5th Octave: **<Insert value>.**
 - f. 6th Octave: **<Insert value>.**
 - g. 7th Octave: **<Insert value>.**
 - h. 8th Octave: **<Insert value>.**

C. Preheat Coil:

1. Heat-Transfer Rate: **<Insert value> Btu/h (kW).**
2. Entering-Air Temperature: **<Insert value> deg F (deg C).**
3. Leaving-Air Temperature: **<Insert value> deg F (deg C).**
4. Face Area: **<Insert value> sq. ft. (sq. m).**
5. Maximum Face Velocity: **<Insert value> fpm (m/s).**
6. Maximum Air-Side, Static-Pressure Drop: **<Insert value> inches wg (Pa).**
7. Fin Spacing: Maximum **<Insert number> fins per inch (per mm).**
8. Minimum Number of Rows: **<Insert number>.**
9. Integral Face-and-Bypass Dampers: **[Horizontal][Vertical], opposed-blade, [galvanized-steel][aluminum][extruded-aluminum] dampers with [zinc-plated]steel operating rods rotating in sintered bronze or nylon bearings mounted in a single [galvanized-steel][aluminum][extruded-aluminum] frame, with operating rods connected with a common linkage. Meeting edges of blades shall have gaskets and edge seals, and blades shall be mechanically fastened.**
10. Water:
 - a. Water Flow: **<Insert value> gpm (L/s).**
 - b. Maximum Water Pressure Drop: **<Insert value> feet of head (kPa).**
 - c. Entering-Water Temperature: **<Insert value> deg F (deg C).**
 - d. Leaving-Water Temperature: **<Insert value> deg F (deg C).**
 - e. Tube Velocity: **<Insert value> fpm (L/s).**
11. Steam:
 - a. Steam Flow: **<Insert value> lb/h (g/s).**
 - b. Inlet Steam Pressure: **<Insert value> psig (kPa).**
 - c. Outer-Tube Diameter: **<Insert value> inches (mm).**

D. Heating Coil:

1. Heat-Transfer Rate: **<Insert value> Btu/h (kW).**
2. Entering-Air Temperature: **<Insert value> deg F (deg C).**
3. Leaving-Air Temperature: **<Insert value> deg F (deg C).**
4. Face Area: **<Insert value> sq. ft. (sq. m).**
5. Maximum Face Velocity: **<Insert value> fpm (m/s).**
6. Maximum Air-Side, Static-Pressure Drop: **<Insert value> inches wg (Pa).**
7. Number of Rows: **<Insert number>.**
8. Fin Spacing: Maximum **<Insert number> fins per inch (per mm).**
9. Water:
 - a. Water Flow: **<Insert value> gpm (L/s).**
 - b. Maximum Water Pressure Drop: **<Insert value> feet of head (kPa).**
 - c. Entering-Water Temperature: **<Insert value> deg F (deg C).**
 - d. Leaving-Water Temperature: **<Insert value> deg F (deg C).**
 - e. Tube Velocity: **<Insert value> fpm (L/s).**
10. Steam:
 - a. Steam Flow: **<Insert value> lb/h (g/s).**
 - b. Inlet Steam Pressure: **<Insert value> psig (kPa).**

E. Electric Heating Coil:

1. Heat-Transfer Rate: **<Insert value> Btu/h (kW).**
2. Input: **<Insert kilowatts>.**
3. Volts: **[120][208][230]<Insert value> V.**
4. Phase: **[Single][Three].**
5. Full-Load Amperes: **<Insert value> A.**
6. Number of Steps: **<Insert number>.**

F. Cooling Coil:

1. Sensible Heat-Transfer Rate: **<Insert value> Btu/h (kW).**
2. Total Heat-Transfer Rate: **<Insert value> Btu/h (kW).**
3. Entering-Air, Dry-Bulb Temperature: **<Insert value> deg F (deg C).**
4. Entering-Air, Wet-Bulb Temperature: **<Insert value> deg F (deg C).**
5. Leaving-Air, Dry-Bulb Temperature: **<Insert value> deg F (deg C).**
6. Leaving-Air, Wet-Bulb Temperature: **<Insert value> deg F (deg C).**
7. Face Area: **<Insert value> sq. ft. (sq. m).**
8. Maximum Face Velocity: **<Insert value> fpm (m/s).**
9. Maximum Air-Side, Static-Pressure Drop: **<Insert value> inches wg (Pa).**
10. Number of Rows: **<Insert number>.**
11. Fin Spacing: Maximum **<Insert number> fins per inch (per mm).**
12. Water:
 - a. Water Flow: **<Insert value> gpm (L/s).**
 - b. Maximum Water Pressure Drop: **<Insert value> feet of head (kPa).**
 - c. Entering-Water Temperature: **<Insert value> deg F (deg C).**
 - d. Leaving-Water Temperature: **<Insert value> deg F (deg C).**
 - e. Tube Velocity: **<Insert value> fpm (L/s).**
13. Refrigerant:

- a. Refrigerant Type: <Insert refrigerant type>.

G. Prefilters:

1. Type: <Insert type>.
2. Face Dimensions, each: <Insert value> inches by inches (mm by mm).
3. Depth: <Insert value> inches (mm).
4. Number of Filters, Wide by High: <Insert number>.
5. Access Location: [Front][Back][Side][Bottom].
6. Maximum or Rated Face Velocity: <Insert value> fpm (m/s).
7. Initial Resistance: <Insert value> inches wg (Pa).
8. Recommended Final Resistance: <Insert value> inches wg (Pa).
9. Minimum Efficiency Reporting Value and Average Arrestance:

- a. MERV Rating: [MERV 1][MERV 2][MERV 3][MERV 4], and corresponding average arrestance according to ASHRAE 52.2.

10. Minimum Efficiency Reporting Value:

- a. MERV Rating: [MERV 6][MERV 13]<Insert value>, according to ASHRAE 52.2.

H. Final Filters:

1. Type: <Insert type>.
2. Face Dimensions, each: <Insert value> inches by inches (mm by mm).
3. Depth: <Insert value> inches (mm).
4. Number of Filters, Wide by High: <Insert number>.
5. Access Location: [Front][Back][Side][Bottom].
6. Maximum or Rated Face Velocity: <Insert value> fpm (m/s).
7. Initial Resistance: <Insert value> inches wg (Pa).
8. Recommended Final Resistance: <Insert value> inches wg (Pa).
9. Minimum Efficiency Reporting Value:

- a. MERV Rating: [MERV 6][MERV 13]<Insert value>, according to ASHRAE 52.2.

I. Dampers: [Zone][Mixing dampers][Face and bypass].

J. Sound Attenuators:

1. Configuration: [Straight][Elbow].
2. Shape: [Rectangular][Round].
3. Attenuation Mechanism: [Acoustic glass fiber][Packless].
4. Maximum Pressure Drop: <Insert value> inches wg (Pa).
5. Length: <Insert value> inches (mm).
6. Face Dimension: <Insert value> inches (mm) wide by <Insert value> inches (mm) high.
7. Face Velocity: <Insert value> fpm (m/s).
8. Dynamic Insertion Loss:

- a. 1st Octave: <Insert dBa>.
- b. 2nd Octave: <Insert dBa>.
- c. 3rd Octave: <Insert dBa>.
- d. 4th Octave: <Insert dBa>.
- e. 5th Octave: <Insert dBa>.
- f. 6th Octave: <Insert dBa>.
- g. 7th Octave: <Insert dBa>.
- h. 8th Octave: <Insert dBa>.

9. Generated Noise:

- a. 1st Octave: <Insert dBa>.
- b. 2nd Octave: <Insert dBa>.
- c. 3rd Octave: <Insert dBa>.
- d. 4th Octave: <Insert dBa>.
- e. 5th Octave: <Insert dBa>.
- f. 6th Octave: <Insert dBa>.
- g. 7th Octave: <Insert dBa>.
- h. 8th Octave: <Insert dBa>.

K. Steam Grid Humidifier:

1. Humidification Rate: <Insert value> lb/h (g/s).
2. Steam Supply Pressure: <Insert value> psig (kPa).
3. Dry-Bulb Air Temperature at Discharge: <Insert value> deg F (deg C).
4. Wet-Bulb Air Temperature at Discharge: <Insert value> deg F (deg C).
5. Maximum Absorption Distance: <Insert value> inches (mm).
6. Number of Distribution [Tubes][Manifolds]: <Insert number>.

L. Self-Contained Electric-Resistance Humidifier.

1. Humidification Rate: <Insert value> lb/h (g/s).
2. Dry-Bulb Air Temperature at Discharge: <Insert value> deg F (deg C).
3. Wet-Bulb Air Temperature at Discharge: <Insert value> deg F (deg C).
4. Maximum Absorption Distance: <Insert value> inches (mm).
5. Minimum Makeup Water Supply Pressure: <Insert value> psig (kPa).
6. Electric-Resistance Evaporation Chamber:
 - a. Power Input per Chamber: <Insert number> kW.
 - b. Number of Chambers: <Insert number>.

M. Self-Contained Gas-Fired Humidifier:

1. Humidification Rate: <Insert value> lb/h (g/s).
2. Dry-Bulb Air Temperature at Discharge: <Insert value> deg F (deg C).
3. Wet-Bulb Air Temperature at Discharge: <Insert value> deg F (deg C).
4. Maximum Absorption Distance: <Insert value> inches (mm).
5. Minimum Makeup Water Supply Pressure: <Insert value> psig (kPa).
6. Gas-Fired Generator:
 - a. Fuel Input: <Insert value> Btu/h (kW).
 - b. Fuel Pressure: <Insert value> inches wg (kPa).
7. Number of Distribution [Tubes][Manifolds]: <Insert number>.

N. Heat-Exchanger Humidifier:

1. Humidification Rate: <Insert value> lb/h (g/s).
2. Dry-Bulb Air Temperature at Discharge: <Insert value> deg F (deg C).
3. Wet-Bulb Air Temperature at Discharge: <Insert value> deg F (deg C).
4. Maximum Absorption Distance: <Insert value> inches (mm).
5. Minimum Makeup Water Supply Pressure: <Insert value> psig (kPa).
6. Steam to Heat Exchanger:



- a. Supply Pressure at Control Valve: **<Insert value> psig (kPa).**
- b. Condensing Rate: **<Insert value> lb/h (g/s).**
- O. Air-to-Air Energy Recovery:
 - 1. Type: **[Heat-wheel air-to-air energy recovery][Fixed-plate air-to-air energy recovery].**
 - 2. Exhaust Air:
 - a. Airflow: **<Insert value> cfm (L/s).**
 - b. Face Velocity: **<Insert value> fpm (m/s).**
 - c. Summer:
 - 1) Entering-Air Temperature, Dry Bulb: **<Insert value> deg F (deg C).**
 - 2) Entering-Air Temperature, Wet Bulb: **<Insert value> deg F (deg C).**
 - 3) Leaving-Air Temperature, Dry Bulb: **<Insert value> deg F (deg C).**
 - 4) Leaving-Air Temperature, Wet Bulb: **<Insert value> deg F (deg C).**
 - d. Winter:
 - 1) Entering-Air Temperature, Dry Bulb: **<Insert value> deg F (deg C).**
 - 2) Entering-Air Temperature, Wet Bulb: **<Insert value> deg F (deg C).**
 - 3) Leaving-Air Temperature, Dry Bulb: **<Insert value> deg F (deg C).**
 - 4) Leaving-Air Temperature, Wet Bulb: **<Insert value> deg F (deg C).**
 - 5) Air Pressure Drop: **<Insert value> inches wg (Pa).**
 - 3. Supply Air:
 - a. Airflow: **<Insert value> cfm (L/s).**
 - b. Face Velocity: **<Insert value> fpm (m/s).**
 - c. Summer:
 - 1) Entering-Air Temperature, Dry Bulb: **<Insert value> deg F (deg C).**
 - 2) Entering-Air Temperature, Wet Bulb: **<Insert value> deg F (deg C).**
 - 3) Leaving-Air Temperature, Dry Bulb: **<Insert value> deg F (deg C).**
 - 4) Leaving-Air Temperature, Wet Bulb: **<Insert value> deg F (deg C).**
 - d. Winter:
 - 1) Entering-Air Temperature, Dry Bulb: **<Insert value> deg F (deg C).**
 - 2) Entering-Air Temperature, Wet Bulb: **<Insert value> deg F (deg C).**
 - 3) Leaving-Air Temperature, Dry Bulb: **<Insert value> deg F (deg C).**
 - 4) Leaving-Air Temperature, Wet Bulb: **<Insert value> deg F (deg C).**
 - 5) Air Pressure Drop: **<Insert value> inches wg (Pa).**
 - e. Wheel Drive:
 - 1) Motor Size: **<Insert horsepower>.**
 - 2) Motor Electrical Characteristics:
 - a) Volts: **[120][208][230]<Insert value> V.**
 - b) Phase: **[Single][Three].**
 - c) Hertz: **[60]<Insert number> Hz.**
 - f. Effectiveness: **<Insert percentage>.**
 - 4. Air Blender:

- a. Airflow: **<Insert value> cfm (L/s).**
- b. Minimum Velocity: **<Insert value> fpm (m/s).**
- c. Air Pressure Drop: **<Insert value> inches wg (Pa).**

5. Diffuser:

- a. Airflow: **<Insert value> cfm (L/s).**
- b. Air Pressure Drop: **<Insert value> inches wg (Pa).**

2.3 OUTDOOR, SEMI-CUSTOM AIR-HANDLING UNITS

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

1. **[Carrier Global Corporation]**
2. **[Coil Company, LLC]**
3. **[Daikin Applied]**
4. **[Dunham-Bush, Inc]**
5. **[Trane]**
6. **[USA Coil & Air]**
7. **[YORK; brand of Johnson Controls International plc, Building Solutions North America]**
8. **<Insert manufacturer's name>**

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

1. **[Carrier Global Corporation]**
2. **[Coil Company, LLC]**
3. **[Daikin Applied]**
4. **[Dunham-Bush, Inc]**
5. **[Trane]**
6. **[USA Coil & Air]**
7. **[YORK; brand of Johnson Controls International plc, Building Solutions North America]**
8. **<Insert manufacturer's name>**

- C. Source Limitations: Obtain from single source from single manufacturer.

D. Unit Casings:

1. Frame: Modular and providing overall structural integrity without reliance on casing panels for structural support.
2. Base Rail:

- a. Material: **[Galvanized steel][Welded structural steel]<Insert material>.**
- b. Height: **[6 inches (150 mm)]<Insert dimension>.**

3. Casing Joints: Hermetically sealed at each corner and around entire perimeter.
4. Double-Wall Construction:

a. Outside Casing Wall:

- 1) Material, Galvanized Steel: Minimum **[18 gauge (1.3 mm)][16 gauge (1.6 mm)][14 gauge (2.0 mm)]<Insert value> thick.**

- 2) Material, Aluminum: Minimum [16 gauge (1.3 mm)][14 gauge (1.6 mm)][12 gauge (2.0 mm)]<Insert value> thick.
 - 3) Material, Stainless Steel: Minimum [18 gauge (1.3 mm)][16 gauge (1.6 mm)][14 gauge (2.0 mm)]<Insert value> thick.
 - 4) Factory Finish: Provide [manufacturer's standard finish][corrosion-resistant coating]<Insert special coating>.
- b. Inside Casing Wall:
- 1) Material, Galvanized Steel: [Solid][Perforated], minimum [18 gauge (1.3 mm)][16 gauge (1.6 mm)]<Insert value> thick.
 - 2) Material, Aluminum: [Solid][Perforated], minimum [16 gauge (1.3 mm)][14 gauge (1.6 mm)]<Insert value> thick.
 - 3) Material, Stainless Steel: [Solid][Perforated], minimum [18 gauge (1.3 mm)][16 gauge (1.6 mm)]<Insert value> thick.
 - 4) Antimicrobial Coating: Applied during the manufacturing process. [EPA approved][NSF approved][FDA listed].
5. Floor Plate:
- a. Material:
- 1) Galvanized steel,[treadplate,] minimum [18 gauge (1.3 mm)][16 gauge (1.6 mm)][14 gauge (2.0 mm)][12 gauge (2.7 mm)][10 gauge (3.5 mm)]<Insert value> thick.
 - 2) Aluminum,[treadplate,] minimum [18 gauge (1.0 mm)][16 gauge (1.3 mm)][14 gauge (1.6 mm)][12 gauge (2.0 mm)][10 gauge (2.6 mm)]<Insert value> thick.
 - 3) Stainless steel,[treadplate,] minimum [18 gauge (1.3 mm)][16 gauge (1.6 mm)][14 gauge (2.0 mm)][12 gauge (2.8 mm)][10 gauge (3.5 mm)]<Insert value> thick.
- b. Antimicrobial Coating: Applied during the manufacturing process. [EPA approved][NSF approved][FDA listed].
6. Roof: Cross-broken and pitched with "C" caps over joints to provide watertight seal.
7. Piping Vestibule: Insulated with same insulation and thickness as casing, [18 inches (450 mm)][24 inches (600 mm)][30 inches (750 mm)]<Insert dimension> deep by full width of piping connections.
8. Casing Insulation:
- a. Materials: [Glass-fiber blanket or board insulation, Type I or Type II ASTM C1071][or][injected polyurethane foam insulation].
 - b. Casing Panel R-Value: Minimum [R-6.5][R-11][R-13]<Insert value>.
 - c. Insulation Thickness: [1 inches (25 mm)][2 inches (50 mm)]<Insert dimension>.
 - d. Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roofs of air-handling unit.
9. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.
10. Static-Pressure Classifications:
- a. For Unit Sections Upstream of Fans: Minus [2-inch wg (500 Pa)][3-inch wg (750 Pa)][4-inch wg (1000 Pa)][6-inch wg (1500 Pa)]<Insert value>.
 - b. For Unit Sections Downstream and Including Fans: [2-inch wg (500 Pa)][3-inch wg (750 Pa)][4-inch wg (1000 Pa)][6-inch wg (1500 Pa)]<Insert value>.
11. Panels, Doors, and Windows:

- a. Panels:
 - 1) Fabrication: Formed and reinforced, double-wall and insulated panels of same materials and thicknesses as casing.
 - 2) Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against airflow
 - 3) Gasket: Neoprene, applied around entire perimeters of panel frames.
 - 4) Size: Large enough to allow unobstructed access for inspection and maintenance of air-handling unit's internal components. At least **[18 inches (450 mm)][24 inches (600 mm)]<Insert dimension>** wide by full height of unit casing up to a maximum height of **[60 inches (1500 mm)][72 inches (1800 mm)]<Insert dimension>**.
- b. Doors:
 - 1) Fabrication: Formed and reinforced, double-wall and insulated panels of same materials and thicknesses as casing.
 - 2) Hinges: A minimum of two ball-bearing hinges or stainless steel piano hinge and two wedge-lever latches, operable from inside and outside. Arrange doors to be opened against airflow. Provide safety latch retainers on doors so that doors do not open uncontrollably.
 - 3) Gasket: Neoprene, applied around entire perimeters of panel frames.
 - 4) Size: Large enough to allow for unobstructed access for inspection and maintenance of air-handling unit's internal components. At least **[18 inches (450 mm)][24 inches (600 mm)]<Insert dimension>** wide by full height of unit casing up to a maximum height of **[60 inches (1500 mm)][72 inches (1800 mm)]<Insert dimension>**.
- c. Windows:
 - 1) Construction: Fabricate windows in access panels and doors of double-glazed, safety glass with an airspace between panes and sealed with interior and exterior rubber seals.
 - 2) Size: Minimum **[6 inches (150 mm)]<Insert dimension>**, square or round.
- d. Locations and Applications:
 - 1) Fan Section: Doors[, **with windows**].
 - 2) Coil Section: Panels.
 - 3) Access Section: Doors[, **with windows**].
 - 4) Access Sections Immediately Upstream and Downstream of Coil Sections: Doors[, **with windows**].
 - 5) Damper Section: Doors[, **with windows**].
 - 6) Filter Section: **[Doors][Panels]** large enough to allow periodic removal and installation of filters.
 - 7) Access Sections Immediately Upstream and Downstream of Filter Sections: **[Doors][Panels]**[, **with windows**].
 - 8) Mixing Section: **[Doors][Panels]**[, **with windows**].
 - 9) Humidifier Section: **[Doors][Panels]**[, **with windows**].
- e. Service Lights: **<Insert number of watts>[LED]<Insert lamp type>** vaporproof luminaire with individual switched junction box located **[outside][inside]**, adjacent to each access door and panel.
 - 1) Locations: **[Each section accessed with a door or panel][Fan section]<Insert location>**.

- f. Convenience Outlets: One 20-A duplex GFCI receptacle per location with junction box located on outside casing wall.
 - 1) Locations: **[Each section accessed with a door or panel][Fan section]<Insert location>.**
12. Condensate Drain Pans:
 - a. Location: Each type of **[cooling coil][heat wheel]**.
 - b. Construction:
 - 1) Single-wall, **[galvanized-steel or noncorrosive polymer][stainless steel]** sheet.
 - 2) Double-wall, **[galvanized-steel or noncorrosive polymer][stainless steel]** sheet with space between walls filled with foam insulation and moisture-tight seal.
 - c. Drain Connection:
 - 1) Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on **[one end][both ends]** of pan.
 - 2) Minimum Connection Size: **[NPS 1 (DN 25)][NPS 2 (DN 50)]<Insert pipe size>.**
 - d. Slope: Minimum **[0.125-in./ft. (10-mm/mm)]<Insert value>** slope, **to comply with ASHRAE 62.1,** in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers and to direct water toward drain connection.
 - e. Length: Extend drain pan downstream from leaving face **[for distance to comply with ASHRAE 62.1]<Insert distance>.**
 - f. Width: Entire width of water producing device.
 - g. Depth: A minimum of **[2 inches (50 mm)]<Insert dimension>** deep.
 - h. **[Formed sections][Integral part of floor plating]**.
 - i. Pan-Top Surface Coating for Galvanized-Steel Drain Pans: Asphaltic waterproofing compound.
 - j. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.
- E. Fan, Drive, and Motor Section:
 1. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.
 2. Fans: Centrifugal, galvanized steel; mounted on solid-steel shaft.
 - a. Shafts: With field-adjustable alignment.
 - 1) Turned, ground, and polished hot-rolled steel with keyway.
 - b. Shaft Bearings:
 - 1) Prelubricated and Sealed, Ball Bearings: Self-aligning, pillow-block type with an **[L-50]<Insert bearing life rating>** rated life of **[200,000]<Insert number>** hours according to ABMA 9.
 - 2) Grease-Lubricated, Tapered-Roller Bearings: Self-aligning, pillow-block type with double-locking collars and two-piece, cast-iron housing **[with grease lines extended to outside unit]** and an **[L-50]<Insert bearing life rating>** rated life of **[200,000]<Insert number>** hours according to ABMA 11.
 - 3) Grease-Lubricated Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing **[with grease lines extended**

to outside unit] and an [L-50]<Insert bearing life rating> rated life of [200,000]<Insert number>.

- c. Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.
 - 1) Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.
- d. Housings, Plenum Fans: Steel frame and panel; fabricated without fan scroll and volute housing. Provide inlet screens for Type SWSI fans.
- e. Plenum Fan Arrays: **[Contained][Uncontained]** as defined in AHRI 430. Steel or aluminum frame with inlet cone and structural framing around each fan built into an array of multiple fans. Provide **[backdraft][motorized]** dampers at each fan to prevent short circuiting of flow if one fan is not operating.
- f. Backward-Inclined, Centrifugal Fan Wheels: Construction with curved inlet flange, backplate, backward-inclined blades welded or riveted to flange and backplate; **[steel][aluminum]** hub riveted to backplate and fastened to shaft with setscrews.
- g. Forward-Curved, Centrifugal Fan Wheels: Inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically fastened to flange and backplate; **[steel][aluminum]** hub swaged to backplate and fastened to shaft with setscrews.
- h. Airfoil, Centrifugal Fan Wheels (Plenum Fan Wheels): Smooth-curved inlet flange, backplate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange and backplate; steel hub riveted to backplate and fastened to shaft with setscrews.
- i. Mounting: For internal vibration isolation[**and seismic control**]. Factory-mount fans with manufacturer's standard[**restrained**] vibration isolation mounting devices having a minimum static deflection of [1 inch (25 mm)][2 inches (50 mm)]<Insert dimension>.
- j. Shaft Lubrication Lines: Extended to a location outside the casing.
- k. Flexible Connector: Factory fabricated with a fabric strip minimum [3-1/2 inches (89 mm)][5-3/4 inches (146 mm)]<Insert dimension> wide, attached to two strips of minimum [2-3/4-inch- (70-mm-) wide]<Insert dimension> by [0.028-inch- (0.7-mm-) thick, galvanized-steel sheet][0.032-inch- (0.8-mm-) thick, aluminum sheets].
 - 1) Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.
 - a) Fabric Minimum Weight: **26 oz./sq. yd. (880 g/sq. m).**
 - b) Fabric Minimum Tensile Strength: **480 lbf/inch (84 N/mm)** in the warp and **360 lbf/inch (63 N/mm)** in the filling.
 - c) Fabric Minimum Service Temperature Range: **Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).**
3. Drive, Direct: Factory-mounted, direct drive.
4. Drive, Belt: Factory-mounted, V-belt drive, with adjustable alignment and belt tensioning, and with [1.5][1.25] service factor based on fan motor.
 - a. Pulleys: Cast iron or cast steel with split, tapered bushing, dynamically balanced at the factory.
 - b. Belts: Oil resistant, non-sparking and nonstatic; in matched sets for multiple-belt drives.
 - c. Belt Guards: Comply with requirements specified by OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards"; [0.146-inch- (2.7-mm-)]<Insert dimension> thick, [3/4-inch (20-mm)]<Insert dimension> diamond-mesh wire screen, welded to steel angle frame; prime coated.

5. Motors:
- a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - b. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - c. Enclosure Type: **[Open, dripproof][Totally enclosed, fan cooled]<Insert type>**.
 - d. Enclosure Materials: **[Cast iron]<Insert material>**.
 - e. Motor Bearings: **<Insert requirements>**.
 - f. Unusual Service Conditions:
 - 1) Ambient Temperature: **<Insert deg C>**.
 - 2) Altitude: **<Insert feet (m)>** above sea level.
 - 3) High humidity.
 - 4) **<Insert conditions>**.
 - g. Efficiency: Premium efficient as defined in NEMA MG 1.
 - h. NEMA Design: **<Insert designation>**.
 - i. Motor Pulleys: Adjustable pitch for use with **[5]<Insert number>**-hp motors and smaller; fixed pitch for use with motors larger than **[5]<Insert number>** hp. Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions.
 - j. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
 - k. **<Insert unique motor characteristics>**.
 - l. Mount unit-mounted disconnect switches on **[exterior][interior]** of unit.
6. Comply with Section 262923 "Variable-Frequency Motor Controllers."
7. Variable-Frequency Motor Controller: Serving **[each fan individually][all fans combined]** in fan array.
- a. Manufactured Units: Pulse-width modulated; **[constant torque][and][variable torque]<Insert application>** for **[Design A and Design B][inverter-duty]** motors.
 - b. Output Rating: Three phase; 10 to **[60 Hz, with voltage proportional to frequency throughout voltage range][66 Hz, with torque constant as speed changes]**; maximum voltage equals input voltage.
 - c. Unit Operating Requirements:
 - 1) Internal Adjustability:
 - a) Minimum Speed: 5 to 25 percent of maximum rpm.
 - b) Maximum Speed: 80 to 100 percent of maximum rpm.
 - c) Acceleration: **[0.1 to 999.9]<Insert range>** seconds.
 - d) Deceleration: **[0.1 to 999.9]<Insert range>** seconds.
 - e) Current Limit: 30 to minimum of 150 percent of maximum rating.
 - 2) Self-Protection and Reliability Features:
 - a) Surge suppression.
 - b) Loss of input signal protection.
 - c) Under- and overvoltage trips.
 - d) Variable-frequency motor controller and motor-overload/overtemperature protection.
 - e) Critical frequency rejection.
 - f) Loss-of-phase protection.
 - g) Reverse-phase protection.

- h) Motor-overtemperature fault.
 - 3) Bidirectional autospeed search.
 - 4) Torque boost.
 - 5) Motor temperature compensation at slow speeds.
 - a) Panel-mounted operator station.
 - b) Historical logging information and displays.
 - c) Digital indicating devices.
 - 6) Control Signal Interface: Electric.
 - 7) Proportional Integral Directive (PID) control interface.
 - 8) DDC system for HVAC Protocols for Network Communications: **[ASHRAE 135]<Insert protocol type>**.
 - d. Line Conditioning:
 - 1) Input line conditioning.
 - 2) Output filtering.
 - 3) EMI/RFI filtering.
 - e. Bypass Systems:
 - 1) Bypass Mode: **[Manual operation only][Field-selectable automatic or manual]**.
 - 2) Bypass Controller, Two-Contactor Style: With bypass and output isolating contactors[**and isolating switch**].
 - 3) Bypass Controller, Three-Contactor Style: With bypass and input and output isolating contactors[**and isolating switch**].
 - 4) Bypass Contactor Configuration: **[Full-voltage (across the line)][Reduced-voltage (autotransformer)]<Insert type>** type.
- F. Coil Section:
 - 1. General Requirements for Coil Section:
 - a. Comply with AHRI 410.
 - b. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
 - c. For multizone units, provide air deflectors and air baffles to balance airflow across coils.
 - d. Coils shall not act as structural component of unit.
 - 2. Preheat Coils:
 - a. Electrical Coils, Controls, and Accessories: Comply with UL 1995.
 - 1) Casing Assembly: **[Slip-in][Flanged]** type with galvanized-steel frame.
 - 2) Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
 - 3) Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout, safety device; serviceable through terminal box without removing heater from coil section.
 - 4) Secondary Protection: Load-carrying, manually resetting or manually replaceable, thermal cutouts; factory wired in series with each heater stage.

- 5) Control Panel: **[Unit][Remote]** mounted with disconnecting means and overcurrent protection.
 - a) **[Magnetic][Mercury]** contactor.
 - b) Solid-state, stepless pulse controller.
 - c) Toggle switches, one per step.
 - d) Step controller.
 - e) Time-delay relay.
 - f) Pilot lights, one per step.
 - g) Airflow proving switch.

- b. Hot-Water Coils: **[Continuous circuit][Self-draining][Cleanable]**.
 - 1) Piping Connections: **[Threaded][Flanged]**, **[same end][opposite ends]** of coil.
 - 2) Tube Material: **[Copper]<Insert material>**.
 - 3) Fin Type: Plate.
 - 4) Fin Material: **[Aluminum][Copper]<Insert material>**.
 - 5) Fin Spacing: Maximum **[10][12]<Insert spacing>** fins per inch (mm).
 - 6) Fin Thickness: **<Insert value> inches (mm)**.
 - 7) Fin and Tube Joint: **[Mechanical bond][Silver brazed]**.
 - 8) Headers:
 - a) Cast iron with **[cleaning plugs and]** drain and air vent tappings **[extended to exterior of unit]**.
 - b) Seamless copper tube with brazed joints, prime coated.
 - c) Fabricated steel, with brazed joints, prime coated.
 - d) Provide insulated cover to conceal exposed outside casings of headers.
 - 9) Frames: Channel frame, **[0.052-inch- (1.3-mm-) thick, galvanized steel][0.064-inch- (1.6-mm-) thick, galvanized steel][0.079-inch- (2.0-mm-) thick, galvanized steel][0.0625-inch- (1.58-mm-) thick, galvanized steel][0.0625-inch- (1.58-mm-) thick, stainless steel]<Insert thickness><Insert material>**.
 - 10) Coil Working-Pressure Ratings: **[200 psig (1380 kPa), 325 deg F (163 deg C)]<Insert value and temperature>**.
 - 11) Coating: **[None][Corrosion-resistant coating]**.
 - 12) Integral Face-and-Bypass Dampers: **[Horizontal][Vertical]**, opposed-blade, **[galvanized-steel][aluminum][extruded-aluminum]** dampers with **[zinc-plated]** steel operating rods rotating in sintered bronze or nylon bearings mounted in a single **[galvanized-steel][aluminum][extruded-aluminum]** frame, with operating rods connected with a common linkage. Meeting edges of blades shall have gaskets and edge seals, and blades shall be mechanically fastened.

- c. Steam Coils: **[Distributed][Single tube]**.
 - 1) Steam Outer-Tube Diameter: **<Insert value> inches (mm)**.
 - 2) Piping Connections: **[Threaded][Flanged]**, **[same end][opposite ends]** of coil.
 - 3) Tube Material: **[Copper]<Insert material>**.
 - 4) Fin Type: Plate.
 - 5) Fin Material: **[Aluminum][Copper]<Insert material>**.
 - 6) Fin Spacing: Maximum **[8][10][12]<Insert spacing>** fins per inch (mm).
 - 7) Fin Thickness: **<Insert value> inches (mm)**.
 - 8) Fin and Tube Joint: **[Mechanical bond][Silver brazed]**.
 - 9) Headers:
 - a) Cast iron with **[cleaning plugs and]** drain and air vent tappings **[extended to exterior of unit]**.

- b) Seamless copper tube with brazed joints, prime coated.
 - c) Fabricated steel, with brazed joints, prime coated.
 - d) Provide insulated cover to conceal exposed outside casings of headers.
 - 10) Frames: Channel frame, **[0.052-inch- (1.3-mm-) thick, galvanized steel][0.064-inch- (1.6-mm-) thick, galvanized steel][0.079-inch- (2.0-mm-) thick, galvanized steel][0.0625-inch- (1.58-mm-) thick, galvanized steel][0.0625-inch- (1.58-mm-) thick, stainless steel]<Insert thickness><Insert material>**.
 - 11) Coil Working-Pressure Ratings: **[200 psig (1380 kPa), 325 deg F (163 deg C)]<Insert value and temperature>**.
 - 12) Coating: **[None][Corrosion-resistant coating]**.
 - 13) Integral Face-and-Bypass Dampers: **[Horizontal][Vertical]**, opposed-blade, **[galvanized-steel][aluminum][extruded-aluminum]** dampers with **[zinc-plated]** steel operating rods rotating in sintered bronze or nylon bearings mounted in a single **[galvanized-steel][aluminum][extruded-aluminum]** frame, with operating rods connected with a common linkage. Meeting edges of blades shall have gaskets and edge seals, and blades shall be mechanically fastened.
3. Heating Coils:
- a. Electrical Coils, Controls, and Accessories: Comply with UL 1995.
 - 1) Casing Assembly: **[Slip-in][Flanged]** type with galvanized-steel frame.
 - 2) Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
 - 3) Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout, safety device; serviceable through terminal box without removing heater from coil section.
 - 4) Secondary Protection: Load-carrying, manually resetting or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
 - 5) Control Panel: **[Unit][Remote]** mounted with disconnecting means and overcurrent protection.
 - a) **[Magnetic][Mercury]** contactor.
 - b) Solid-state, stepless pulse controller.
 - c) Toggle switches, one per step.
 - d) Step controller.
 - e) Time-delay relay.
 - f) Pilot lights, one per step.
 - g) Airflow proving switch.
 - b. Hot-Water Coils: **[Continuous circuit][Self-draining][Cleaning]**.
 - 1) Piping Connections: **[Threaded][Flanged]**, **[same end][opposite ends]** of coil.
 - 2) Tube Material: **[Copper]<Insert material>**.
 - 3) Fin Type: Plate.
 - 4) Fin Material: **[Aluminum][Copper]<Insert material>**.
 - 5) Fin Spacing: Maximum **[10][12]<Insert spacing>** fins per inch (mm).
 - 6) Fin Thickness: **<Insert value> inches (mm)**.
 - 7) Fin and Tube Joint: **[Mechanical bond][Silver brazed]**.
 - 8) Headers:
 - a) Cast iron with **[cleaning plugs and]** drain and air vent tappings **[extended to**

exterior of unit].

- b) Seamless copper tube with brazed joints, prime coated.
- c) Fabricated steel, with brazed joints, prime coated.
- d) Provide insulated cover to conceal exposed outside casings of headers.

- 9) Frames: Channel frame, **[0.052-inch- (1.3-mm-) thick, galvanized steel][0.064-inch- (1.6-mm-) thick, galvanized steel][0.079-inch- (2.0-mm-) thick, galvanized steel][0.0625-inch- (1.58-mm-) thick, galvanized steel][0.0625-inch- (1.58-mm-) thick, stainless steel]<Insert thickness><Insert material>.**
- 10) Coil Working-Pressure Ratings: **[200 psig (1380 kPa), 325 deg F (163 deg C)]<Insert value and temperature>.**
- 11) Coating: **[None][Corrosion-resistant coating].**

c. Steam Coils: **[Distributed][Single tube].**

- 1) Steam Outer-Tube Diameter: **<Insert value> inches (mm).**
- 2) Piping Connections: **[Threaded][Flanged], [same end][opposite ends]** of coil.
- 3) Tube Material: **[Copper]<Insert material>.**
- 4) Fin Type: Plate.
- 5) Fin Material: **[Aluminum][Copper]<Insert material>.**
- 6) Fin Spacing: Maximum **[10][12]<Insert spacing> fins per inch (mm).**
- 7) Fin Thickness: **<Insert value> inches (mm).**
- 8) Fin and Tube Joint: **[Mechanical bond][Silver brazed].**
- 9) Headers:
 - a) Cast iron with **[cleaning plugs and]** drain and air vent tappings **[extended to exterior of unit].**
 - b) Seamless copper tube with brazed joints, prime coated.
 - c) Fabricated steel, with brazed joints, prime coated.
 - d) Provide insulated cover to conceal exposed outside casings of headers.
- 10) Frames: Channel frame, **[0.052-inch- (1.3-mm-) thick, galvanized steel][0.064-inch- (1.6-mm-) thick, galvanized steel][0.079-inch- (2.0-mm-) thick, galvanized steel][0.0625-inch- (1.58-mm-) thick, galvanized steel][0.0625-inch- (1.58-mm-) thick, stainless steel]<Insert thickness><Insert material>.**
- 11) Coil Working-Pressure Ratings: **[200 psig (1380 kPa), 325 deg F (163 deg C)]<Insert value and temperature>.**
- 12) Coating: **[None][Corrosion-resistant coating].**

4. Cooling Coils:

a. Chilled-Water Coil: **[Continuous circuit][Self-draining][Cleanable].**

- 1) Piping Connections: **[Threaded][Flanged], [same end][opposite ends]** of coil.
- 2) Tube Material: **[Copper]<Insert material>.**
- 3) Tube Thickness: **<Insert value> inches (mm).**
- 4) Fin Type: Plate.
- 5) Fin Material: **[Aluminum][Copper]<Insert material>.**
- 6) Fin Spacing: **[0.125 inch (3.18 mm)][0.091 inch (2.31 mm)][0.071 inch (1.80 mm)][0.067 inch (1.70 mm)][0.056 inch (1.42 mm)][0.0075 inch (0.19 mm)]<Insert fins per inch (mm)>.**
- 7) Fin Thickness: **<Insert value> inches (mm).**
- 8) Fin and Tube Joint: **[Mechanical bond][Silver brazed].**
- 9) Headers:
 - a) Cast iron with **[cleaning plugs and]** drain and air vent tappings **[extended to**

- G. Air Filtration Section:

- ## Outdoor, Semi-Custom Air-Handling Units

- a. Description: Factory-fabricated, **[adhesive-coated]**disposable, packaged air filters with media perpendicular to airflow, and with holding frames.
 - b. Filter Unit Class: UL 900.
 - c. Media: Fibrous material, coated with antimicrobial agent, constructed so individual pleats are maintained in pleated form under rater-airflow conditions by corrugated aluminum separators.
 - d. Filter Media Frame: **[Galvanized steel]<Insert material>**.
7. Adhesive, Sustainability Projects: As recommended by air-filter manufacturer and with a VOC content of 80 g/L or less.
 8. Adhesive, LEED for Schools Projects: As recommended by air-filter manufacturer and that complies with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 9. Front- or Back-Access Filter Mounting Frames:
 - a. Particulate Air Filter Frames: **[Galvanized-steel][Aluminum]** framing members with **[front][back]** access for filter servicing, cut to size and prepunched for assembly into modules. Vertically support filters to prevent deflection of horizontal members without interfering with either filter installation or operation.
 - 1) Prefilters: Incorporate a separate **[2-inch- (50-mm-)]<Insert dimension>** thick track**[with spring clips]**, with same access as primary filter.
 - 2) Sealing: Full periphery foam gaskets.
 - b. HEPA Filter Frames: **[Aluminum][Stainless steel]** framing members, cut to size and prepunched for assembly into modules. Vertically support filters to prevent deflection of horizontal members without interfering with either filter installation operation. Bolted filter-sealing mechanism shall mount and continuously seal each individual filter.
 - 1) Prefilters: Incorporate a separate **[2-inch- (50-mm-)][4-inch- (50-mm-)]<Insert dimension>** thick track**[with spring clips]** with same access as primary filter.
 - 2) Sealing: **[Gasketed][or][gel]**, hand-crank locking mechanism to provide positive-sealing for each filter to ensure seal between filter elements to prevent bypass of unfiltered air.
 - c. Gas-Phase Air Filter Frames: **[Galvanized-steel][Aluminum]** framing members with access for filter servicing, cut to size and prepunched for assembly into modules. Vertically support filters to prevent deflection of horizontal members without interfering with either filter installation or operation.
 - 1) Prefilters: Incorporate a separate **[2-inch- (50-mm-)]<Insert dimension>** thick track**[with spring clips]**.
 - 2) Sealing: **[Full periphery foam gaskets][Positive-sealing-device for each row of filters to ensure seal between gasketed filter elements to prevent bypass of unfiltered air]**.
 10. Side-Access Filter Mounting Frames:
 - a. Particulate Air Filter Frames: Match inner casing and outer casing material, and insulation thickness. **[Galvanized steel][Aluminum]** track.
 - 1) Prefilters: Incorporate an integral **[2-inch- (50-mm-)]<Insert dimension>** thick track with same access as primary filter.
 - 2) Sealing: Incorporate positive-sealing device to ensure seal between gasketed material on channels to seal top and bottom of filter cartridge frames to prevent

bypass of unfiltered air.

b. HEPA Filter Frames:

- 1) Frames: Match inner casing and outer casing material, and insulation thickness. **[Aluminum][Stainless steel]** track.
- 2) Prefilters: Incorporate an integral **[2-inch- (50-mm-)][4-inch- (100-mm-)]<Insert dimension>** thick track,
- 3) Sealing: Incorporate positive-sealing clamping device on each filter between **[gasket][gel]** seal on all sides of filter cartridge frames to prevent bypass of unfiltered air.

c. Gas-Phase Air Filter Frames:

- 1) Frames: Matching inner casing and outer casing material, and insulation thickness. **[Galvanized-steel][Aluminum]** track.
- 2) Prefilters: Incorporate an integral **[2-inch- (50-mm-)]<Insert dimension>** thick track.
- 3) Sealing: Incorporate positive-sealing gasket material on channels to seal top and bottom of filter cartridge frames to prevent bypass of unfiltered air.

H. Dampers:

1. Comply with requirements in Section 230923.12 "Control Dampers."
2. Outdoor- and Return-Air Dampers: Low-leakage, double-skin, airfoil-blade, **[galvanized-steel][aluminum][extruded-aluminum]<Insert material>** dampers with compressible jamb seals and extruded-vinyl blade edge seals in **[opposed][parallel]-**blade arrangement with **[zinc-replated]** steel operating rods rotating in **[stainless steel sleeve][sintered bronze or nylon]<Insert material>** bearings mounted in a single **[galvanized-steel][aluminum][extruded-aluminum]<Insert material>** frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed **[4 cfm/sq. ft. (20 L/s per sq. m) at 1-inch wg (250 Pa) and 8 cfm/sq. ft. (40 L/s per sq. m) at 4-inch wg (1.0 MPa), leakage Class 1]<Insert requirement>**, **tested, rated, and labeled in accordance with AMCA 511**.
3. Face-and-Bypass Dampers: Opposed-blade, **[galvanized-steel][aluminum][extruded-aluminum]** dampers with **[zinc-plated]** steel operating rods rotating in sintered bronze or nylon bearings mounted in a single **[galvanized-steel][aluminum][extruded-aluminum]** frame and with operating rods connected with a common linkage. Provide blade gaskets and edge seals, and mechanically fasten blades to operating rod.
4. Zone Dampers: Two single-blade, **[galvanized-steel][aluminum][extruded-aluminum]<Insert materials>** dampers offset 90 degrees from each other on **[zinc-plated]** steel operating rod rotating in sintered bronze or nylon bearings mounted in a single **[galvanized-steel][aluminum][extruded-aluminum]<Insert material>** frame. Provide blade gaskets and edge seals, and mechanically fasten blades to operating rod.
5. Damper Operators: Comply with requirements in Section 230923.12 "Control Dampers."
6. Electronic Damper Operators:
 - a. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
 - b. Electronic damper position indicator shall have visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
 - c. Operator Motors:
 - 1) Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - 2) Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.

- 3) Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
 - d. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running torque of **150 in. x lbf (16.9 N x m)** and breakaway torque of **300 in. x lbf (33.9 N x m)**.
 - e. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running and breakaway torque of **150 in. x lbf (16.9 N x m)**.
 - f. Size dampers for running torque calculated as follows:
 - 1) Parallel-Blade Damper with Edge Seals: **7 inch-lb/sq. ft. (86.8 kg-cm/sq. m)** of damper.
 - 2) Opposed-Blade Damper with Edge Seals: **5 inch-lb/sq. ft. (62 kg-cm/sq. m)** of damper.
 - 3) Parallel-Blade Damper without Edge Seals: **4 inch-lb/sq. ft. (49.6 kg-cm/sq. m)** of damper.
 - 4) Opposed-Blade Damper without Edge Seals: **3 inch-lb/sq. ft. (37.2 kg-cm/sq. m)** of damper.
 - 5) Dampers with 2- to 3-Inch wg (500 to 750 Pa) of Pressure Drop or Face Velocities of 1000 to 2500 fpm (5 to 13 m/s): Increase running torque by 1.5.
 - 6) Dampers with 3- to 4-Inch wg (750 to 1000 Pa) of Pressure Drop or Face Velocities of 2500 to 3000 fpm (13 to 15 m/s): Increase running torque by 2.0.
 - g. Coupling: V-bolt and V-shaped, toothed cradle.
 - h. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
 - i. Fail-Safe Operation: Mechanical, spring-return mechanism with external, manual gear release on nonspring-return actuators.
 - j. Power Requirements (Two-Position Spring Return): **[24 V dc][120 V ac][230 V ac]**.
 - k. Power Requirements (Modulating): Maximum 10 VA at 24 V ac or 8 W at 24 V dc.
 - l. Proportional Signal: 2 to 10 V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
 - m. Temperature Rating: **[Minus 22 to plus 122 deg F (Minus 30 to plus 50 deg C)][40 to 104 deg F (5 to 40 deg C)]**.
 - n. Run Time: **[12 seconds open, 5 seconds closed][30 seconds][60 seconds][120 seconds]**.
 7. Mixing Section: Multiple-blade, air-mixer assembly located immediately downstream of mixing section.
 8. Combination Filter and Mixing Section:
 - a. Cabinet support members shall hold **[2-inch- (50-mm-)]<Insert dimension>** thick, pleated, flat, permanent or throwaway filters.
 - b. Multiple-blade, air-mixer assembly shall mix air to prevent stratification, located immediately downstream of mixing box.
 - I. Sound Attenuators:
 1. General Requirements:
 - a. Factory fabricated.
 - b. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials with flame-spread index not exceeding 25 and smoke-developed index not exceeding 50; ASTM E84.
 - c. Airstream Surfaces: Surfaces in contact with the airstream shall comply with ASHRAE 62.1.

2. Shape: **[Rectangular, straight][Round, straight][Rectangular, elbow][Round, elbow]**.
3. Rectangular Silencer Outer Casing: **[Galvanized steel]<Insert material>**.
4. Round Silencer Outer Casing: **[Galvanized steel]<Insert material>**.
5. Inner Casing and Baffles: **[Galvanized steel]<Insert material>**.
6. Principal Sound-Absorbing Mechanism:
 - a. Packless Type: Controlled impedance membranes and broadly tuned resonators without adsorptive media.
 - b. Dissipative Type: **[Polymer film-lined]**absorptive fill material.
 - 1) Fill Material: **[Inert and vermin-proof fibrous material]<Insert material type>**.
 - c. Joints: Lock formed and sealed, continuously welded or flanged.

J. Humidifiers:

1. Direct-steam-injection humidifiers are specified in Section 238413.23 "Direct-Steam-Injection Humidifiers."
2. Self-contained humidifiers are specified in Section 238413.29 "Self-Contained Humidifiers."
3. Heat-exchanger humidifiers are specified in Section 238413.36 "Heat Exchanger Humidifiers."

K. Air-to-Air Energy Recovery Units:

1. Heat Wheels:
 - a. Casing:
 - 1) Galvanized steel, stainless steel, or aluminum with manufacturer's standard factory finish.
 - 2) Integral purge section limiting carryover of exhaust air to between **[0.05 percent at 1.6-inch wg and 0.20 percent at 4-inch wg (0.5 percent at 400-Pa and 0.20 percent at 1000-Pa)]<Insert values>** differential pressure.
 - 3) Casing seals on periphery of rotor, on duct divider, and on purge section.
 - 4) Support vertical rotors on grease-lubricated ball bearings with extended grease fittings. Mount horizontal rotors on tapered roller bearing.
 - b. Rotor, Aluminum or Polymer: Segmented wheel, strengthened with radial spokes[, **with nontoxic, noncorrosive, silica-gel desiccant coating**].
 - c. Rotor - Aluminum, Metallic, or Polymer: Segmented wheel, strengthened with radial spokes impregnated with nonmigrating, water-selective, 3-angstrom molecular-sieve desiccant coating.
 - d. Drive: Fractional horsepower motor and gear reducer[, **with speed changed by variable-frequency controller**]. Permanently lubricated wheel bearings with an **[L-10]<Insert bearing life>[400,000 hours]<Insert hours>**.
 - e. Controls:
 - 1) Starting relay, factory mounted and wired, and manual motor starter for field wiring.
 - 2) Variable-frequency controller, factory mounted and wired, permitting input of field connected 4- to 20-mA or 1- to 10-V control signal.
 - 3) Variable-frequency controller, factory mounted and wired, with exhaust-air sensor to vary rotor speed and maintain exhaust temperature above freezing.
 - 4) Variable-frequency controller, factory mounted and wired, with exhaust- and outdoor-air sensors, automatic changeover thermostat and set-point adjuster, to vary rotor speed and maintain **[exhaust temperature above freezing and]**air differential temperature above set point. Provide maximum rotor speed when

- exhaust-air temperature is less than outdoor-air temperature.
 - 5) Pilot-Light Indicator: Display rotor rotation and speed.
 - 6) Speed Settings: Adjustable settings for maximum and minimum rotor speed limits.
 2. Fixed-Plate Sensible Heat Exchangers:
 - a. Casing: **[Aluminum][Galvanized steel]<Insert material>**.
 - b. Plates: Evenly spaced and sealed and arranged for **[counter][cross]** airflow.
 - c. Plate Material: **[Embossed aluminum][Stainless steel][High-density plastic]**.
 - d. Plate Coating: **[Epoxy]<Insert coating>**.
 - e. Bypass: Plenum within casing, with gasketed face-and-bypass dampers that have operating rods extended outside casing.
 - f. Heat-Exchanger Prefilters:
 - 1) Thickness: **[1 inch (25 mm) thick, disposable][2 inches (50 mm) thick, disposable]<Insert type>**.
 - 2) MERV Rating: **[MERV 6]<Insert MERV rating>**.
- L. Air Blenders:
 1. Description: Static air mixer device to provide mixing of two airstreams to within **[plus/minus 6 deg F (3 deg C)]<Insert mixing differential>**.
 2. Material: **[Galvanized steel][Aluminum]<Insert material>**.
 3. Coating: **[None][Corrosion-resistant coating]**.
- M. Diffusers:
 1. Description: Velocity profile equalizer device for providing equalized airflow profile downstream of Type DWDI fans.
 2. Material: **[Galvanized steel][Aluminum]<Insert material>**.
- N. UV-C Lamp Systems:
 1. Description:
 - a. UV-C lamp system consisting of power supply, power supply housing, wiring, UV lamp(s), lamp plug, lamp plug protector, encapsulated lamp, and lamp holder used for UV germicidal irradiation of cooling coil and condensate drain pan.
 - b. Factory installed and preengineered.
 2. Standard: UL Category Code ABQK, HVAC accessories, air-duct mounted.
 3. Lamps: High output, hot cathode.
 4. Lamp-Holder Construction:
 - a. UV- and moisture-resistant materials and designed to connect the lamp to the plug.
 - b. Adjustable positioning.
 5. Lamp-Clamp Construction:
 - a. UV- and moisture-resistant materials, water-tight connection.
 - b. Adjustable positioning.
 6. Lamp Protection: Hermetically sealed to provide protection against lamp breakage and to ensure lamp contents from a broken lamp are contained.
 7. Lamp Output: UV-C energy, primarily at the 254-nm wavelength with a 360-degree energy distribution.

8. Access Door Interlocks: Automatic disconnect on all access doors into UV-installed casing sections to shield servicing personnel from contact with light.
9. Power Supply: UL-listed, single-point electrical connection[**with service disconnect**].
10. Power Consumption: Maximum of [15 W/sq. ft. (161 W/sq. m)]<Insert value>.

O. Roof Curbs:

1. Roof curbs with vibration isolators [and][wind][or][seismic] restraints are specified in [Section 230548 "Vibration and Seismic Controls for HVAC."][Section 230548.13 "Vibration Controls for HVAC."]
2. Materials: Galvanized steel with corrosion-resistant coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.
 - a. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
 - 1) Materials: ASTM C1071, Type I or II.
 - 2) Thickness: [1 inch (25 mm)][1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension>.
 - b. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.
 - 1) Liner Adhesive: Comply with ASTM C916, Type I.
 - 2) Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
 - 3) Liner materials applied in this location shall have airstream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.
3. Curb Dimensions: Height of [14 inches (355 mm)][24 inches (610 mm)][36 inches (910 mm)]<Insert dimension>.[**Adaptable horizontal dimensions as required for existing roof openings.**]
4. Wind and Seismic Restraints: Metal brackets compatible with the curb and casing, painted to match unit, used to anchor unit to the curb, and designed for loads at Project site. Comply with requirements in [Section 230548 "Vibration and Seismic Controls for HVAC"] [Section 230548.13 "Vibration Controls for HVAC"] for wind-load requirements.

P. Intake and Relief Air Openings:

1. Provide hood, including moisture eliminator, over all unit intake and relief openings. Match material and finish of casing exterior.

2.4 MATERIALS

A. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for steel sheet.

B. Stainless Steel:

1. Manufacturer's standard grade for casing.
2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or

moisture.

- C. Galvanized Steel: ASTM A653/A653M.
- D. Aluminum: **ASTM B209 (ASTM B209M)**.
- E. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating.
- F. Corrosion-Resistant Coating: Coat with a corrosion-resistant coating capable of withstanding a **[3000]<Insert time>**-hour salt-spray test according to ASTM B117.
 - 1. Standards:
 - a. ASTM B117 for salt spray.
 - b. ASTM D2794 for minimum impact resistance of **100 in-lb (11.3 N-m)**.
 - c. ASTM B3359 for cross-hatch adhesion of 5B.
 - 2. Application: **[Immersion][Spray]**.
 - 3. Thickness: **[1 mil (0.025 mm)]<Insert value>**.
 - 4. Gloss: Minimum gloss of 60 on a 60-degree meter.

2.5 SOURCE QUALITY CONTROL

- A. AHRI 430 Certification: Test, rate, and label air-handling units and their components in accordance with AHRI 430.
- B. AHRI 1060 Certification: Test, rate, and label air-handling units that include air-to-air energy recovery devices in accordance with AHRI 1060.
- C. AHRI 260 or AMCA 311 Sound Performance Rating Certification: Test, rate, and label in accordance with AHRI 260 or AMCA 311.
- D. Fan Aerodynamic Performance Rating: Test and rate fan performance for airflow, pressure, power, air density, rotation speed, and efficiency in accordance with AMCA 210.
- E. Fan Energy Index (FEI): Test in accordance with AMCA 210 and rate in accordance with AMCA 99, AMCA 207, and AMCA 208.
- F. Fan Operating Limits: Classify fans in accordance with AMCA 99, Section 14.
- G. Water Coils: Factory tested to **300 psig (2070 kPa)** according to AHRI 410 and ASHRAE 33.
- H. Steam Coils: Factory tested to **300 and 200 psig (2070 and 1380 kPa)** underwater according to AHRI 410 and ASHRAE 33.
- I. Refrigerant Coils: Factory tested to minimum **450-psig (3105-kPa)** internal pressure and to minimum **300-psig (2070-kPa)** internal pressure while underwater, according to AHRI 410 and ASHRAE 33.
- J. Witnessed Casing Leakage Tests:
 - 1. Pay for all expenses, for one representative designated by Owner, to travel to the factory to witness cabinet air-leakage testing on the specific assembled unit(s) prior to release for delivery to Project site.
 - 2. If the unit(s) does not meet specified leakage requirements, perform factory modifications and

retest. Do not release unit for shipment until tested leakage is measured to be within specified leakage and leakage testing report has been accepted by Owner's designated representative.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine casing insulation materials and filter media before air-handling unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for steam, hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF OUTDOOR, SEMI-CUSTOM AIR-HANDLING UNITS

- A. Roof Curb: Install on roof structure or concrete base, level and secure, according to **[NRCA's "NRCA Roofing Manual: Membrane Roof Systems."][AHRI Guideline B.]** Install units on curbs and coordinate roof penetrations and flashing with roof construction specified in Section 077200 "Roof Accessories." Secure units to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts. Coordinate sizes and locations of roof curbs with actual equipment provided.
- B. Unit Support: Install unit level on structural **[curbs][steel supports]**. Coordinate roof penetrations and flashing with roof construction. Secure units to structural support with anchor bolts. Coordinate sizes and locations of **[curbs][steel supports]** with actual equipment provided.
 - 1. Comply with requirements for vibration isolation[, **wind-control**][and][**seismic-control**] devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 2. Comply with requirements for vibration isolation **[and][wind-control]** devices specified in Section 230548.13 "Vibration Controls for HVAC."
- C. Arrange installation of units to provide access space around air-handling units for service and maintenance.
- D. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.
- E. Install filter-gauge, static-pressure taps upstream and downstream of filters. Mount filter gauges on outside of filter housing or filter plenum in accessible position. Provide filter gauges on filter banks, installed with separate static-pressure taps upstream and downstream of filters.
- F. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."

3.3 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to air-handling unit, allow space for service and maintenance.
- C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.
- D. Connect condensate drain pans using **[NPS 1-1/4 (DN 32)]<Insert pipe size>, ASTM B88, Type M (ASTM B88M, Type C)** copper tubing. Extend to nearest equipment or roof drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.
- E. Hot- and Chilled-Water Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.
- F. Steam and Condensate Piping: Comply with applicable requirements in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties." Install shutoff valve at steam supply connections, float and thermostatic trap, and union or flange at each coil return connection. Install gate valve and inlet strainer at supply connection of dry steam humidifiers, and inverted bucket steam trap to condensate return connection.
- G. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Install shutoff valve and union or flange at each supply and return connection.

3.4 ELECTRICAL CONNECTIONS

- A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch (13 mm)** high.

3.5 CONTROL CONNECTIONS

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

3.6 STARTUP SERVICE

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that shipping, blocking, and bracing are removed.
3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
4. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
5. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
6. Verify that zone dampers fully open and close for each zone.
7. Verify that face-and-bypass dampers provide full face flow.
8. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
9. Comb coil fins for parallel orientation.
10. Verify that proper thermal-overload protection is installed for electric coils.
11. Install new, clean filters.
12. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

B. Starting procedures for air-handling units include the following:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. **[Replace fan and motor pulleys as required to achieve design conditions.]**
2. Measure and record motor electrical values for voltage and amperage.
3. Manually operate dampers from fully closed to fully open position and record fan performance.

3.7 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.
- C. Occupancy Adjustments: When requested within **[12]<Insert number>** months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to **[two]<Insert number>** visits to Project during other-than-normal occupancy hours for this purpose.

3.8 CLEANING

- A. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.9 FIELD QUALITY CONTROL

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

- C. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
1. Leak Test: After installation, fill water and steam coils with water, and test coils and connections for leaks.
 2. Charge refrigerant coils with refrigerant and test for leaks.
 3. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 4. HEPA Filters: Pressurize housing to a minimum of **3-inch wg (750 Pa)** or to designed operating pressure, whichever is higher; test housing joints, door seals, and sealing edges of filter with soapy water to check for air leaks.
 5. HEPA Filters, Critical Applications: Pressurize housing to a minimum of **3-inch wg (750 Pa)** or to designed operating pressure, whichever is higher; test housing joints, door seals, and sealing edges of filter for air leaks according to ASME AG-1, pressure-decay method.
 6. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 7. Air-handling unit and components will be considered defective if unit or components do not pass tests and inspections.
 8. Prepare test and inspection reports.

3.10 DEMONSTRATION

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

END OF SECTION 23 74 00 00



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SECTION 23 74 00 00A - OUTDOOR, CUSTOM AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Outdoor, custom air-handling units.

B. Related Requirements:

1. Section 237313.19 "Indoor, Custom Air-Handling Units."

1.2 ACTION SUBMITTALS

A. Product Data: For each outdoor, custom air-handling unit.

1. Product information organized to show compliance with each performance requirement of "Performance Requirements" article.
2. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
3. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
4. Include unit dimensions and weight.
5. Include cabinet material, metal thickness, finishes, insulation, and accessories.
6. Fans:
 - a. Include certified fan-performance curves with system operating conditions indicated. For fans operating at variable speeds include curves in [10]<Insert number> percent speed increments starting at design speed down to minimum speed.
 - b. Include fan-sound power ratings in all eight octave bands. Include inlet or outlet sound power levels to coincide with sound requirements indicated on Drawings.
 - c. Include fan construction and accessories. Submit sufficient information to show product compliance with requirements indicated.
 - d. Include dimensions and weight.
 - e. Include motor ratings, electrical characteristics, and motor accessories.
7. Vibration isolation product data with performance ratings. Uniquely identify and include information for each different isolator type and indicate for each air-handling unit where each isolator type is being used.
8. Include certified coil-performance ratings with system operating conditions indicated. Product data to include: dimensions, dry and operating weight, volume of fluid contained, materials of construction, and performance ratings with system operating conditions indicated.
9. Casing insulation product data and performance ratings.
10. Access door and access panel product data and performance ratings.
11. Roofing product data and performance ratings.
12. Louver product data and performance ratings.
13. Paint product data and performance ratings.
14. Electrical product data and performance ratings.
15. Metal grating product data and performance ratings.
16. Electric heater product data with performance ratings.

17. Steam humidifier product data with performance ratings.
18. Dampers product data, including housings, linkages, and operators with performance ratings.
19. Filters product data with performance characteristics.
20. Heat wheels product data with performance ratings.
21. Fixed plate heat exchangers product data with performance ratings.
22. Heat pipe heat exchangers product data with performance ratings.
23. Duct silencers product data with performance ratings.
24. Air blender product data with dimensions, weights, materials of construction, performance ratings, and installation requirements.
25. UV-C lamp systems product data with performance ratings.
26. Pumps product data with performance ratings.
27. Hydronic pipe, valves, fittings, vents, strainers, and hydronic accessories product data.
28. Steam and condensate pipe, valves, fittings, vents, strainers, and steam specialties product data.
29. Pipe insulation and jacket product data.
30. Roof curbs product data.
31. **<Insert requirements>.**

B. Sustainable Design Submittals:

1. Product Data: Showing compliance with ASHRAE 62.1.
2. Product data indicating compliance with ASHRAE/IES 90.1.
3. Product Data: For air filtration performance.
4. Product Data: For adhesives, mastics, and sealants, indicating VOC content.
5. Laboratory Test Reports: For adhesives, mastics, and sealants, indicating compliance with requirements for low-emitting materials.

C. Shop Drawings: For each type and configuration of indoor, custom air-handling unit.

1. Prepared by manufacturer's factory employees with review and sign-off by those individuals responsible for manufacturing the air-handling units.
2. Include plans, elevations, sections, and **[mounting][attachment]** details. **[For air-handling units consisting of multiple levels, create drawings for each level showing interrelationship of levels superimposed.]**
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, methods of field assembly, components, and location and size of each field connection.
4. Detail fabrication and assembly of indoor, custom air-handling units, as well as procedures and diagrams.
5. Indicate details of construction with materials description including applicable specified standards and material grades in sufficient detail for reviewers to evaluate point by point compliance with requirements indicated for each air-handling unit.
6. Use actual dimensions of internal equipment in preparing Shop Drawings. Identify mechanical equipment shown on Shop Drawings with equipment designations on Drawings.
7. Thickness and finish of all casing materials with cross references indicated where each is used. Uniquely identify and include information for each different casing construction.
8. Details for each unique casing joint and reinforcing. Indicate wall joints, wall to floor joints, wall to roof joints, floor joints, and roof joints.
9. Roofing details.
10. Assembly details of base and casing for units consisting of multiple sections requiring field assembly.
11. Sizes and dimensioned locations of field connections for ductwork, piping, electrical, and controls.
12. Base and casing penetration and sealing details for factory-installed conduit.
13. Base and casing penetration and sealing details for factory-installed piping including coils **[and steam humidifiers]**.
14. Details of casing connections to field-installed ductwork.

15. Size, shape and layout of base members including localized support of internal components.
16. Base materials, thickness, finishes, lifting provisions, and mounting requirements. Uniquely identify and include information for each different base construction. Clearly indicate for each air-handling unit.
17. Recommended points of field attachment with dimensioned locations.
18. Size and location of each access door, including clearing opening size, with door swing indicated.
19. Size and location of each access panel with service equipment superimposed to show relationship of panel to internal equipment.
20. Drain pans and associated piping, with sizes and locations dimensioned, including relationship to internal equipment.
21. Floor drains and associated piping, with sizes and locations dimensioned, including relation to internal equipment.
22. Coil framework and support including enlarged details showing framework attachment to air-handling unit base, coil attachment to framework, and means for individual coil removal.
23. Mounting details of all internal components, such as fans, filters, and dampers.
24. Hoist rails layout for internal equipment showing size of members, attachments to structure, and serviced equipment superimposed to indicate relationships.
25. Size and location of catwalks, handrails, ladders, and safety cages including construction details and details of attachment to air-handling unit base.
26. Location of UV-C lamp systems, service clearances, and mounting details.
27. Location of receptacles, service lights, and switches.
28. Location of motor controllers and disconnect switches.
29. Size and location of junction boxes used for interface with field electrical power.
30. Point-to-point electrical power wiring diagrams including wire size, conduit size, motor controllers sizes, switch types and ratings, receptacle types and ratings, service light fixture types and ratings.
31. Point-to-point control wiring diagrams including cable types and sizes, conduit sizes, and connected control devices.
32. Point-to-point control tubing diagrams including tubing types and sizes, conduit sizes, and connection controls devices.
33. Control panel drawings drawn to scale showing detailed internal layout.
34. Plans, sections and isometric reviews of **[hydronic][and][steam and condensate]** piping systems showing pipe, fittings, flanges, unions, valves, vents, strainers, accessories, specialties and insulation.
35. Indicate code, operating, and maintenance clearances drawn to scale using dashed lines.
36. Indicate weights of internal components, weight of each separately shipped section, and air-handling unit total weight.
37. **<Insert requirements>**.

D. Comparison Schedule:

1. Submit a schedule to indicate performance of equipment scheduled on Drawings directly compared to performance of submitted equipment.
2. Clearly identify each line in schedule to indicate "Scheduled" where indicating performance scheduled on Drawings and "Submitted" where indicating performance of submitted equipment.
3. Organize schedule to first indicate performance scheduled on Drawings on one line followed by line directly below that indicates performance of submitted equipment.
4. Comparison schedule shall follow arrangement and organization of scheduled information indicated on Drawings.
5. Submitted equipment shall have a value for each scheduled value indicated.

E. Delegated Design Submittals: For vibration isolation[**and seismic restraints**] indicated to comply with performance requirements and design criteria, including analysis data[**signed and sealed by the professional engineer responsible for their preparation**].

1. For seismic restraints indicated to comply with performance requirements and design criteria,

including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

- a. Include design calculations for selecting seismic restraints.

2. <Insert requirements>.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans, sections, and other details, or BIM model, drawn to scale, showing the items described in this Section and coordinated with all building trades.
- B. Seismic Qualification Data: Certificates for air-handling units, accessories, and components, from manufacturer.
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
 4. Restraint of internal components.
- C. Source quality-control reports.
- D. Startup service reports.
- E. Field quality-control reports.
- F. Sample Warranty: For manufacturer's warranty.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air-handling units to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Bag Filters: [One]<Insert number> set(s) for each air-handling unit.
 2. Cartridge Filters: [One]<Insert number> set(s) for each air-handling unit.
 3. Panel Filters: [One]<Insert number> set(s) for each air-handling unit.
 4. Absolute Filters: [One]<Insert number> set(s) for each air-handling unit.
 5. Gas-Phase Filters: [One]<Insert number> set(s) for each air-handling unit.
 6. Access Door Gaskets: [One]<Insert number> set(s) for each [unique]access door.
 7. Fan Belts: [One]<Insert number> set(s) for each fan with belt-drive assembly.
 8. Heat Wheel Belts: [One]<Insert number> set(s) for each heat wheel with belt-drive assembly.
- B. Tool Kit: Manufacturer to provide a tool kit including special tools required for air-handling unit service.

See "Accessories" Article for additional requirements.

1.6 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.
- B. Coordinate sizes and locations of structural-steel support members, if any, with actual equipment provided.

1.7 FACTORY VISITS FOR PRODUCT INSPECTION

- A. While units are being manufactured, and during factory normal working hours, allow escorted access to manufacturing facility for **[Owner][or][and][Owner's designated representative]** to verify product compliance with requirements indicated.
 - 1. As many as **<Insert number>** persons shall visit the factory for product inspection.
- B. Manufacturer shall provide **[Owner][and][Architect]** with written notice at least **[30]<Insert number>** business days before units go into assembly.
- C. Inspection visits shall be scheduled with manufacturer at least **[10]<Insert number>** business days before visit.
- D. Personnel making visits for purposes of product inspection shall comply with manufacturer requirements for visitors.

1.8 DELIVERY, STORAGE, HANDLING

- A. Deliver air-handling units with factory-installed shipping skids and lifting lugs; pack small components in factory-fabricated protective containers. Cover units with heat-shrinkable plastic sheeting suitable for shipping from point of manufacture to Project.
- B. Handle air-handling units carefully to avoid damage to components, casing, and finish. Do not install damaged components; replace and return damaged components to air-handling unit manufacturer.
- C. Store air-handling units in a clean dry place and protect them from weather and construction activities.
- D. Keep air-handling units fully covered and protected during construction. Remove dirt and debris and clean units to a factory-cleaned condition.
- E. Comply with manufacturer's written rigging and installation instructions for unloading air-handling units and moving them to their final locations.
- F. For air-handling units equipped with key locks on access doors, keep doors locked during construction.
 - 1. If access is required within air-handling units, only open the doors to sections that require access and lock doors at the end of each **[workday][work shift]<Insert requirement>**.
 - 2. Protect inside of air-handling units from damage and keep inside of units as clean as the factory-cleaned condition.
 - 3. Report observed abuse to **<Insert entity>** for immediate corrective action.



1.9 WARRANTY

- A. Warranty: Manufacturer agrees to repair or replace components of air-handling units that fails in materials or workmanship within specified warranty period.
 - 1. Warranty Period: **<Insert number>** year(s) from date of Substantial Completion.
- B. Extended warranties include, but are not limited to, the following:
 - 1. Complete Air-Handling Unit: **[Two][Three][Five]<Insert number>** years from date of Substantial Completion for entire air-handling unit and longer where indicated for individual components.
 - 2. Air-Handling Unit Casing: **[25][30]<Insert number>** years from date of Substantial Completion.
 - 3. Air-Handling Unit Roofing: **[25][30]<Insert number>** years from date of Substantial Completion.
 - 4. Motors: **[Two][Five]<Insert number>** years from date of Substantial Completion
 - 5. Heat Wheels: **[Five][10]<Insert number>** years from date of Substantial Completion.
 - 6. **<Insert requirement>**.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.
- C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- E. Delegated Design: Engage a qualified professional **[specialist][engineer]**, as defined in Section 014000 "Quality Requirements," to design air-handling units, **[vibration isolation,][and seismic restraints]** including comprehensive engineering analysis, using performance requirements and design criteria indicated.
- F. Casing Structural Performance:
 - 1. Floor: Capable of withstanding positive/negative **[8 inches wg (2000 Pa)]<Insert value>** of internal static pressure, without exceeding a deflection of **[L/300][L/360]<Insert deflection>** of span.
 - 2. Walls and Roof: Capable of withstanding positive/negative **[8 inches wg (2000 Pa)]<Insert value>** of internal static pressure, without exceeding a midpoint deflection of **[L/200][L/240]<Insert deflection>** of span.
- G. Casing Leakage Performance, ASHRAE 111: **[Class 3 leakage]<Insert leakage class>** or better at **[plus or minus 8 inches wg (2000 Pa)]<Insert pressure>**.
- H. Casing Leakage Performance: Comply with more stringent of the following requirements:

1. ASHRAE 111, [Class 3 leakage]<Insert leakage class> or better at [plus or minus 8 inches wg (2000 Pa)]<Insert pressure>.
 2. Not more than [0.5]<Insert number> percent of the total unit airflow at [8 inches wg (2000 Pa)]<Insert pressure>.
- I. Casing Thermal Performance:
1. Surface Condensation: Air-handling manufacturer shall evaluate potential for condensation and design and manufacture entire unit casing to prevent condensation at most extreme operating conditions encountered.
 2. Thermal Break: Incorporate a thermal break at each through metal path to prevent condensation from occurring on interior and exterior of casing.
 3. U-Value: Overall U-value or equivalent R-value of casing shall not exceed governing codes and ASHRAE/IES 90.1 while considering the effects of metal-to-metal contact and thermal bridging in calculations.
- J. Air Tunnel Aerodynamic Performance: Position air-handling unit internal components and transition between internal components to maintain uniform airflow; minimize sound levels and energy consumption. Use methods indicated and other means to ensure compliance.
1. Use turning vanes if necessary to direct the air path.
 - a. Design, manufacture, and install vanes in accordance with applicable requirements in ASHRAE and SMACNA guidelines, handbooks, and standards.
 - b. Install vanes firmly in place so that no vane movement occurs at worst-case airflow capacity possible.
 2. Use fan inlet and discharge transitions and other devices to maximize system regain and minimize airborne sound levels.
 3. Center system components such as coils, fans, and filters, vertically and horizontally, in the airstream.
 4. Maintain spacing between components such that airflow patterns to adjacent components are as uniform as possible and that component "dead spots" or "jetted areas" are avoided.
 5. Design and install internal structural supports, piping, and conduit that do not block airflow and impede performance of coils, fans, filters, and other unit components, and service space clearances.
- K. Air-Handling Unit Acoustical Performance:
1. Radiated Noise: Noise radiated from air-handling unit casing[and openings not ducted] shall not exceed following sound pressure levels when measured [3 feet (900 mm)]<Insert distance> away from any exterior surface of unit. Sound pressure levels indicated in each octave band are in decibels (dB) (reference 20 µPa).
 - a. 63 Hz: <Insert value> dB.
 - b. 125 Hz: <Insert value> dB.
 - c. 250 Hz: <Insert value> dB.
 - d. 500 Hz: <Insert value> dB.
 - e. 1000 Hz: <Insert value> dB.
 - f. 2000 Hz: <Insert value> dB.
 - g. 4000 Hz: <Insert value> dB.
- L. Casing Acoustical Performance:
1. Sound Absorption: Minimum acceptable sound absorption coefficient and noise reduction coefficient (NRC) of perforated inside casing assemblies when tested by an independent testing

laboratory in accordance with ASTM C423 and ASTM E795:

- a. 125 Hz: <Insert value> dB.
 - b. 250 Hz: <Insert value> dB.
 - c. 500 Hz: <Insert value> dB.
 - d. 1000 Hz: <Insert value> dB.
 - e. 2000 Hz: <Insert value> dB.
 - f. 4000 Hz: <Insert value> dB.
 - g. NRC: <Insert value>.
- M. Durability Performance: Design and manufacture air-handling units with underlying requirement to provide a highly durable piece of equipment.
1. Unit Life Expectancy: [25]<Insert number> years.
 2. Supporting Documentation: Submit documentation showing proposed products to consider and include design features, components, and materials to satisfy requirement.
- N. Extreme Operating Conditions:
1. Corrosive Environments: Air-handling unit manufacturer shall evaluate the quality and potential corrosiveness of air passing through air-handling units and propose additional protective finishes and better-quality materials of a heavier thickness if required to comply with requirements indicated.
 - a. Unless otherwise indicated, air-handling units for HVAC applications may use up to 100 percent of outdoor air or a mix of outdoor air with return air from habitable areas served. [**Projects located in coastal and industrial areas may require added protection.**]
 - b. Air-handling units circulating [Class 3][and][Class 4] exhaust air in accordance with ASHRAE 62.1 could potentially be hot, humid, and corrosive and may require added protection.
 2. Humidity and Temperatures: Materials and components of air-handling units shall be suitable for use in low and high humidity and temperature extremes when operating under normal and abnormal conditions without permanent degradation or loss in material performance.
- O. Outdoor Environment:
1. Air-handling units specially designed to withstand effects of wind, rain, ice, snow, seismic, air quality, sun, and other influences associated with outdoor installations.
 2. Comply with requirements of air-handling unit and governing codes.
- P. Safety:
1. Comply with OSHA regulations.
 2. Exposed sharp edges and corners of metal shall be protected or rounded to prevent injury to personnel not wearing gloves.
 3. Cover exposed ends of screws with plastic or metal covers to prevent injury to personnel coming in contact with screws.
- Q. Serviceability:
1. Hoisting Provisions: Fans and motors weighing more than [200 lb (91 kg)]<Insert weight> shall have full-length hoist rails mounted over the equipment to facilitate service, removal, and replacement.
 2. Mounting Location: Install internal components in readily accessible locations to facilitate ease of

- service and replacement.
 - 3. Service Access:
 - a. Internal components shall be serviceable through access sections with doors indicated on Drawings.
 - b. Internal components shall be removable and replaceable through access doors or panels.
 - c. Review requirements for access doors and panels indicated and recommend additional access doors and panels if required for uninhabited service, removal, and replacement of components.
 - 4. Tripping Hazards: Floors in accessible sections of air-handling unit shall be free of standing seams, reinforcing, supports, or section splits located in the walking path that is capable of causing a tripping hazard. Locate section splits immediately adjacent to internal walls.
 - R. Quality: Type and thickness of materials indicated are the minimum acceptable. Provide better-quality materials of a heavier thickness if required to comply with performance requirements indicated.
 - 1. If manufacturer's standard construction exceeds requirements indicated, use manufacturer's standard construction.
 - 2. If manufacturer's standard construction does not comply with requirements indicated, modify manufacturer's standard construction to comply with requirements.
 - S. Seismic Performance: Air-handling units shall withstand the effects of earthquake motions determined in accordance with [ASCE/SEI 7]<Insert requirement>.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."
 - 2. Component Importance Factor: [1.5][1.0].
 - 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>.**
 - T. Vibration Performance: Air-handling unit manufacturer shall evaluate vibration of internal components installed inside of air-handling units and include internal vibration isolation required to limit the vibration transmitted to the building at a low enough level that vibration is not perceived by building occupants.
- 2.2 CAPACITIES AND CHARACTERISTICS
- A. See equipment schedules on Drawings.
- 2.3 SOURCE LIMITATIONS
- A. Source all outdoor [**and indoor**]custom air-handling units from same manufacturer.
 - B. Like components furnished with air-handling units shall be from same manufacturer.
 - C. Air-handling units shall be manufactured in [**United States**][**United States or Canada**][**North America**]<Insert requirement>.
 - D. **<Insert requirements>.**

2.4 OUTDOOR, CUSTOM AIR-HANDLING UNITS

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

1. **[Air Enterprises, LLC]**
2. **[Buffalo Air Handling]**
3. **[Climate Craft]**
4. **[Engineered Air]**
5. **[Environmental Air Systems]**
6. **[Haakon Industries]**
7. **[HUNTAIR; A Nortek Air Solutions Company]**
8. **[Temtrol; A Nortek Air Solutions Company]**
9. **[Trane; An Ingersoll Rand Company]**
10. **<Insert manufacturer's name>**

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

1. **[Air Enterprises, LLC]**
2. **[Buffalo Air Handling]**
3. **[Climate Craft]**
4. **[Engineered Air]**
5. **[Environmental Air Systems]**
6. **[Haakon Industries]**
7. **[HUNTAIR; A Nortek Air Solutions Company]**
8. **[Temtrol; A Nortek Air Solutions Company]**
9. **[Trane; An Ingersoll Rand Company]**
10. **<Insert manufacturer's name>**

- C. Unit Arrangement and Configuration:

1. Arrangement: Project-specific arrangement and configuration of air-handling units indicated on Drawings. Do not deviate from requirements indicated **[without submitting a formal request clearly describing each deviation and reason for each deviation, and only after receiving Architect's written acceptance]**.
2. Mounting Requirements: **[Indicated on Drawings][Units mounted on concrete housekeeping pads][Units mounted on structural floor][Units mounted on structural-steel frame][Units suspended from structure][Units mounted on roof curbs]**.
3. Multiple Sections: Each air-handling unit shall consist of multiple sections for field assembly to comply with requirements indicated on Drawings.
4. Multiple Sections, Splits: Air-handling unit manufacturer to determine number of sections and location of section splits required for each air-handling unit in accordance with the following criteria:
 - a. Physical size and weight of each section, on-site path of travel, and methods for erection and installation. Air-handling manufacturer to review criteria with Installer before preparing Shop Drawings.
 - b. Maximize physical size of each air-handling unit section considering, shipping, moving, erecting, and installation.
 - c. Minimize the number of air-handling unit sections requiring field assembly. Preference is for single-piece air-handling units where possible.

- D. Air-Handling Unit Base:

1. Performance:
 - a. Air-handling unit manufacturer shall design and assemble air-handling unit casing and internal components for attachment and support by air-handling unit structural base.
 - b. Design air-handling units to be lifted from only the air-handling unit structural base and not the casing.
 - c. Support air-handling units from only the perimeter base unless otherwise indicated on Drawings.
 - d. Air-handling unit manufacturer to size and locate intermediate structural base supports as required to comply with structural performance indicated for air-handling unit floors.
 - e. Level base before factory assembly of air-handling unit casing and internal components to ensure proper fit and alignment.
2. Structural Member Size:
 - a. Air-handling unit manufacturer shall select size of base members and construction of base to withstand the rigors of loading, unloading, shipping, and rigging without damage to air-handling unit components or misalignment of factory-assembled components.
 - b. Depth and weight of structural members shall be selected by air-handling unit manufacturer to comply with performance requirements indicated.
 - c. Depth of perimeter base members is not less than **[size indicated on Drawings][1/10 of the unit width][8 inches (200 mm) deep]<Insert requirement>**.
3. Structural Member Spacing: Positioned as required to comply with requirements indicated, but not to exceed **[24 inches (600 mm)]<Insert requirement>**.
4. Materials: **[Structural aluminum, ASTM B209 (ASTM B209M), Alloy 6061 T6][Structural carbon steel, ASTM A36/A36M][Structural stainless steel, ASTM A276/A276M, Type 304L][or][structural stainless steel, ASTM A276/A276M, Type 316L][as indicated on Drawings]**.
 - a. Perimeter Members: **[Angle][channel][I or W beam shapes][or][tube]**.
 - b. Intermediate Members (Spanning Full Width of Unit): **[Angle][channel][or][I or W beam shapes][or][tube]**.
 - c. Cross Members (Spanning Intermediate Members): **[Angle][channel][or][tube]**.
5. Carbon Steel Finish, Mill Galvanized: Mill-galvanized carbon steel with weld-damaged areas cleaned, prepared, and painted with galvanized paint after fabrication.
6. Carbon Steel Finish: Carbon steel bases shall be shot-blasted, cleaned, prepared, and **[painted][or][hot-dip galvanized]** after fabrication.
7. Welding Filler Metals: Comply with AWS welding codes for welding materials appropriate for thickness and chemical analysis of material being welded.
 - a. Use welding materials with corrosion properties equal to material being welded.
8. Welding Procedures:
 - a. Structural Welding Codes: **[AWS D1.1/D1.1M for carbon steel][AWS D1.2/D1.2M for aluminum][AWS D1.6/D1.6M for stainless steel]**.
 - b. Join structural members to one another using **[continuous][or][stitch]** welds.
 - c. After welding and fabrication, deburr and grind exposed welds to provide smooth surfaces free of sharp edges.
9. Penetrations through Base Perimeter: Seal **[weld]** pipe, tubing, and conduit penetrations through base perimeter members to provide a watertight assembly.
10. Section Joints: Air-handling units consisting of multiple sections for field assembly shall be joined with structural joining plates.

- a. Joining plate material type to match base.
 - b. Joining plate of thickness required to join sections without resulting in a permanent deflection, minimum [1/2 inch (13 mm)]<Insert dimension> thick.
 - c. Continuously weld joining plates to each mating end of base.
 - d. Joining plates shall not extend beyond outer edge of adjoining base.
 - e. Plates to include at least three equally spaced holes for field connection using factory-furnished threaded hardware of a nominal diameter of at least [1/2 inch (13 mm)]<Insert diameter>.
 11. Lifting Provisions: Air-handling unit manufacturer to design and install lifting lugs of size and location required to comply with performance requirements indicated. [**Lifting lugs extending beyond the base shall be easily removable in the field after unit is installed.**]
 12. Curb Cap:
 - a. For air-handling units installed on a continuous perimeter curb, provide air-handling unit base with a continuous structural angle counterflashing.
 - b. Angle shall extend down vertical face of curb to completely cover wood nailer.
 - c. Coordinate inside dimension of angle counterflashing with curb dimension and roofing. Provide adequate clearance between angle counterflashing and roofing over curb.
- E. Unit Casings:
1. Casing Assembly:
 - a. Appearance:
 - 1) Exposed exterior surfaces of casing shall have a neat and finished appearance free of standing seams, exposed reinforcing, and other casing protrusions more than [0.25 inch (7 mm)][0.5 inch (15 mm)]<Insert dimension> beyond the exterior skin surface.
 - 2) Underside of air-handling units with finished installation exposed to view shall have finished appearance matching casing walls. Casing shall be recessed within the perimeter structural base to provide a single contiguous plane.
 - 3) Interior surfaces of casing shall have a neat and finished appearance free of standing seams, exposed reinforcing, and other casing protrusions more than [0.25 inch (7 mm)][0.5 inch (15 mm)]<Insert dimension> beyond the skin surface.
 - b. Dissimilar Metals: Isolate dissimilar metals that are in contact to prevent galvanic action and corrosion.
 - c. Framing and Supports: Interconnect and support individual casing wall and roof panels using either formed panel construction or framed construction with structural support members. For framed casing construction, materials used to construct casing of structural support members shall be as follows:
 - 1) Casings with Aluminum Outer and Inner Skins: Aluminum extrusions in accordance with ASTM B211 Alloy 6063 T6.
 - 2) Casings with Galvanized-Steel Outer and Inner Skins: Galvanized steel.
 - 3) Casings with Galvanized-Steel Outer Skin and Aluminum or Stainless Steel Inner Skins: Stainless steel.
 - 4) Casings with Stainless Steel Outer and Inner Skins: Stainless steel.
 - d. Seals: Seal interior and exterior joints and seams to make casing air- and watertight. Trim factory-applied sealant flush with adjacent surface.
 - e. Double-Wall Casings: Consisting of insulation sandwiched between an outer and inner metal wall. Use double-wall casings to construct air-handling units unless septum casings

- are required.
- f. Septum Casings: Triple-wall construction consisting of a solid metal inner wall sandwiched between insulation layers that are covered with metal walls. Use septum casings for applications having performance requirements that are not achievable with double-wall casings.
 - g. Wall and Roof Penetrations: Seal voids around conduit, piping, and tubing penetrations.
 - 1) Conduit, Pipe, and Tube: Sizes NPS 3 (DN 80) and smaller:
 - a) Seal void through casing with a nonhardening vapor-barrier caulk covered by an escutcheon on both interior and exterior sides of casing. Back caulk using formed insulation within a sheet metal sleeve.
 - b) Seal void using a friction fit neoprene or EPDM sheet material attached to casing using a bed of adhesive.
 - c) Cover penetration and sealing sheet material with metal escutcheon matching adjacent casing material.
 - 2) Larger Conduit, Pipe, and Tube Sizes: Seal annular void using an adjustable compression-type sealing sleeve.
 - h. Floors: Route conduit, pipe, and tube within a floor-mounted pipe sleeve.
 - 1) Sleeve:
 - a) Fabricate sleeve of aluminum[, **galvanized-steel**,] or stainless steel pipe.
 - b) Extend top of sleeve above adjacent floor surface to prevent standing water on floor from entering annular space of sleeve.
 - c) Seal[**weld**] sleeve to top of floor for an air- and watertight seal.
 - d) Seal annular void of sleeve using an adjustable compression seal [or][**nonhardening packing material**].
 - i. Floor Openings with Metal Grating:
 - 1) Factory install walk-on safety gratings over any floor opening large enough to create a safety hazard for operators including, but not be limited to, supply-, return-, and exhaust-air openings.
 - 2) Bar Grating:
 - a) Materials: Use [**stainless steel grating for aluminum**][**stainless steel grating for stainless steel**][**hot-dip galvanized-steel grating for galvanized-steel**][**painted steel grating for painted steel**] floors.
 - b) Air-handling unit manufacturer shall select depth and thickness of grating bars to limit deflection to 1/360 of span when subjected to a dynamic load of not less than [**500 lb (227 kg)**]<Insert weight>.
 - c) Industry-standard welded grating with bars at least **1-1/2 inches (38 mm)** deep by at least **3/16 inch (5 mm)** thick with nominal **1-3/16-inch (30-mm)** main bar spacing and **4-inch (100-mm)** cross bar spacing.
 - d) Source: Product manufacturer specializing in metal gratings.
 - e) Grating bearing surface shall extend beyond clear opening in floor at least [**2 inches (50 mm)**][**3 inches (75 mm)**]<Insert dimension>.
 - 3) Mounting Frame:
 - a) Mount grating in a continuous structural angle or bar frame so no ends of grating bars are exposed. Top of frame to be flush with top of grating.
 - b) Secure grating to frame with threaded hardware so grating does not move

- when walked on but can be easily removed from top to gain access behind grating.
- c) Continuously weld mounting frame to air-handling unit floor.
- d) Fasten mounting frame to air-handling unit floor with hardware and seal attachment air- and watertight.
- e) For applications with automatic dampers installed at floor openings, elevate height of mounting frame and grating to enclose entire damper assembly including jackshaft so walk-on surface of grating is above damper assembly.
- j. Waterproof Floors: Continuously weld floor joints, seams, and penetrations to completely seal floor. Roll all edges of floor up at least **[1 inch (25 mm)]<Insert dimension>** to create a shallow tub capable of holding standing water.
- k. Duct Connections - Direct to Casing: Frame and reinforce unit casing around perimeter of unit duct openings to accommodate direct attachment of field-installed ductwork. Coordinate requirements with Installer to accommodate field connection.
- l. Duct Connections - Elevated Off Casing:
 - 1) Terminate with angle flange face elevated **[3 inches (75 mm)]<Insert dimension>** from exterior surface of casing.
 - 2) Flange Thickness: **[0.25 inch (6 mm)]<Insert dimension>**.
 - 3) Flange face with holes located not more than **[4 inches (100 mm)]<Insert dimension>** o.c., starting at corners, and sized for **[0.375-inch- (9-mm-)]** diameter, field-installed hardware.
 - 4) Size flange face to mate to full face of duct flange.
 - a) Clear inside dimension of unit connection to match clear inside dimension of duct.
 - b) For connections to acoustically lined ducts, increase unit flange face to accommodate thickness of liner so end of duct liner is concealed by air-handling unit flange.
- m. **<Insert requirements>**.
- 2. Materials for Outer Skin of Casing Walls and Roofs:
 - a. Galvanized-Steel Solid Sheet: ASTM A653/A653M; **[G90 (Z275)]<Insert coating>** coating; minimum (nominal) **[18 gauge (1.3 mm)][16 gauge (1.6 mm)][14 gauge (2.0 mm)]<Insert value>** thick.
 - b. Aluminum Solid Sheet: **ASTM B209 (ASTM B209M)**; Alloy 3003-H14, **[smooth][stucco-embossed texture][or][leather-grain texture]<Insert finish>** finish; minimum (nominal) **[0.063 inch (1.6 mm)][0.080 inch (2.0 mm)]<Insert value>** thick.
 - c. Stainless Steel Solid Sheet: ASTM A240/A240M or ASTM A480/A480M, **[Type 304][Type 304L][Type 316][Type 316L]<Insert type>**; No. **[2D][or][4]<Insert finish>** finish; minimum (nominal) **[18 gauge (1.3 mm)][16 gauge (1.6 mm)][14 gauge (2.0 mm)]<Insert value>** thick.
 - d. Application: See Drawings for application of different materials indicated.
- 3. Materials for Inner Skin of Casing Walls and Roofs:
 - a. Galvanized-Steel Solid Sheet: ASTM A653/A653M; **[G90 (Z275)]<Insert coating>** coating, minimum (nominal) **[20 gauge (1.0 mm)][18 gauge (1.3 mm)][16 gauge (1.6 mm)]<Insert value>** thick.
 - b. Galvanized-Steel Perforated Sheet: ASTM A653/A653M; **[G90 (Z275)]<Insert coating>** coating, minimum (nominal) **[20 gauge (1.0 mm)][18 gauge (1.3 mm)][16 gauge (1.6 mm)]<Insert value>** thick.

- c. Aluminum Solid Sheet: **ASTM B209 (ASTM B209M)**; Alloy 3003-H14, [smooth]<Insert finish> finish; minimum (nominal) [0.032 inch (0.8 mm)][0.040 inch (1.1 mm)][0.063 inch (1.6 mm)][0.080 inch (2.0 mm)]<Insert value> thick.
 - d. Aluminum Perforated Sheet: **ASTM B209 (ASTM B209M)**; Alloy 3003-H14, [smooth]<Insert finish> finish; minimum (nominal) [0.032 inch (0.8 mm)][0.040 inch (1.1 mm)][0.063 inch (1.6 mm)][0.080 inch (2.0 mm)]<Insert value> thick.
 - e. Stainless Steel Solid Sheet: ASTM A240/A240M or ASTM A480/A480M; [Type 304][Type 304L][Type 316][Type 316L]<Insert type>; No. [2D]<Insert finish> finish; minimum (nominal) [20 gauge (1.0 mm)][18 gauge (1.3 mm)][16 gauge (1.6 mm)]<Insert value> thick.
 - f. Stainless Steel Perforated Sheet: ASTM A240/A240M or ASTM A480/A480M; [Type 304][Type 304L][Type 316][Type 316L]<Insert type>; No. [2D]<Insert finish> finish; minimum (nominal) [20 gauge (1.0 mm)][18 gauge (1.3 mm)][16 gauge (1.6 mm)]<Insert value> thick.
 - g. Application: See Drawings for application of different materials indicated.
4. Materials for Floor Walking Surface:
- a. Galvanized-Steel Solid Sheet: ASTM A653/A653M; [G90 (Z275)]<Insert coating> coating; minimum (nominal) [14 gauge (2.0 mm)][12 gauge (2.8 mm)][10 gauge (3.5 mm)]<Insert value> thick.
 - b. Stainless Steel Solid Sheet: ASTM A240/A240M or ASTM A480/A480M, [Type 304][Type 304L][Type 316][Type 316L]<Insert type>; No. [2D]<Insert finish> finish; minimum (nominal) [14 gauge (2.0 mm)][12 gauge (2.8 mm)][10 gauge (3.6 mm)]<Insert value> thick.
 - c. Carbon Steel Diamond Treadplate: ASTM A786/A786M, painted finish; minimum (nominal) [0.125 inch (3.2 mm)][0.1875 inch (4.8 mm)]<Insert value> thick.
 - d. Aluminum Diamond Treadplate: ASTM B632/B632M, Alloy 6061 T6; mill finish; minimum (nominal) [0.125 inch (3.2 mm)][0.1875 inch (4.8 mm)]<Insert value> thick.
 - e. Stainless Steel Diamond Treadplate: ASTM A793; [Type 304][Type 304L][Type 316][Type 316L]<Insert type>; mill finish; minimum (nominal) [0.125 inch (3.2 mm)][0.1875 inch (4.8 mm)]<Insert value> thick.
 - f. Application: See Drawings for application of different materials indicated.
5. Materials for Underside of Floor Insulation:
- a. Galvanized-Steel Solid Sheet: ASTM A653/A653M; [G90 (Z275)]<Insert coating> coating; minimum (nominal) [18 gauge (1.3 mm)][16 gauge (1.6 mm)]<Insert value> thick.
 - b. Aluminum Solid Sheet: **ASTM B209 (ASTM B209M)**; Alloy 3003-H14, [smooth]<Insert finish> finish; minimum (nominal) [0.040 inch (1.1 mm)][0.063 inch (1.6 mm)][0.080 inch (2.0 mm)]<Insert value> thick.
 - c. Stainless Steel Solid Sheet: ASTM A240/A240M or ASTM A480/A480M; [Type 304][Type 304L][Type 316][Type 316L]<Insert type>; No. [2D][4]<Insert finish> finish; minimum (nominal) [18 gauge (1.3 mm)][16 gauge (1.6 mm)]<Insert value> thick.
 - d. Application: See Drawings for application of different materials indicated.
6. Materials for Internal Walls:
- a. Galvanized-Steel Solid Sheet: ASTM A653/A653M; [G90 (Z275)]<Insert coating> coating; minimum (nominal) [16 gauge (1.6 mm)][14 gauge (2.0 mm)]<Insert value> thick.
 - b. Aluminum Solid Sheet: **ASTM B209 (ASTM B209M)**; Alloy 3003-H14, smooth finish; minimum (nominal) [0.063 inch (1.6 mm)][0.080 inch (2.0 mm)]<Insert value> thick.
 - c. Stainless Steel Solid Sheet: ASTM A240/A240M or ASTM A480/A480M, [Type 304][Type 304L][Type 316][Type 316L]<Insert type>; No. 2D finish; minimum (nominal) [16 gauge (1.6 mm)][14 gauge (2.0 mm)]<Insert value> thick.
 - d. Application: See Drawings for application of different materials indicated.

7. Surfaces in Contact with Airstream:
 - a. Comply with ASHRAE 62.1 and NFPA 90A.
 - b. Glass or mineral-fiber insulation installed behind perforated metal shall be encapsulated to prevent insulation fibers from entering the airstream by using a **[polymer sheet material][or][tightly woven glass cloth material that does not impact the acoustical absorption properties of insulation]**.
8. Insulation for Casing Walls and Roofs Not Exposed to Airstream:
 - a. Materials Not Exposed to Airstream: **[Glass or mineral-fiber board][injected or sprayed polyurethane foam][or][polyurethane foam board]** insulation with a minimum nominal density of **[2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)]<Insert density>**.
 - b. R-Value: Minimum **[R-8][R-10][R-12][R-16]<Insert value>**.
 - c. Thickness: Minimum **[2 inches (50 mm)][2.5 inches (68 mm)][3 inches (75 mm)][4 inches (100 mm)]<Insert dimension>**.
 - d. Insulation shall completely fill the casing cavity so no voids exist.
9. Insulation for Casing Walls and Roofs Exposed to Airstream:
 - a. Materials Exposed to Airstream: Glass or mineral-fiber board insulation with a minimum density of **[2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density>**.
 - b. R-Value: Minimum **[R-8][R-10][R-12][R-16]<Insert value>**.
 - c. Thickness: Minimum **[2 inches (50 mm)][2.5 inches (68 mm)][3 inches (75 mm)][4 inches (100 mm)]<Insert dimension>**.
 - d. Insulation shall completely fill the casing cavity so no voids exist.
10. Insulation for Casing Floors:
 - a. Materials: **[Glass or mineral-fiber board insulation][injected or sprayed polyurethane foam][or][polyurethane foam board]** insulation with a minimum nominal density of **[2 lb/cu. ft. (32 kg/cu. m)][3 lb/cu. ft. (48 kg/cu. m)]<Insert density>**.
 - b. R-Value: Minimum **[R-8][R-10][R-12][R-16]<Insert value>**.
 - c. Thickness: Minimum **[2 inches (50 mm)][2.5 inches (68 mm)][3 inches (75 mm)][4 inches (100 mm)]<Insert dimension>**.
 - d. Insulation shall completely fill the casing cavity so no voids exist.
11. Access Doors:
 - a. Application: **[Install access doors in air-handling units at locations indicated on Drawings][Install access doors downstream and upstream of all internal components]<Insert requirement>**.
 - b. Adjustment: Design doors for field adjustment capable of maintaining specified leakage rate.
 - c. Mounting Height: Install bottom of door frame within **[2 inches (50 mm)]<Insert dimension>** of air-handling unit floor walking surface. **[Where internal conditions require access doors to be mounted higher above air-handling unit floor, include permanent retractable stairs inside and outside of air-handling unit to limit stair risers to 6 inches (150 mm).]**
 - d. Performance: Leakage as required to satisfy overall unit leakage performance indicated, but not more than **[1.0 cfm (0.47 L/s)]<Insert leakage rate>** per door when tested at **10 inches wg (2500 kPa)**.
 - e. Fabrication: Formed and reinforced, constructed of same materials and thicknesses as casing. **[Where doors are installed in casing walls with perforated interior, install**

- doors with solid interior.]**
- f. Swing: Arrange doors to be opened against pressure, unless otherwise indicated on Drawings.
 - g. Frame: **[Extruded aluminum with thermal break][galvanized steel][or][stainless steel]** with **[welded]** mitered corners.
 - h. Handles:
 - 1) Secure door closed using not less than two **[roller-style]** latches with handles located at quarter points along door height.
 - 2) If three latches with handles are included, install one at midpoint of door height and equally space others.
 - 3) Air-handling unit manufacturer has option to use a multipoint latching mechanism that is operable from a single door handle located at midpoint of door height, but secures door to frame at top, bottom, and handle location.
 - 4) Include door handles on outside and inside of door to allow operator access to open and close door from outside and inside of unit.
 - 5) Field adjustable to accommodate changes to fit and gasket compression.
 - 6) Durable product capable of withstanding repeated opening and closing of door while operating under design pressure without damage.
 - i. Hinges: **[Minimum of two hinges][minimum of three hinges][or][full-length, concealed, stainless steel piano hinge]**.
 - j. Gasket:
 - 1) Design: Specially formed with an internal air chamber specifically designed to seal on two surfaces without taking a permanent set.
 - 2) Dual Gaskets: Primary and secondary gasket.
 - 3) Location: Install gaskets around entire perimeter of doors or frames.
 - 4) Material: EPDM, neoprene, or santoprene.
 - 5) Protection: Seat gasket in a protective metal ribbed chamber integral to door or door frame to protect gasket from damage by operator incidental contact.
 - 6) Service: Field replaceable.
 - 7) Adhesive-backed tape-type gaskets adhered to a single flat surface are unacceptable.
 - k. Size of Door Frame Clear Opening: Large enough to allow for unobstructed access for inspection and maintenance of air-handling unit's internal components.
 - 1) Width: At least **[18 inches (450 mm)][24 inches (600 mm)]<Insert dimension>** clear inside of door frame.
 - 2) Height: Full clear height of unit casing up to a maximum height of **[60 inches (1500 mm)][72 inches (1800 mm)]<Insert dimension>** clear inside of door frame.
 - 3) Door sizes indicated on Drawings.
 - l. Safety Latches and Stops:
 - 1) Safety Latches: Install safety latch with retainers on outward swing doors that do not open against pressure to allow restricted travel for purpose of pressure relief and so that doors do not open uncontrollably due to inside pressure.
 - 2) Stops: Install cushioned door stops on inward swinging doors where necessary to limit door travel that could potentially damage the door or internal components.
 - m. Tie-Backs: Install tie-backs with retainers on **[outward-swinging]** access doors to hold doors in an open position during service.
 - n. Locks: Include each access door with an integral key lock. Pad locks are unacceptable.

- 1) Incorporate key lock into door handle where feature is available.
 - 2) A common key shall be used to lock and unlock access doors of **[each][all]** air-handling unit(s).
 - 3) Include **[two]<Insert value>** keys **[for each air-handling unit]**.
 - 4) Lock access doors at factory to ensure that unauthorized access is in place before air-handling unit packaging and shipment.
- o. Windows:
- 1) Construction: Fabricate windows with frame mounted in access doors of double-glazed safety glass with an airspace between panes and interior and exterior seals.
 - 2) Condensation Control: Install desiccant material in airspace between panes if necessary to prevent condensation from forming on glazing.
 - 3) Clear Viewing Size: Minimum **[6 inches (150 mm)][8 inches (200 mm)][12 inches (300 mm)]<Insert dimension>**, square **[or round]**.
 - 4) Mounting Location: Center window in door width. For doors up to **[60 inches (1500 mm)]<Insert dimension>** high, locate top of window **[6 inches (150 mm)]<Insert dimension>** below top of door. For taller doors, locate center of windows at optimal viewing height, approximately **[60 inches (1500 mm)]<Insert dimension>** above floor adjacent to unit.
 - 5) Application: Install windows in **[all access doors][only access doors servicing fans][only access doors servicing fans and filters][only access doors servicing coils, dampers, heat wheels, fans, filters, and UV-C lamps]<Insert requirement>**.
- p. Nameplates:
- 1) On each access door, include a nameplate defining the access to service within. Nameplates shall be included for, but not be limited to, the following:
 - a) Dampers.
 - b) Filters.
 - c) Gas-phase filters.
 - d) Cooling coils.
 - e) Heating coils.
 - f) Electric heaters.
 - g) Duct silencers.
 - h) Heat wheels.
 - i) Fixed plate exchangers.
 - j) Heat pipe heat exchangers.
 - k) UV-C lamp systems.
 - l) Supply fans.
 - m) Exhaust fans.
 - n) Return fans.
 - o) Humidifiers.
 - p) Air blenders.
 - q) **<Insert items>**.
 - r) Air-handling unit designation.
 - s) Where door access is to multiple components, list all components accessed. For example: Filter/Cooling Coil.
 - t) For each door that does not open against static pressure, include a warning sign stating: "DANGER: DOOR UNDER PRESSURE. DO NOT OPEN WITH FAN ON."
 - 2) Lettering Size and Style: At least **[1-inch- (25-mm-)]<Insert dimension>** high, block

- style.
 - 3) Material: Lettering engraved in black plastic on a white plastic back. Engraving shall penetrate through black plastic so lettering reads white.
 - 4) Attachment: Attach nameplates to door using high-strength bonding cement and **[stainless steel]**screws.
 - 5) Mounting Location:
 - a) For access doors without windows, locate top of nameplate **[6 inches (150 mm)]<Insert dimension>** from top of door and center in door width.
 - b) For access doors with windows, locate nameplate directly **[above][or][below]** window frame and center in door width.
 - c) Align nameplates of all doors for uniform placement.
12. Access Door Gutters and Downspouts: Install rain gutters directly above each access door to deflect rain away from doors.
- a. Construct gutters of same materials and finish as casing exterior.
 - b. Extend gutters beyond vertical edge of doors at least **[3 inches (75 mm)]<Insert dimension>**.
 - c. Install gutter with a downspout located adjacent to access door frame. Construct downspout of **[aluminum][or][stainless steel]** pipe **[or][copper tube]** of a size determined by unit manufacturer. Terminate downspout at a height below unit floor.
13. Access Panels:
- a. Performance: Leakage as required to satisfy overall unit leakage performance indicated.
 - b. Fabrication: Formed and reinforced panels of same material and thickness as casing.
 - c. Fasteners: Adjustable, reusable type for multiple operations without degradation due to reuse. **[Do not use screws capable of stripping.]**
 - d. Arrangement: Panels removable from exterior side of casing.
 - e. Gasket: EPDM, neoprene, or santoprene similar to access doors, applied around entire perimeter of panels or frames.
 - f. Location and Size:
 - 1) Coils: Oversized access panel to allow removal and replacement without impacting adjacent casing.
 - 2) Electric Heaters: Oversized access panel to allow removal and replacement without impacting adjacent casing.
 - 3) Fans: Oversized access panel to allow removal and replacement of entire fan assembly **[including base]**without impacting adjacent casing.
 - 4) Heat Wheels and Heat Exchangers: Oversized access panel to allow removal and replacement of internal components without impacting adjacent casing.
 - 5) Humidifiers: Oversized access panel to allow removal and replacement without impacting adjacent casing.
 - 6) **<Insert component>**.
 - g. Nameplates:
 - 1) On each access panel, include a nameplate defining the access to service within. Nameplates shall be included for, but not be limited to, the following:
 - a) Cooling coils.
 - b) Heating coils.
 - c) Electric heaters.
 - d) Heat wheels.
 - e) Fixed plate exchangers.

- f) Heat pipe heat exchangers.
 - g) Humidifiers.
 - h) Supply fans.
 - i) Exhaust fans.
 - j) Return fans.
 - k) <Insert description>.
- 14. Standing-Seam Metal Roof: Construct air-handling unit roof casing with standing seams designed for waterproof roofing applications.
 - a. Construct air-handling unit roof using same materials and finish as walls.
 - b. Slope roof away from primary access side of unit at not less than [1][2]<Insert number> percent.
 - c. For air-handling units shipped in multiple sections, include standing-seam joiners at each split with adhesive, hardware, and cover strips for field joining by Installer.
- 15. Roofing Membrane:
 - a. Cover entire roof with a roofing membrane. Extend membrane down sides of unit a sufficient distance to provide a waterproof roof assembly and secure in place with a metal flashing matching casing material and finish.
 - 1) Roofing membrane shall have an elongation of at least 450 percent when tested in accordance with ASTM D412.
 - 2) Roofing membrane shall not become brittle at temperatures down to minus **40 deg F (40 deg C)**.
 - b. Slope unit roof away from primary access side of unit at a slope in accordance with roofing manufacturer's written instructions, but not less than [1][2]<Insert number> percent.
 - c. Application: Factory or field applied as determined by air-handling unit manufacturer; in accordance with roof manufacturer's written instructions.
 - 1) Field-applied roofing to be supervised by an air-handling unit manufacturer's factory service representative.
- 16. Liquid-Applied Roofing:
 - a. Cover entire roof with a liquid-applied roofing. Extend liquid-applied roofing down sides of unit a sufficient distance to provide a waterproof roof assembly and cover sides with a metal flashing matching casing material and finish.
 - 1) Cured roofing shall have an elongation of at least 500 percent at **77 deg F (25 deg C)** and at least 300 percent at **0 deg F (minus 17 deg C)**, when tested in accordance with ASTM D412.
 - 2) Roofing shall not become brittle at temperatures down to minus **40 deg F (40 deg C)**.
 - b. Slope unit roof away from primary access side of unit at a slope in accordance with roofing manufacturer's written instructions, but not less than [1][2]<Insert number> percent.
 - c. Application: Factory or field applied as determined by air-handling unit manufacturer; in accordance with roof manufacturer's written instructions.
 - 1) Field-applied roofing to be supervised by an air-handling unit manufacturer's factory service representative.

17. Service Corridors:

- a. Description: Integral walk-in service corridors with **[heated][and][cooled][ventilated]** temperature-controlled indoor environment for weather-protected service access to unit access doors and factory-installed **[piping][electrical][and][controls]**.
- b. Size and Arrangement: **[As indicated on Drawings][Full length of unit by 6 feet (2 m) deep]<Insert requirements>**.
- c. Construction: Base, floor, walls, and roof to match air-handling unit.
- d. Access Doors:
 - 1) Width: Minimum **[36-inch (900-mm)][42-inch (1050-mm)]<Insert dimension>** clear inside frame opening.
 - 2) For double-door applications, include door frames with removable center mullions for unrestricted access.
- e. Electrical: Factory install and wire **[service lights with switches][and][receptacles]**.
- f. Indoor Environmental Control: Factory install **[self-contained, packaged]** HVAC equipment required to thermostatically controlled indoor environment to maintain following indoor conditions:
 - 1) Minimum Temperature: **<Insert temperature>**.
 - 2) Maximum Temperature: **<Insert temperature>**.
 - 3) Maximum Coincident Relative Humidity: **[60]<Insert number>** percent.
- g. Field Connections to Factory-Installed Piping, Electrical, and Controls: Arranged to make field connections to factory terminations inside of service corridor and within **<Insert distance>** of floor walking surface. Frame openings in air-handling unit floor to accommodate field connections.

18. Piping Enclosures:

- a. Description: Integral accessible enclosure(s) to house field-installed piping from below and connecting to hydronic **[and steam]** coils **[and steam humidifiers]**.
- b. Size: Adequate clearance for field installation of piping, valves, accessories, and associated insulation.
 - 1) Maintain at least **[6 inches (150 mm)]<Insert dimension>** of clearance between inside of enclosure and face of pipe insulation at most restricted point.
- c. Construction:
 - 1) Base, Walls, and Roof: Match air-handling unit.
 - 2) Floor: Not required, open to below.
 - 3) Access Doors:
 - a) Size for full front access to piping, valves, and accessories installed within enclosure.
 - b) Double-door applications with removable center mullions for unrestricted access.
- d. Electrical: Factory install and wire **[service light with switch][and][receptacle]** for each enclosure.

F. Wall Louvers:

- 1. Wall Louvers, Drainable Blade:



- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Greenheck Fan Corporation]**
 - 2) **[Pottorff]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **<Insert manufacturer's name>**
- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Greenheck Fan Corporation]**
 - 2) **[Pottorff]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **<Insert manufacturer's name>**
- c. Source Limitations: Obtain louvers from single source from single manufacturer.
- d. Performance:
 - 1) Air Pressure Drop, Design: Less than **[0.1 inch wg (2.5 Pa)]<Insert pressure drop>** at airflow indicated on Drawings.
 - 2) Air Pressure Drop, Rating: Less than **0.1 inch wg (2.5 Pa)** at free area intake face velocity of **700 fpm (3.6 m/s)**.
 - 3) Face Velocity: If louver size is not indicated on Drawings, size louver for **[500-fpm (2.5-m/s)]<Insert value>** velocity across louver free area.
 - 4) Free Area: 54 percent or more for a **48-by-48-inch (1200-by-1200-mm)** representative sample.
 - 5) AMCA 500-L: Beginning point of water penetration at **870 fpm (4.4 m/s)**.
- e. Features:
 - 1) Depth: **4 inches (100 mm)**.
 - 2) Frame: **0.080 inch (2 mm)** thick, ASTM B211, Grade 6063, T5 temper, extruded-aluminum alloy.
 - 3) Blades: **0.080 inch (2 mm)** thick, ASTM B211, Grade 6063, T5 temper, extruded-aluminum alloy; stationary in horizontal position, drainable.
 - 4) Stationary vertically positioned blades.
 - 5) Bird Screen: **0.5-by-0.040-inch (13-by-1.0-mm)** expanded flattened aluminum attached to back of louver.
 - 6) Finish: Match exterior casing.
- f. Air-Handling Unit Factory Assembly:
 - 1) Install louver face flush with exterior of casing and seal to provide a weathertight installation.
 - 2) Secure louver in casing and include additional bracing if required to handle loading of extreme outdoor environmental performance indicated.
- g. Application: Factory install louvers in air-handling casing **[at locations indicated on Drawings][for each outdoor intake][for each outdoor intake and exhaust discharge]**.

2. Wall Louvers, Wind-Driven Rain:

- a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - 1) [Greenheck Fan Corporation]
 - 2) [Pottorff]
 - 3) [Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]
 - 4) <Insert manufacturer's name>
- b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1) [Greenheck Fan Corporation]
 - 2) [Pottorff]
 - 3) [Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]
 - 4) <Insert manufacturer's name>
- c. Source Limitations: Obtain louvers from single source from single manufacturer.
- d. Performance:
 - 1) Air Pressure Drop, Design: Less than [0.1 inch wg (2.5 Pa)]<Insert pressure drop> at airflow indicated on Drawings.
 - 2) Air Pressure Drop, Rating: Less than 0.1 inch wg (2.5 Pa) at free area intake face velocity of 800 fpm (4.1 m/s).
 - 3) Face Velocity: If louver size is not indicated on Drawings, size louver for [500-fpm (2.5-m/s)]<Insert value> velocity across louver free area.
 - 4) Free Area: 47 percent or more for a 48-by-48-inch (1200-by-1200-mm) representative sample.
 - 5) AMCA 500-L:
 - a) Wind-Driven Rain Penetration Class: Class A, with wind-driven rain penetration effectiveness of 99 percent at core velocity up to [408 fpm (2.1 m/s)]<Insert velocity> with 50-mph (80-kph) wind and rainfall of 8 inches (200 mm) per hour.
 - b) Intake Discharge Loss Class: Class 2.
- e. Features:
 - 1) Depth: 5 inches (125 mm).
 - 2) Frame: 0.080 inch (2 mm) thick, ASTM B211, Grade 6063, T5 temper, extruded-aluminum alloy.
 - 3) Blades: 0.063 inch (1.6 mm) thick, ASTM B211, Grade 6063, T5 temper, extruded-aluminum alloy; stationary in horizontal position, double drainable, and sightproof.
 - 4) Stationary vertically positioned blades.
 - 5) Bird Screen: 0.5-by-0.040-inch (13-by-1.0-mm) expanded flattened aluminum attached to back of louver.
 - 6) Finish: Match exterior casing.
- f. Air-Handling Unit Factory Assembly:
 - 1) Install louver face flush with exterior of casing and seal to provide a weathertight installation.
 - 2) Secure louver in casing and include additional bracing if required to handle loading of extreme outdoor environmental performance indicated.

- g. Application: Factory install louvers in air-handling casing **[at locations indicated on Drawings][for each outdoor intake][for each outdoor intake and exhaust discharge]**.
3. Wall Louvers, Hurricane Rated:
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
- 1) **[Greenheck Fan Corporation]**
 - 2) **[Pottorff]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **<Insert manufacturer's name>**
- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- 1) **[Greenheck Fan Corporation]**
 - 2) **[Pottorff]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **<Insert manufacturer's name>**
- c. Source Limitations: Obtain louvers from single source from single manufacturer.
- d. Certification: Miami-Dade Notice of Acceptance.
- e. Performance:
- 1) Air Pressure Drop, Design: Less than **[0.1 inch wg (2.5 Pa)]<Insert pressure drop>** at airflow indicated on Drawings.
 - 2) Air Pressure Drop, Rating: Less than **0.1 inch wg (2.5 Pa)** at free area face velocity of **1500 fpm (7.5 m/s)**.
 - 3) Face Velocity: If louver size is not indicated on Drawings, size louver for **[500-fpm (2.5-m/s)]<Insert value>** velocity across louver free area.
 - 4) Free Area: 33 percent for a **48-by-48-inch (1200-by-1200-mm)** representative sample.
 - 5) AMCA 500-L, Wind-Driven Rain Penetration Class: Class A, with wind-driven rain penetration effectiveness of 100 percent at core velocity up to **[960 fpm (4.9 m/s)]<Insert velocity>** with **50-mph (80-kph)** wind and rainfall of **8 inches (200 mm)** per hour.
 - 6) AMCA 540 and AMCA 550: Listed.
 - 7) Wind Loading: Positive **160 psf (7.66 kPa)**, negative **140 psf (6.7 kPa)**.
- f. Features:
- 1) Depth: **6 inches (150 mm)** nominal.
 - 2) Frame: **0.095 inch (2.4 mm)** thick, ASTM B211, Grade 6063, T5 temper, extruded-aluminum alloy.
 - 3) Blades: **0.080 inch (2.1 mm)** thick, ASTM B211, Grade 6063, T5 temper, extruded-aluminum alloy; stationary in vertical position.
 - 4) Bird Screen: **0.5-by-0.063-inch (13-by-1.6-mm)** expanded flattened aluminum attached to back of louver in a removable frame.
 - 5) Finish: Match exterior casing.
- g. Air-Handling Unit Factory Assembly:

- 1) Install louver face flush with exterior of casing and seal to provide a weathertight installation.
 - 2) Secure louver in casing and include additional bracing if required to handle loading of extreme outdoor environmental performance indicated.
- h. Application: Factory install louvers in air-handling casing **[at locations indicated on Drawings][for each outdoor intake][for each outdoor intake and exhaust discharge]**.

G. Internal Structural Supports:

1. General:
 - a. Air-handling unit manufacturer shall design and assemble air-handling unit internal structural supports for attachment and support by air-handling unit structural base.
 - b. Factory install structural supports for internal support casing if required to comply with casing structural performance.
 - c. Factory install hoist beams and rails over equipment to comply with performance requirements for service.
2. Structural Member Size and Spacing:
 - a. Size: Air-handling unit manufacturer shall select size of members and construction to do the following:
 - 1) Withstand the rigors of loading, unloading, shipping and rigging without damage to air-handling unit components or misalignment of factory-assembled casing and components.
 - 2) Comply with performance requirements indicated.
 - b. Spacing: Positioned as required to comply with requirements.
3. Materials: **[Structural aluminum, ASTM B209 (ASTM B209M), Alloy 6061 T6][Structural carbon steel, ASTM A36/A36M][Structural stainless steel, ASTM A276/A276M, Type 304L][or][structural stainless steel, ASTM A276/A276M, Type 316L][as indicated on Drawings]**.
 - a. Structural Supports: **[Angle][channel][I or W beam shapes][or][tube]** shapes selected by air-handling unit manufacturer for application.
 - b. Hoist Beams for Internal Components (Spanning Full Width of Unit): I or W beam shapes.
4. Carbon Steel Finish, Mill Galvanized: Mill-galvanized carbon steel with weld damaged areas cleaned, prepared, and painted with galvanized paint after fabrication.
5. Carbon Steel Finish: Carbon steel bases shall be shot-blasted, cleaned, prepared, and **[painted][or][hot-dip galvanized]** after fabrication.

H. Factory-Manufactured Roof Curbs:

1. General:
 - a. Air-handling unit manufacturer shall furnish a continuous perimeter curb for **[each][each roof-mounted]<Insert requirement>** air-handling unit.
 - b. Design curb to support operating air-handling unit from its base with attachments to withstand environmental forces. Curbs with intermediate reinforcing as required.
 - c. Frame curb for ductwork, piping, and conduit located within curb.
 - d. Fabricate curb to maintain top of curb level even where installed on sloping substrate.
 - e. Furnish top of curb to provide for field attachment of unit base to curb.

- f. Furnish curb with a fully mitered and raised cant where required by adjacent insulation and roofing.
 - g. Include bottom of curb with attachment flange that extends beyond base of curb and is suitable for attachment to substrate.
 - h. Furnish curb with integral crickets if required by roof installation.
- 2. Size:
 - a. Size curb to provide continuous support of unit base and to fit within footprint of unit perimeter base.
 - b. Height:
 - 1) See Drawings.
 - 2) **[12 inches (300 mm)][18 inches (450 mm)]<Insert dimension>** from top of curb to finished roofing surface at highest point along perimeter of curb.
- 3. Materials:
 - a. Galvanized-Steel Solid Sheet: ASTM A653/A653M; **[G90 (Z275)]<Insert coating>** coating; minimum (nominal) **[14 gauge (2.0 mm)][12 gauge (2.8 mm)][10 gauge (3.5 mm)]<Insert value>** thick. Treat welded areas to protect against corrosion with a zinc-rich coating.
 - b. Stainless Steel Solid Sheet: ASTM A240/A240M or ASTM A480/A480M, **[Type 304][Type 304L][Type 316][Type 316L]<Insert grade>** grade; No. **[2D]<Insert finish>** finish; minimum (nominal) **[14 gauge (2.0 mm)][12 gauge (2.8 mm)][10 gauge (3.6 mm)]<Insert value>** thick.
- 4. Insulation:
 - a. Insulate curb to provide thermal performance equal to unit casing.
 - b. Completely encapsulate insulation within metal curb.
- 5. Gaskets:
 - a. Include a continuous gasket between air-handling unit base and top of curb for an air and watertight seal.
 - b. Select gasket materials suitable for installation while complying with requirements indicated.
 - c. Furnish gasket materials with air-handling units and curbs for field installation.
 - d. Air-handling unit manufacturer to provide instruction to installer on proper installation techniques.
- I. Centrifugal Fan Arrays:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ebm-papst Inc.]**
 - b. **[Greenheck Fan Corporation]**
 - c. **[Lau Fan]**
 - d. **[Loren Cook Company]**
 - e. **[Rosenberg USA, Inc.]**
 - f. **[Twin City Fan & Blower]**
 - g. **[ZIEHL-ABEGG Inc.]**

- h. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [ebm-papst Inc.]
 - b. [Greenheck Fan Corporation]
 - c. [Lau Fan]
 - d. [Loren Cook Company]
 - e. [Rosenberg USA, Inc.]
 - f. [Twin City Fan & Blower]
 - g. [ZIEHL-ABEGG Inc.]
 - h. <Insert manufacturer's name>
- 3. Sourcing Option: In lieu of sourcing fan array assemblies from a specialty fan manufacturer, air-handling unit manufacturer has option to furnish in-house fan array assemblies that achieve equal or better performance while complying with other requirements indicated.
- 4. Operating Performance:
 - a. Air-handling unit manufacturer shall account for, and include in, submitted fan selections any static pressure drops associated with unit, and system effect due to fan operating in the air-handling unit.
 - 1) Add additional static pressure to fan scheduled total static pressure.
 - 2) If fan motor horsepower is increased, notify Architect.
 - b. Fans shall have sharply rising pressure characteristics at operating point and stable in operation. Fan horsepower characteristics shall be self-limiting and non-loading.
 - c. Fan speed, brake horsepower, and sound power levels indicated are maximum acceptable.
 - d. Scheduled motor horsepower, airflow rate, and static pressure are minimum acceptable. Motor horsepower shall be capable of handling maximum horsepower of fan at scheduled speed.
 - e. At a minimum, fans shall have AMCA class indicated on Drawings.
 - 1) Fan operating limits shall be in accordance with AMCA 99 for AMCA class indicated.
 - 2) If AMCA class is not indicated, use AMCA 99 as basis for determining AMCA class.
 - 3) AMCA class selected shall be capable of accommodating a plus 10 percent increase to fan static pressure indicated on Drawings.
 - f. Motor starting torque shall exceed fan speed-torque requirements.
 - g. Airflow Profile:
 - 1) Fan arrangement within fan array shall produce a uniform airflow and velocity profile across air-handling unit air tunnel when measured [12 inches (300 mm)]<Insert dimension> upstream of fan inlet and [48 inches (1200 mm)]<Insert dimension> downstream of fan inlet.
- 5. Vibration Balance:
 - a. Each fan/motor assembly shall be factory balanced to AMCA 204, [BV-5, Balance Quality Grade G1.0][BV-4, Balance Quality Grade G2.5][BV-3, Balance Quality Grade G6.3][Balance Quality Grade indicated on Drawings]<Insert fan vibration balance requirements> or better through entire operating speed range from minimum speed to maximum speed. If minimum speed is not indicated on Drawings, assume minimum speed



- to be [10][20]<Insert number> percent of design speed.
 - b. Identify and record each speed and speed range within the fan operating range that could cause potential vibration problems.
 - c. Submit test reports as an informational submittal for Project record.
6. Vibration Isolation: Install vibration isolation on each fan/motor assembly in the fan array, except vibration isolation may be omitted on fans/motor assemblies balanced to AMCA 204, BV-5, with a maximum residual imbalance of **0.22-in./s (5.6-mm/s)** peak, filter in.
7. Operation and Service Requirements:
- a. Remaining fans in array shall continue to operate with one or multiple failed fans.
 - b. Each fan/motor assembly of fan array shall be capable of lock-out/tag-out procedure without interrupting operation of other fans in the array.
 - c. Each fan/motor assembly shall be controlled through a variable-frequency controller, except for fans with electronically commutated (EC) motors having integral motor controls.
 - 1) Include a dedicated variable-frequency controller for each fan/motor assembly in the fan array.
 - 2) If fan array is served from a single variable-frequency controller, include a redundant variable-frequency controller with automatic switchover in event of primary variable-frequency controller failure.
 - d. A single mechanical, electrical, and control device failure shall not result in a fan array available capacity of less than [33]<Insert number> percent of air-handling unit total scheduled airflow capacity.
 - e. Fan wheel/motor assembly shall pass through the air-handling unit access door servicing fans. Entire individual fan assembly shall pass through the door to the room where air-handling unit is located.
 - f. Design and incorporate features to permit safe, rapid, and economical maintenance.
8. Airflow Measurement, Local Indication, and Remote Monitoring:
- a. Each fan within fan array shall include airflow measurement indication in **cfm (L/s)**.
 - b. Include airflow totalization of all operating fans in fan array.
 - c. Airflow measurement instrumentation shall not restrict or deflect air travel through fan and shall not impact fan air and sound performance.
 - d. Include digital display of individual fan airflow and total fan array airflow on face of fan control panel.
 - e. Include a 4- to 20-mA output signal for remote monitoring of total fan array airflow.
9. Fan Array Local Control:
- a. Include fan control panel with operator interface to control fan array locally through the fan control panel and to switch to control of fan array through a remote-control source.
 - b. Local control shall include on/off operation [**and speed adjustment**] for entire fan array and each individual fan/motor in fan array.
10. Fan Array Remote Control:
- a. Include fan control panel with control interface for remote control.
 - b. Fan array on/off operation shall be remotely controlled through a single hardwired digital output signal.
 - c. Fan array speed shall be remotely controlled through a single hardwired analog (4- to 20-mA) output signal.

11. Fan Base, Stackable Fan Units:
 - a. Mount fan/motor on **[aluminum][galvanized-steel][or][powder-coated steel]** base.
 - b. Include base and vibration isolators in accordance with requirements indicated.
 - c. Weld structural members to form a rigid base.
 - d. Size and design the base construction to withstand the rigors of shipping and rigging.
 - e. Include the base with lifting lugs or holes.
12. Fan Frame:
 - a. Construct frame of **[aluminum][galvanized-steel][or][powder-coated steel]**.
 - b. Reinforce and brace frame to prevent excessive deflection and pulsation.
 - c. Include stiffeners to form a rigid frame that is free of structural resonance and vibration.
13. Fan Panel:
 - a. Construct fan panel of **[continuously welded][aluminum][galvanized steel][or][powder-coated steel]**.
 - b. Reinforce and brace fan panel to prevent excessive deflection and pulsation.
 - c. Include stiffeners to form a rigid panel that is free of structural resonance and vibration.
14. Fan Inlet Cone:
 - a. Include a precision-spun or die-formed, matched inlet and wheel cone to ensure streamlined airflow into the wheel and full loading of fan blades.
 - b. Inlet cone shall be a smooth hyperbolic shape.
 - c. Inlet cone shall be a single piece, constructed of aluminum or powder-coated steel.
 - d. Fasten inlet cone to fan panel using bolts, nuts, and washers to provide a positive and secure attachment that can be field removable.
15. Fan Wheel:
 - a. Fan blades shall be a true hollow airfoil shape, welded to backplate and wheel cone.
 - b. Construct blades of aluminum, reinforced for AMCA fan class.
 - c. Design blades to provide smooth airflow over all surfaces of blade.
 - d. Construct fan hubs of aluminum with integral bracing for extra strength and stiffness.
 - 1) Castings shall be sound and free of shrink holes, blow holes, cracks, scale, blisters, or other similar injurious defects.
 - 2) Clean surfaces of castings by blasting, pickling, or any other standard method.
 - 3) Mold-parting fins and remains of gates and risers shall be chipped, filed, and ground flush.
 - 4) Design hubs to maintain a high resistance to fatigue and low relative wheel imbalance.
 - e. Hubs shall be keyed and setscrewed to motor shaft for positive attachment.
 - f. Construct wheel backplates of aluminum.
 - g. Select entire rotating assembly so first critical speed is at least **[30]<Insert number>** percent greater than fan design speed and at least **[20]<Insert number>** percent greater than maximum speed in AMCA fan class.
16. Fan Drive:
 - a. Direct drive, arrangement 4 in accordance with AMCA 99.
 - b. Adjust wheel width and diameter to match motor speed while providing performance scheduled.



- c. Fasten fan wheel directly to motor shaft using a key in motor shaft and setscrew.
 - d. Construct motor base and pedestal supports of **[aluminum][galvanized steel][or][powder-coated steel]**.
 - e. Fan Speed Limitation:
 - 1) Fan speed at design conditions indicated shall not exceed speed on motor nameplate.
 - 2) Do not select fans to operate at motor speeds greater than motor nameplate.
17. Fan Motors: See "Fan Motors" Article for ac motors.
18. Fan Motors, Electronically Commutated (EC):
- a. Description: EC, variable-speed, dc, programmable brushless motor.
 - b. Features:
 - 1) Integral controller/inverter operates wound stator and senses rotor position to electronically commute the stator.
 - 2) Controller shall control motor speed either through manual adjustment locally at fan array control panel or through a remote 0- to 10-V-dc control signal.
 - 3) Motor Mounting: Coordinate with driven equipment; suitable for mounting with motor shaft in either horizontal or vertical position.
 - c. Performance:
 - 1) Altitude: Suitable for operation at site altitude.
 - 2) Electrical Characteristics: Suitable for operation with field power source. Coordinate with electrical Installer.
 - 3) Energy Efficiency: Complying with governing energy codes; **[80]<Insert number>** percent or higher maintained throughout entire operating range.
 - 4) Power Factor: **[0.9]<Insert value>** or higher at full load.
 - 5) Service Factor: 1.0 or higher.
 - 6) Speed Control: Variable, zero to 100 percent.
 - a) Synchronous speed rotation with no slip losses.
 - b) Gradual ramp-up to set point upon receiving a start signal.
 - c) Soft speed change ramps.
 - d) Able to overcome reverse rotation without impact.
 - e) Control airflow within 5 percent of set point regardless of static pressure.
 - 7) Temperature: Suitable for operation in ambient temperature range encountered.
 - 8) Thermal Protection:
 - a) Automatically breaks electrical power to motor when temperature exceeds a safe value.
 - b) Automatically resets and restores power when temperature returns to normal range.
 - d. Bearings: Sealed and permanently lubricated ball bearings.
 - e. Enclosure: ODP or TEFC.
 - f. Insulation: Class B or Class F.
 - g. Rotor: Permanent magnet with near zero rotor losses that operates independent of motor current.
 - h. Materials and Construction:
 - 1) Enclosure and Frame: Aluminum, painted steel, or stainless steel.

- 2) End Brackets: Cast aluminum.
- 3) Shaft: Steel or stainless steel.
- 4) Motor Leads: Pin or screw terminals.
- 5) Nameplates: Manufacturer's standard.
- 6) Paint: Manufacturer's standard.

19. Fan Enclosure:

- a. Include each fan in fan array with integral single-wall enclosure constructed of solid **[aluminum][galvanized-steel][or][powder-coated steel]** sheet.
- b. Enclosure shall not increase fan array length beyond size indicated on Drawings.
- c. Enclosure shall not add static pressure loss.
- d. Enclosure shall provide a physical separation between operating adjacent fans to prevent negative performance.

20. Fan Sound Silencing Enclosure:

- a. Include each fan of fan array with integral sound silencer enclosure to reduce the bare fan discharge sound levels by at least **[8][15]<Insert value>** dB through octave band frequencies from 125 to 8000 Hz.
- b. Enclosure shall not increase the fan array length beyond size indicated on Drawings.
- c. Silencing enclosure shall not add static pressure loss.
- d. Double-wall construction consisting of sound absorbing insulation sandwiched between a solid metal outer skin and perforated metal inner skin.
 - 1) Outer Skin Material: **[Aluminum][Galvanized steel][Powder-coated steel]**.
 - 2) Inner Skin: Material **[Aluminum][Galvanized steel][Powder-coated steel]**.
 - 3) Insulation Material: **[Mineral fiber][mineral fiber wrapped in a tight woven fiberglass cloth or polymer sheet][or][fiber free]**.
- e. Enclosure shall provide a physical separation between operating adjacent fans to prevent a negative performance.

21. Backdraft Damper:

- a. Include each fan in the fan array with a backdraft damper at the fan **[inlet][or][outlet]** to prevent air circulation through a fan that is not operating.
- b. Open backdraft damper when fan is operating and close when fan is not operating.
- c. Design backdraft damper assembly to operate with little to no static pressure loss with fan operating throughout entire operating range from design to minimum airflow.
 - 1) Add damper pressure loss shall to fan scheduled total static pressure.
 - 2) If pressure loss requires a change field electrical power, air-handling unit manufacturer shall be responsible for associated cost of change.
- d. Fasten backdraft damper assembly to fan panel or enclosure using hardware designed for easy removal by maintenance personnel.
- e. Dampers shall not create measurable additional noise above the sound level of fan.
- f. Dampers shall not vibrate or rattle.
- g. Construct dampers of extruded aluminum, stainless steel, or powder-coated steel.

22. Blank-off Panels:

- a. Include **[one][two][10 percent of]<Insert number>** blank-off panel(s) with each air-handling unit fan array for use by operators in the field to prevent air circulation through any of the fans in fan array that are not operating.

- b. Design blank-off panels for attachment to fan panels using easily removable and reusable hardware.
 - c. Construct blank-offs of aluminum, stainless steel, or powder-coated steel sheets, not less than **[0.07 inch (1.8 mm)]<Insert dimension>** thick.
 - d. Mount fan blank-off panels in the fan inlet access section for convenient operator access and use in the future.
23. Protective Screens:
- a. Include easily removable safety screens where fan inlet and outlet are exposed to maintenance personnel, including walk-in air-handling unit plenums.
 - 1) Safety screens are not required on fan inlets and outlets with backdraft dampers.
 - b. Expanded-metal or wire screens, fastened to a flat bar perimeter frame.
 - c. Screens shall comply with OSHA requirements.
 - d. Screens and frame shall be constructed of aluminum, stainless steel, or powder-coated steel.
 - e. Fasten screens to fan using removable and reusable hardware designed for easy removal by maintenance personnel.
24. Hardware: Hex-head, high-strength **[carbon steel with corrosion-resistant coating][or][300 series stainless steel]**.
25. Nameplates:
- a. Construct nameplates and rotation arrows of aluminum or 300 series stainless steel.
 - b. Securely fasten nameplate and rotation arrow to fan housing using pins or sheet metal screws.
 - c. Locate nameplates in a highly visible location on motor side of fan.
 - d. Provide the following information on nameplate: **[Engraved][stamped][or][labeled]**.
 - 1) Manufacturer, address, phone number, and website address.
 - 2) Manufacturer model number.
 - 3) Serial number.
 - 4) Manufacturing date.
 - 5) Fan size.
 - 6) Fan schedule equipment designation (may be listed on a separate nameplate if there is insufficient space).
 - 7) Design airflow.
 - 8) Design static pressure.
 - 9) Design fan speed.
 - 10) AMCA fan class.
 - 11) **<Insert requirement>**.
26. Air-Handling Unit Factory Assembly:
- a. Internal Access: Include each fan with internal access from **[downstream][and][upstream]** sides as indicated on Drawings.
 - b. Removal and Replacement: Each fan wheel and motor shall be independently removable and replaceable through a removable access door installed in air-handling unit casing.
 - c. Stackable Fan Arrays: Construct frame work from aluminum[, **galvanized steel,**], **painted steel,**] or stainless steel.
 - d. Panel-Mounted Fan Array Supports:
 - 1) Construct a freestanding and self-supporting structural framework to support each

- fan individually from and independent of adjacent fans.
- 2) Construct frame work from aluminum[, **galvanized steel**],[, **painted steel**,] or stainless steel.

J. Centrifugal Plenum Fans:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Greenheck Fan Corporation]**
 - b. **[Loren Cook Company]**
 - c. **[New York Blower Company (The)]**
 - d. **[Twin City Fan & Blower]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Greenheck Fan Corporation]**
 - b. **[Loren Cook Company]**
 - c. **[New York Blower Company (The)]**
 - d. **[Twin City Fan & Blower]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain fans from single source from single manufacturer.
4. Operating Performance:
 - a. Air-handling unit manufacturer shall account for, and include in, submitted fan selections any static pressure drops associated with unit, and system effect due to fan operating in the air-handling unit.
 - 1) Add additional static pressure to fan scheduled total static pressure.
 - 2) If fan motor horsepower is increased, notify Architect.
 - b. Fans shall have sharply rising pressure characteristics at operating point and stable in operation. Fan horsepower characteristics shall be self-limiting and non-loading.
 - c. Fan speed, brake horsepower, and sound power levels indicated are maximum acceptable.
 - d. Motor horsepower, airflow rate, and static pressure are minimum acceptable. Motor horsepower shall be capable of handling maximum horsepower of fan at scheduled speed.
 - e. Fan air performance ratings shall be based on tests in accordance with ASHRAE 51/AMCA 51 and AMCA 210.
 - f. Base fans sound ratings on AMCA 300 and calculation methods in accordance with AMCA 301.
 - g. At a minimum, fans shall have AMCA class indicated on Drawings.
 - 1) Fan operating limits shall be in accordance with AMCA 99 for AMCA class indicated.
 - 2) If AMCA class is not indicated, use AMCA 99 as basis for determining AMCA class.
 - 3) AMCA class selected shall be capable of accommodating a plus 10 percent increase to fan static pressure indicated on Drawings.
 - h. Motor starting torque shall exceed fans speed-torque requirements.



5. Vibration Balance:
 - a. Each fan/motor assembly shall be factory balanced to AMCA 204, **[BV-5, Balance Quality Grade G1.0][BV-4, Balance Quality Grade G2.5][BV-3, Balance Quality Grade G6.3][Balance Quality Grade indicated on Drawings]**<Insert fan vibration balance requirements> or better through entire operating speed range from minimum speed to maximum speed. If minimum speed is not indicated on Drawings, assume minimum speed to be **[10][20]<Insert number>** percent of design speed.
 - b. Identify and record each speed and speed range within the fan operating range that could cause potential vibration problems.
 - c. Submit test reports as an information submittal for Project record.
6. Operation and Service Requirements:
 - a. Each fan/motor assembly shall be capable of lock-out/tag-out procedure without interrupting operation of other fans in air-handling unit.
 - b. Design and incorporate features to permit safe, rapid, and economical maintenance.
7. Fan Base:
 - a. Mount fan, motor, and drive on a structural-steel or an aluminum base; except, where indicated on Drawings, install fan on a concrete-filled inertia base.
 - b. Include base and vibration isolators in accordance with requirements indicated.
 - c. Electrically weld the base.
 - d. Size and design the base construction to withstand the rigors of shipping and rigging.
 - e. Include the base with lifting lugs or holes.
 - f. Construct base with gusseted brackets to accommodate spring isolators indicated.
8. Fan Panel:
 - a. Construct fan panel of aluminum or powder-coated steel.
 - b. Support fan wheel and bearings from a structural aluminum or powder-coated steel framework.
 - c. Reinforce and brace fan panel to prevent vibration and pulsation.
 - d. Include stiffeners to form a rigid panel that is free of structural resonance and vibration.
9. Fan Inlet and Wheel Cone:
 - a. Precision-spun or die-formed, matched inlet and wheel cone to ensure streamlined airflow into the wheel and full loading of blades.
 - b. Inlet and wheel cones shall be hyperbolic.
 - c. Inlet cone shall be a single piece, constructed of aluminum or powder-coated carbon steel.
 - d. Fasten inlet cone to fan panel using bolts, nuts and washers to provide a positive and secure attachment that can be field removable.
 - e. Inlet cones that are held in place using retaining clips are unacceptable.
10. Fan Wheel:
 - a. Fan blades shall be a true hollow airfoil shape, **[continuously]** welded to backplate and wheel cone.
 - b. Construct blades of aluminum, reinforced for AMCA fan class and operating conditions scheduled.
 - c. Design blades to provide smooth and aerodynamic airflow over all surfaces of blade.
 - d. Construct fan hubs of cast aluminum or cast-iron ASTM A48/A48M Class 20A and better, with integral bracing for extra strength and stiffness.

- 1) Castings shall be sound and free of shrink holes, blow holes, cracks, scale, blisters, or other similar injurious defects.
 - 2) Clean surfaces of castings by blasting, pickling, or other standard method.
 - 3) Mold-parting fins and remains of gates and risers shall be chipped, filed, and ground flush.
 - 4) Design hubs to maintain a high resistance to fatigue and low relative wheel imbalance.
 - e. Hubs shall be keyed and setscrewed to shaft for positive attachment.
 - f. Construct the wheel backplates of aluminum.
 - g. Statically and dynamically balance fan wheel before fan is assembled.
 - h. Select entire rotating assembly so first critical speed is at least **[30]<Insert number>** percent greater than fan design speed and at least **[20]<Insert number>** percent greater than maximum AMCA class speed.
11. Fan Drive:
- a. Direct drive, arrangement 4 in accordance with AMCA 99 for single-width, single-inlet fans.
 - b. Adjust wheel width and diameter to match motor speed while providing performance scheduled.
 - c. Fasten fan wheel directly to motor shaft using a key and setscrew as previously specified.
 - d. Construct motor base and pedestal of aluminum or powder-coated carbon steel plate.
 - e. Fan Speed Limitation: Fan speed at design conditions indicated shall not exceed speed on motor nameplate for direct-drive applications. Do not select fans to operate at motor speeds greater than motor nameplate.
12. Protective Screens: Factory furnish and install protective screens on fan inlet and discharge.
- a. **[Expanded metal][or][welded wire]** welded to a **[painted carbon steel][or][stainless steel]** frame.
 - b. Screens shall comply with OSHA requirements.
 - c. Screens shall be constructed of **[painted carbon][or][stainless]** steel.
 - d. Fasten screens to fan frame for easy removal by maintenance personnel.
13. Welding:
- a. Use AWS- or ASME-certified welders to weld materials required by application.
 - b. **[Where indicated on Drawings,][All]**welds shall be continuous full penetration welds.
14. Hardware: Hex-head, high-strength **[carbon steel][or][300 series stainless steel]**.
15. Nameplates:
- a. Construct nameplates and rotation arrows of aluminum or 300 series stainless steel.
 - b. Securely fasten nameplate and rotation arrow to fan housing using pins or sheet metal screws.
 - c. Locate nameplates in a highly visible location on motor side of fan.
 - d. Provide the following information on nameplate: **[Engraved][stamped][or][labeled]**.
 - 1) Manufacturer, address, phone number, and website address.
 - 2) Manufacturer model number.
 - 3) Serial number.
 - 4) Manufacturing date.
 - 5) Fan size.
 - 6) Fan schedule equipment designation (may be listed on a separate nameplate if there is insufficient space).
 - 7) Design airflow.

- 8) Design static pressure.
- 9) Design fan speed.
- 10) AMCA fan class.
- 11) **<Insert requirement>**.

16. Air-Handling Unit Factory Assembly:

- a. Internal Access: Include each fan with internal access from **[downstream][and][upstream]** sides as indicated on Drawings.
- b. Removal and Replacement: Each fan shall be independently removable and replaceable through a removable access panel installed in air-handling unit casing.
- c. Fan Supports:
 - 1) Construct a freestanding and self-supporting structural framework to support each fan individually from and independent of adjacent fans.
 - 2) Construct frame work from aluminum[, **galvanized steel,**][, **painted steel,**] or stainless steel.

K. Housed Centrifugal Fans:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Greenheck Fan Corporation]**
 - b. **[Howden American Fan Company]**
 - c. **[Loren Cook Company]**
 - d. **[New York Blower Company (The)]**
 - e. **[Twin City Fan & Blower]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Greenheck Fan Corporation]**
 - b. **[Howden American Fan Company]**
 - c. **[Loren Cook Company]**
 - d. **[New York Blower Company (The)]**
 - e. **[Twin City Fan & Blower]**
 - f. **<Insert manufacturer's name>**
3. Source Limitations: Obtain fans from single source from single manufacturer.
4. Operating Performance:
 - a. Air-handling unit manufacturer shall account for, and include in, submitted fan selections any static pressure drops associated with unit, and system effect due to fan operating in the air-handling unit.
 - 1) Add additional static pressure to fan scheduled total static pressure.
 - 2) If fan motor horsepower is increased, notify Architect.
 - b. Fans shall have sharply rising pressure characteristics at operating point and stable in operation. Fan horsepower characteristics shall be self-limiting and non-loading.

- c. Fan speed, brake horsepower, and sound power levels indicated are maximum acceptable.
 - d. Motor horsepower, airflow rate, and static pressure are minimum acceptable. Motor horsepower shall be capable of handling maximum horsepower of fan at scheduled speed.
 - e. Fan air performance ratings shall be based on tests in accordance with ASHRAE 51/AMCA 51 and AMCA 210.
 - f. Base fans sound ratings on AMCA 300 and calculation methods in accordance with AMCA 301.
 - g. At a minimum, fans shall have AMCA class indicated on Drawings.
 - 1) Fan operating limits shall be in accordance with AMCA 99 for AMCA class indicated.
 - 2) If AMCA class is not indicated, use AMCA 99 as basis for determining AMCA class.
 - 3) AMCA class selected shall be capable of accommodating a plus 10 percent increase to fan static pressure indicated on Drawings.
 - h. Motor starting torque shall exceed fan speed-torque requirements.
5. Vibration Balance:
- a. Each fan/motor assembly shall be factory balanced to AMCA 204, **[BV-5, Balance Quality Grade G1.0][BV-4, Balance Quality Grade G2.5][BV-3, Balance Quality Grade G6.3][Balance Quality Grade indicated on Drawings]<Insert fan vibration balance requirements>** or better through entire operating speed range from minimum speed to maximum speed. If minimum speed is not indicated on Drawings, assume minimum speed to be **[10][20]<Insert number>** percent of design speed.
 - b. Identify and record each speed and speed range within the fan operating range that could cause potential vibration problems.
 - c. Submit test reports as an information submittal for Project record.
6. Operation and Service Requirements:
- a. Each fan/motor assembly shall be capable of lock-out/tag-out procedure without interrupting operation of other fans in air-handling unit.
 - b. Design and incorporate features to permit safe, rapid, and economical maintenance.
7. Fan Base:
- a. Mount fan, motor, and drive assembly on an open structural base, except where Drawings indicate an inertia base.
 - b. Continuously weld base structural members constructed of **[aluminum][carbon steel][or][stainless steel]**.
 - c. **[Air-handling unit][or][fan]** manufacturer to size and design the fan base construction to withstand the rigors of shipping and rigging.
 - d. Fabricate base with lifting lugs or holes and gusseted brackets to accommodate spring isolators indicated.
8. Fan Housing:
- a. Continuously weld housing constructed of **[aluminum][carbon steel][or][stainless steel]** sheets, plates, and structural shapes.
 - b. Support fan housing and shaft bearings from a rigid structural framework.
 - c. Brace fan housing to prevent vibration and pulsation with external stiffeners to form a rigid housing that is free of operating resonance.
 - d. Extend fan housing side sheets not more than **[1/2 inch (13 mm)]<Insert dimension>** past fan scroll.
 - e. Fan Cut-off: Designed for pressure distribution required by the application.



- f. Fan Blast Area: At least **[80]<Insert number>** percent of fan outlet area.
 - g. Wheel Removal: Construct fan housing for fan wheel(s) removal through the inlet opening when the inlet cone is removed.
 - h. Split Housings: For fans with wheel diameters nominal **[49 inches (1225 mm)]<Insert dimension>** and larger, include diagonally flanged, gasketed and bolted split housings.
 - i. Access Doors: Quick-opening, gasketed, with heavy-duty latches.
 - 1) Conform to housing contour.
 - 2) Locate in 5 o'clock or 7 o'clock position about the end of the shaft and position to gain internal access.
 - 3) Maximize size of square access door up to **[24 inches (600 mm)]<Insert dimension>**.
 - j. Drains: **[NPS 1 (DN 25)]<Insert pipe size>** female NPT threaded half coupling welded to lowest point of fan housing. Position the drain connection to accommodate field-installed drain piping. Include each drain coupling with a stainless steel threaded plug.
 - k. Flanged Discharge Connections: Welded flanged discharge with a matching companion flange having evenly spaced holes for threaded hardware.
 - l. Flanged Inlet Connections: Welded flanged inlet with a matching companion flange having evenly spaced holes for threaded hardware.
9. Fan Inlet and Wheel Cones:
- a. Precision-spun or die-formed, matched inlet and wheel cones with hyperbolic shape to ensure streamlined airflow into the wheel and fully load the blades for efficient aerodynamic performance.
 - b. Inlet cone shall be a single piece, constructed of **[aluminum][carbon steel][or][stainless steel]**.
 - c. Fasten inlet cone to fan housing using bolts, nuts, and washers to provide a positive and secure attachment that can be removed and replaced in the field.
10. Fan Wheel:
- a. Fan blades with true hollow airfoil shape, continuously welded to backplate or centerplate and wheel cone(s).
 - b. Construct blades of **[aluminum][carbon steel][or][stainless steel]**, reinforced for AMCA fan class.
 - c. Design blades to provide smooth and aerodynamic airflow over all surfaces of blade.
 - d. Construct fan hubs of **[cast aluminum][cast iron, ASTM A48/A48M Class 20A and better][or][stainless steel]**, with integral bracing for extra strength and stiffness.
 - 1) Castings shall be sound and free of shrink holes, blow holes, cracks, scale, blisters, or other similar injurious defects.
 - 2) Clean surfaces of castings by blasting, pickling, or other standard method.
 - 3) Mold-parting fins and remains of gates and risers shall be chipped, filed, and ground flush.
 - 4) Design hubs to maintain a high resistance to fatigue and low relative wheel imbalance.
 - e. Key and setscrew hubs to shaft for positive attachment.
 - f. Construct wheel backplates or centerplates of **[aluminum][carbon steel][or][stainless steel]**.
 - g. Statically and dynamically balance fan wheel before fan is assembled.
 - h. Select entire rotating assembly so first critical speed is at least **[30]<Insert number>** percent greater than fan design speed and at least **[20]<Insert number>** percent greater

than maximum AMCA class speed.

11. Fan Shafts:

- a. Fan shaft shall be one piece, solid **[carbon][or][stainless]** steel, accurately turned, ground, polished, and inspected.
- b. Polish shafts at the point of bearing contact to comply with bearing manufacturer's recommended tolerances.
- c. Inspect shafts for straightness after the keyways are cut.
- d. Coat carbon steel shafts with a rust-inhibitive coating.

12. Fan Shaft Bearings:

- a. Fan bearings shall be foot-mounted type, bolted on a rigid welded steel framework that is integral with, or independent of, the housing.
- b. Size bearings for L-10 life of at least **[200,000]<Insert value>** hours, a DN factor less than **[200,000]<Insert value>** and a load factor less than **[2,700,000]<Insert value>** at the maximum fan class load limit horsepower, including belt pull.
- c. Select bearings in accordance with **[ABMA 9][and][or][ABMA 11]**.
- d. Types:
 - 1) Bearings for Fans with Motor Horsepower up to 10 hp (7.5 kW): Single-row ball or spherical bearings, self-aligning, grease lubricated, and housed in a pillow block housing.
 - 2) Bearings for Larger-Size Fans: Double-row spherical, self-aligning, grease lubricated, and housed in a horizontally split pillow block housing.
- e. Grease Fittings:
 - 1) Extend **[copper][or][plastic]** grease lines to an accessible location within sight of bearing for greasing the bearings without removing guards, inlet screens, linkages, and other appurtenances.
 - 2) Terminate bearings and extended grease lines with grease gun fittings.

13. Fan Drives: Fan-drive type, belt or direct, as indicated on Drawings.

a. Direct Drives:

- 1) Double Width, Double Inlet: Arrangement 7 in accordance with AMCA 99.
- 2) Single Width, Single Inlet: Arrangement **[4][or][5]** in accordance with AMCA 99.
- 3) For AMCA arrangements 4 and 5, fasten fan wheel directly to motor shaft using a key and setscrew indicated.
- 4) Construct motor base and pedestal for AMCA arrangement 4 and 7 fans of **[aluminum][carbon steel][stainless steel]** plate.

b. Belt Drives:

- 1) Multiple V-Belt Design:
 - a) Size two belt drives for at least **[2.0]<Insert value>** times the fan motor horsepower.
 - b) Size belt drives with more than two belts, for at least **[1.5]<Insert value>** times the fan motor horsepower.
 - c) Coordinate, with motor manufacturer, the size and location of motor sheave required to satisfy the motor L-10 bearing life using motor manufacturer's written instructions.

- d) Sheave and V-belt selections shall be in accordance with manufacturer's published data.
- 2) Sheaves:
 - a) Constant-Speed Applications: Fixed or variable sheaves for applications up to **[5 hp (4 kW)]<Insert size>** and fixed sheaves for applications with larger horsepower.
 - b) Variable-Speed Applications: Fixed sheaves.
 - c) Profile machined to Mechanical Power Transmission Association Standards.
 - d) Construct sheaves of high-strength cast iron having a minimum tensile strength of **[25,000 psi (172.4 MPa)]<Insert value>**.
 - e) Sheave rim speeds shall not exceed **[5000 fpm (25.4 m/s)]<Insert value>**.
 - f) Sheave side wobble and runout, and eccentricity shall be within Mechanical Power Transmission Association and Rubber Manufacturers Association (RMA) tolerances.
 - g) Balance sheaves to satisfy vibration performance requirements.
 - h) Mount sheaves on the shaft using a taperlock split and keyed bushing or an integral keyed bushing.
- 3) V-Belts:
 - a) V-belts shall be oil resistant, non-static conducting, and high quality in accordance with RMA standards.
 - b) Classic A, B, C, D, and E, non-cogged, cross sections.
 - c) Multiple belt drives shall be a matched set with belt tolerances in accordance with RMA standards.
 - d) Tension belts in accordance with manufacturer's written instructions.
- c. Drive Guards: Furnish and factory install fan drive guard(s) for bearing assemblies, rotating shafts, sheaves, belts, couplings, and heat slingers.
 - 1) Arrangement 3 fans do not require guards for bearings on the side opposite the drive.
 - 2) Make provision for motor and fan rpm measurement without removing the guard.
 - 3) Construct the guard of flattened expanded aluminum or steel wrapped around a channel frame, suitably braced to prevent vibration.
 - 4) Paint guards using the same coating as fan, except color shall be safety yellow.
 - 5) Design attachment to fan for easy removal by maintenance personnel using a clamp and latch.
- 14. Discharge Damper, Counterbalanced Backdraft:
- 15. Performance:
 - a. Velocity and Pressure Rating: Suitable for a face velocity of up to **[4000 fpm (20 m/s)]<Insert value>** and a static pressure differential of **[8.0 inches wg (2000 Pa)]<Insert value>**.
 - b. Leakage: Not to exceed **[15 cfm/sq. ft. (0.66 L/s per sq. m)]<Insert value>** at a static pressure differential of **[1.0 inch wg (250 Pa)]<Insert value>**.
- 16. Construction:
 - a. Frame: Minimum **[10-gauge- (3.6-mm-)]<Insert thickness>** thick, **[galvanized-steel][or][stainless steel]** channel frame. Frame to extend beyond blade in open position.
 - b. Blades: Double-skin airfoil-type parallel blades, constructed of minimum **[18-gauge- (1.3-**

- mm-)]<Insert thickness> thick, [galvanized][or][stainless] steel. Include dividers and bracing to form a rigid framework.
- c. Axles: [Steel][or][stainless steel]; full length of blade and supported by lubricated ball bearings.
17. Mounting:
- a. Mount blade axle linkage [in][or][out] of airstream.
18. Seals:
- a. Blades: EPDM.
- b. Jams: Stainless steel, compression-type seals.
19. Discharge Damper, Motorized: Where indicated on Drawings, furnish fans with factory-installed automatic dampers assembled complete in all respects to functions intended.
- a. Performance:
- 1) Velocity and Pressure Rating: Suitable for a face velocity of at least [5000 fpm (25.4 m/s)]<Insert value> and a static pressure differential of [8.5 inches wg (2125 Pa)]<Insert value>.
 - 2) Leakage: Not to exceed [8 cfm/sq. ft. (0.35 L/s per sq. m)]<Insert value> at a static pressure differential of [4.0 inches wg (1000 Pa)]<Insert value>.
- b. Construction:
- 1) Frame: Minimum [10-gauge- (3.6-mm-)]<Insert thickness> thick, [galvanized-steel][or][stainless steel] channel frame. Frame to extend beyond blade in open position.
 - 2) Blades: Double-skin airfoil-type parallel blades, constructed of minimum [14-gauge- (2.0-mm-)]<Insert thickness> thick, [galvanized][or][stainless] steel. Include dividers and bracing to form a rigid framework.
 - 3) Axles: Each blade with full length axle supported by lubricated ball bearings. Include thrust bearings for dampers mounted in the vertical orientation.
- c. Mounting:
- 1) Mount blade axle linkage out of airstream.
 - 2) Mount damper to fan discharge so damper blades are perpendicular to fan shaft.
 - 3) Configure linkage assembly to interface with single electric actuator.
- d. Seals:
- 1) Blades: EPDM.
 - 2) Jams: Stainless steel, compression-type, double seals. Jamb seal shall use an outer standard width seal and a narrow inner seal for maximum compression and minimum leakage when blade is in closed position.
- e. Damper Electric Actuator:
- 1) Furnish and factory install an electric actuator for each automated fan discharge damper.
 - 2) Mount actuator on damper frame.
 - 3) Construct interconnecting linkages, lever, and brackets of [aluminum][carbon steel][or][stainless steel]. Paint interconnecting linkages, lever, and brackets to

- match the fan coating.
 - 4) Action, either modulating or two position, as indicated on Drawings.
 - 5) Fail-safe operation (open, closed, or last position) as indicated on Drawings.
 - 6) Size actuators to do the following:
 - a) Shut off against fan maximum pressure on fan curve at design speed.
 - b) Operate the damper with sufficient reserve power to provide smooth modulating action or two-position action and proper speed of response at velocity and pressure conditions to which damper is subjected.
 - 7) Actuator to include the following:
 - a) Indicator and graduated scale on each actuator to show open and closed positions at travel limits.
 - b) Adjustable stops for both maximum and minimum positions.
 - 8) Coordinate control interface requirements with external controls to comply with operation indicated.
20. Shaft Seals:
- a. Provide single-width, single-inlet fans with shaft seal(s) where indicated on Drawings.
 - b. Shaft seal(s) shall minimize fan leakage when operating and not operating.
 - c. Construct shaft seal of an aluminum or split stainless steel plate with non-asbestos material fitted under the split metal plate and seated around the shaft.
 - d. Secure split plates to housing using threaded hex-head hardware.
 - e. Shaft seals shall be replaceable from outside the housing without disturbing the shaft or bearings.
 - f. Select shaft seal clearances and materials for operating temperature, pressure, and air quality encountered.
 - g. Shaft seals, including labyrinth, floating bushing, or close clearance annulus, are acceptable alternatives.
21. Protective Screens: Factory furnish and install safety screens on unducted fan inlets and discharge openings.
- a. **[Expanded metal][or][welded wire]** welded to a **[painted carbon steel][or][stainless steel]** frame.
 - b. Screens shall comply with OSHA requirements.
 - c. Screens shall be constructed of **[painted carbon steel][or][stainless steel]**.
 - d. Fasten screens to fan for easy removal by maintenance personnel.
22. Piezometer Ring: Mount at fan inlet cone for airflow measurement.
23. Welding:
- a. Use AWS- or ASME-certified welders to weld materials required by application.
 - b. **[Where indicated on Drawings,][All]**welds shall be continuous full-penetration welds.
24. Hardware: Hex-head, high-strength **[carbon steel][or][Type 304 or Type 316 stainless steel]**.
25. Nameplates:
- a. Construct nameplates and rotation arrows of aluminum or 300 series stainless steel.
 - b. Securely fasten nameplate and rotation arrow to fan housing using pins or sheet metal screws.
 - c. Locate nameplates in a highly visible location on motor side of fan.

- d. Provide the following information on nameplate: **[Engraved][stamped][or][labeled]**.
 - 1) Manufacturer, address, phone number, and website address.
 - 2) Manufacturer model number.
 - 3) Serial number.
 - 4) Manufacturing date.
 - 5) Fan size.
 - 6) Fan schedule equipment designation (may be listed on a separate nameplate if there is insufficient space).
 - 7) Design airflow.
 - 8) Design static pressure.
 - 9) Design fan speed.
 - 10) AMCA fan class.
 - 11) **<Insert requirement>**.
26. Special Fan Construction: Where indicated on Drawings, construct individual fans with the following additional features.
- a. Spark-Resistant Construction: Construct fans in accordance with AMCA 99 **[Type A][Type B][Type C]** spark-resistant construction **[where indicated on Drawings]**.
 - b. Heat Slinger: Provide for fans handling air with temperatures exceeding **[150 deg F (65 deg C)]<Insert temperature>**.
 - 1) Cast aluminum, split-design, internally-finned rotor to create a strong circulation of air over the shaft and inboard bearing, and reduce heat conduction along the shaft to bearings.
 - 2) Secure the split halves together using at least two stainless steel bolts and use a setscrew to secure the assembly to fan shaft.
 - c. Corrosion-Resistant Coating:
 - 1) Baked phenolic, **[equal to Heresite's "P-4403 Brown Baked Phenolic Coating."]<Insert manufacturer's name and product name or designation.>**
 - 2) Total Dry Film Thickness: **[7]<Insert value>** mils.
 - 3) Application in accordance with manufacturer's written instructions and the following:
 - a) Mist bonding pass and allow to flash off for several minutes, but not long enough to allow film to completely dry.
 - b) Not less than three crisscross multipasses maintaining a wet-appearing film.
 - c) Air dry approximately 45 to 60 minutes with ventilation before applying heat.
 - d) After air dry period has elapsed, raise temperature in recommended increments of 30 minutes until desired temperature is reached.
 - e) Bake intermediate coats at approximately half the final temperature for 10 to 20 minutes.
 - f) Final Bake: **[400 deg F (205 deg C)]<Insert temperature>** for 1-1/2 hours.
 - d. **<Insert requirements>**.
27. Air-Handling Unit Factory Assembly:
- a. Internal Access: Include each fan with internal access from **[downstream][and][upstream]** sides as indicated on Drawings.
 - b. Removal and Replacement: Each fan shall be independently removable and replaceable through a removable access panel installed in air-handling unit casing.
 - c. Fan Supports:

- 1) Construct a freestanding and self-supporting structural framework to support each fan individually from and independent of adjacent fans.
- 2) Construct frame work from aluminum[, **galvanized steel**][, **painted steel**,] or stainless steel.

L. Fan Motors:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Baldor Electric Company]**
 - b. **[Emerson Electric Company]**
 - c. **[Regal Beloit (Genteq)]**
 - d. **[Siemens Industry, Inc., Building Technologies Division]**
 - e. **[Toshiba International Corporation]**
 - f. **[US Motors; Nidec Motor Corporation; Nidec Corporation]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Baldor Electric Company]**
 - b. **[Emerson Electric Company]**
 - c. **[Regal Beloit (Genteq)]**
 - d. **[Siemens Industry, Inc., Building Technologies Division]**
 - e. **[Toshiba International Corporation]**
 - f. **[US Motors; Nidec Motor Corporation; Nidec Corporation]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Obtain motors from single source from single manufacturer.
4. Standard: Comply with NEMA MG 1 unless more stringent requirements are indicated.
5. Description: NEMA MG 1, **[Design B]<Insert design>**, as required to comply with capacity and torque characteristics; medium-induction motor.
 - a. Performance:
 - 1) Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
 - 2) Efficiency: NEMA Premium Efficiency rating complying with NEMA MG 1.
 - 3) Motor Horsepower: Minimum size as indicated on Drawings. Motor shall operate fan under all conditions indicated without exceeding motor nameplate and without use of motor service factor.
 - 4) Inverter-Duty Rating: Comply with minimum requirements of Class F or Class H insulation, suitable for "inverter-duty" or "drive-duty" applications in accordance with NEMA MG 1. Motor operation through a variable-frequency controller shall not adversely affect the motor performance, operation, useful life, and warranty.
 - 5) Service Factor: **[1.15]<Insert value>**.
 - 6) Temperature Rise: **[Match][One class lower than]<Insert requirements>** insulation rating.

6. Enclosure Type: **[See Drawings for motor enclosure type][ODP][or][TEFC]**.
7. Shaft Grounding System:
 - a. Shaft grounding system to protect bearings from induced voltage.
 - b. Shaft grounding system shall have low drag (less than 0.05 percent of motor horsepower), and shall operate for a minimum of three years without periodic maintenance or adjustments.
 - c. Mounting: External **[or internal]**to motor enclosure.
8. Frame:
 - a. Frames with integrally cast feet unless other requirements of driven equipment require a different arrangement.
 - b. Frame, front and back end brackets, and front and back end bearing intercaps constructed of cast iron, ASTM A48/A48M, Class 25 or better.
9. Rotor:
 - a. Fabricate rotor frame from die-cast aluminum, copper, or associated alloys.
 - b. Key rotors to motor shaft.
 - c. Rotating assembly shall be dynamically balanced to within limits defined in NEMA MG 1.
 - d. Motors shall have the entire rotating assembly between bearing inner caps coated with a corrosion-resistant coating.
10. Stator:
 - a. Copper windings shall be spike resistant to withstand 1600 peak V.
 - b. Entire wound and insulated stator coated with a coating to protect against moisture and corrosion.
11. Shaft:
 - a. Solid shaft fabricated of **[carbon][Type 304 stainless][Type 316 stainless][Type 416 stainless]** steel, accurately turned, ground and polished, and inspected for accuracy.
 - b. End of shaft with drilled hole for use in field measurements.
12. Bearings:
 - a. Grease-lubricated ball or roller bearings.
 - b. ABMA 11 L-10 motor bearing life of **[100,000]<Insert value>** hours.
 - c. Bearing Lubrication:
 - 1) Factory lubricate motor bearings using a premium moisture-resistant polyurea thickened grease with rust inhibitors suitable for extreme operating temperatures encountered.
 - 2) Coordinate special requirements that may impact lubrication and include appropriate lubrication.
13. Grease Fittings:
 - a. Equip each bearing housing with an easily accessible grease inlet.
 - b. Fit grease inlets with a grease fitting and protective fitting cap.
 - c. Equip inlets with an automatic grease relief fitting to prevent excessive greasing.
 - d. Equip each bearing housing with grease drain and threaded plug.
14. Conduit Box:

- a. Material same as frame.
 - b. For motor frames 365T and below, furnish conduit boxes sized with internal volumes in accordance with NEMA MG 1.
 - c. For motor frames larger than 365T, furnish conduit boxes one size larger than NEMA MG 1.
 - d. Coordinate the location and mounting of conduit box with driven equipment manufacturer.
 - e. Factory mount conduit box on motor.
15. Grounding: NRTL-listed clamp-type grounding lug mounted in conduit box.
16. Motor Leads:
- a. Non-wicking type, Class F temperature rating or better and permanently numbered over entire length for identification.
 - b. Lead terminals shall be manufacturer's standard.
17. Condensate Drains:
- a. Motor with drain holes at the lowest point for drainage of condensate.
 - b. Each drain hole with a threaded removable plug.
18. TEFC Motor Fans: Corrosion-resistant construction, non-sparking, metallic or non-metallic, bi-directional, and keyed to shaft.
- a. Motor Fan Cover: **[Steel][Same material as frame]**.
19. Hardware: Hex-head, high-strength, zinc-plated carbon steel or stainless steel.
20. Lifting Eyebolts: Eyebolt threaded into frame receptacle and design to prevent moisture and other foreign material from entering motor cavity when eyebolt is removed.
21. Nameplates:
- a. Construct nameplates of aluminum or stainless steel and attach to motor frame with aluminum, stainless steel, or brass drive pins.
 - b. Engrave or stamp data on the nameplate.
 - c. At a minimum, include nameplate data in accordance with NEMA MG 1. **[Also include ABMA bearing designation for the drive and opposite end bearing.]**
22. Paint: Successfully pass **[500][1000][2000]<Insert value>**-hour salt spray test for corrosion in accordance with ASTM B117.
- M. Vibration Isolation:
1. General:
- a. Provide fans inside air-handling units with base and vibration isolation indicated on Drawings.
2. Inertia Bases:
- a. Description: Reinforced structural base designed for concrete infill with integral bolting provisions for fan mounting.
 - b. Design and Performance:
 - 1) Weight of inertia base including concrete infill a minimum of 1.5 times the operating weight of fan.
 - 2) Base thickness not less than 1/12 of longest span.

- 3) Minimum base thickness is as follows:
 - a) Up to 15 HP (11 kW): **[6 inches (150 mm)]<Insert thickness>**.
 - b) 20 to 50 HP (15 to 37 kW): **[8 inches (200 mm)]<Insert thickness>**.
 - c) 60 to 75 HP (45 to 56 kW): **[10 inches (250 mm)]<Insert thickness>**.
 - d) 100 HP (75 kW) and Larger: **[12 inches (300 mm)]<Insert thickness>**.
- c. Construction:
 - 1) Base Materials: **[Structural carbon steel, ASTM A36/A36M][structural stainless steel, ASTM A276/A276M, Type 304L][or][structural stainless steel, ASTM A276/A276M, Type 316L]**.
 - a) Carbon Steel Finish, Mill Galvanized: Mill-galvanized carbon steel bases with weld-damaged areas cleaned, prepared, and painted with galvanized paint after fabrication.
 - b) Carbon Steel Base Finish: Carbon steel bases cleaned in accordance with SSPC SP-1, **[SSPC SP-6/NACE No. 3][SSPC SP-10/NACE No. 5]** and **[painted][or][hot-dip galvanized]** after fabrication.
 - 2) Base Structural Members:
 - a) Perimeter Members: **[Channel][I or W beam shapes][or][tube]**.
 - b) Intermediate Members (Spanning Full-Width Base): **[Channel][or][I or W beam shapes][or][tube]**.
 - c) Cross Members (Spanning Intermediate Members): **[Angle][channel][or][tube]**.
 - 3) Reinforcing Bars: Carbon steel, ASTM A615/A615M, sized for a maximum stress of **20,000 psi (138 000 kPa)** when subjected to both static and dynamic loads, and welded in place.
 - 4) Floor: Design inertia base with solid floor in bottom for concrete placement after base installation. Seal to prevent leakage or seepage.
 - a) Galvanized-Steel Solid Sheet: ASTM A653/A653M; **[G90 (Z275)]<Insert coating>** coating, minimum (nominal) **[18 gauge (1.3 mm)][16 gauge (1.6 mm)]<Insert value>** thick.
 - b) Stainless Steel Solid Sheet: ASTM A240/A240M or ASTM A480/A480M; **[Type 304][Type 304L][Type 316][Type 316L]<Insert type>**; No. **[2D][4]<Insert finish>** finish; minimum (nominal) **[18 gauge (1.3 mm)][16 gauge (1.6 mm)]<Insert value>** thick.
 - 5) Isolator Brackets: Gusseted, height-saving brackets.
 - 6) Welding Filler Metals: Comply with AWS welding codes for welding materials appropriate for thickness and chemical analysis of material being welded.
- d. Air-Handling Unit Factory Assembly: Install fans with inertia bases where indicated on Drawings.
 - 1) Coordinate placement of inertia bases with design of air-handling unit structural base. Make provisions for attachment and support.
 - 2) Coordinate inertia base mounting provisions with spring isolators.

3. Spring Isolators:

a. Performance:

- 1) Deflection: Minimum deflection indicated on Drawings. Use a greater deflection if required to maintain an isolator efficiency of at least **[98]<Insert number>** percent under all operating conditions encountered. Calculate isolator efficiency using actual support conditions considering the rigidity of structure.
 - 2) Laterally stable freestanding open-spring mounting.
 - 3) Spring diameter not less than 0.8 of compressed spring height at rated load and in the installed and operating condition.
 - 4) Reserve travel to solid shall be equal to a minimum of 50 percent of rated deflection and in no case less than 25 percent of rated deflection in an installed and operating condition.
 - 5) Ratio of horizontal stiffness to vertical stiffness equal to approximately one.
 - 6) Design and install so that ends of springs remain parallel.
 - 7) Select springs that are non-resonant with equipment related frequencies and natural frequencies of support structure.
 - 8) Springs shall not take a permanent set when compressed to coil bind.
 - 9) Seismic restraints to limit motion under seismic forces to **[1/4 inch (6 mm)]<Insert dimension>**.
- b. Construction:
- 1) Coat springs with PVC or neoprene. Color-code springs to allow positive identification after installation.
 - 2) Construct baseplates, spring retainers, and other components of **[aluminum][galvanized carbon steel][or][stainless steel]**. Etch and paint aluminum components.
 - 3) Use nuts, bolts, and washers and other associated hardware constructed of **[zinc-electroplated carbon steel][or][stainless steel]**.
 - 4) Isolators with integral leveling bolts.
 - 5) Baseplates with holes and isolation grommets for bolting.
 - 6) Bond nominal **[1/4-inch- (6-mm-)]<Insert dimension>** thick, neoprene friction pad to baseplate.
4. Thrust Restraints:
- a. In sets of two or more, thrust restraints shall consist of springs in series with neoprene isolators.
 - b. Coordinate and select deflection of thrust restrains with equipment being restrained.
 - c. Thrust restraints complete with rods and adjustment nuts, plus angle brackets and backing plates for attachment to substrate and equipment being restrained.
5. Elastomeric Grommets:
- a. Elastomeric grommets shall be a combination of neoprene washer and bushing.
 - b. Elastomer shall be 56-durometer maximum.
 - c. Grommets formed to prevent bolts from directly contacting the secured item.
6. Flexible Connections:
- a. Construct flexible connection **[galvanized-steel][or][stainless steel]** edges firmly attached to waterproof and fire-retardant fabric.
 - b. Fabric shall be **[6 inches (150 mm)]<Insert dimension>** wide or more.
 - c. Suitable for operation in extreme temperatures encountered.
 - d. NRTL listed for application and complying with NFPA 90A.
7. Air-Handling Unit Factory Assembly:

- a. Use precompression -type height-saving brackets with isolators having [2-1/2 inch (65-mm)]<Insert dimension> deflection or greater, to limit exposed bolt length.
- b. Install spring isolators plumb and adjust isolators that are not plumb under operating conditions to make plumb.
- c. Adjust isolators to prevent stress transfer to equipment.
- d. Verify that installed isolators and mounting systems permit equipment motion in all directions.
- e. Restraint fans with isolated thrust resistors to limit displacement to [1/4 inch (6 mm)]<Insert dimension>. Design for the maximum lateral thrust the fan can develop.
- f. Adjust or include additional resilient restraints to flexibly limit fan lateral motion to [1/4 inch (6 mm)]<Insert dimension> during startup and operation of equipment.
- g. Anchor restraints to fixed supports having a stiffness greater than the thrust encountered.
- h. Include at least [2-inch (50-mm)]<Insert dimension> operating clearance between fan bases and walking surface of air-handling unit floor. Before startup, clean out foreign matter between bases and equipment to prevent short circuit.
- i. Flexible Connections:
 - 1) Install flexible connections at connections to fans.
 - 2) Install flexible connections in accordance with SMACNA standards and manufacturer's written instructions.
 - 3) Make fabric joints on the flat run, not the corners, with overlap to provide an area sufficient to make a positive seal.
 - 4) Apply adhesive between fabric layers.
 - 5) Attach connections using screws or bolts.
 - 6) Reinforce fabric if required to keep fabric from collapsing and impacting airflow into fan.

N. Hydronic Coils:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Aerofin]
 - b. [Coilmaster Corporation]
 - c. [Modine Manufacturing Company]
 - d. [Super Radiator Coils]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Aerofin]
 - b. [Coilmaster Corporation]
 - c. [Modine Manufacturing Company]
 - d. [Super Radiator Coils]
 - e. <Insert manufacturer's name>
3. Sourcing Option: In lieu of sourcing hydronic coils from a specialty coil manufacturer, air-handling unit manufacturer has option to furnish in-house hydronic coils that achieve equal or better performance while complying with other requirements indicated.
4. General: Provide air-handling units with hydronic coils where indicated on Drawings.
5. Description: Plate fin coils constructed of staggered tubes mechanically expanded into continuous collars that are die formed into plate fins.

6. Design and Performance:
- a. Capacities, face area, and number of rows indicated on Drawings are minimum acceptable.
 - b. Air pressure drop, water pressure drop, fin spacing, and face velocity indicated on Drawings are the maximum acceptable.
 - c. Coils shall be counterflow design, air to fluid. Fluid supply shall enter air leaving side of coil and exit air entering side.
 - d. Design coils to be drainable.
 - 1) Coils shall have all circuits drainable when coils are installed in horizontal position and level.
 - 2) Coil supply **[and return]**header shall be furnished with a drain connection at lowest point on header.
 - e. Design coils to be self-venting.
 - 1) Supply connection near bottom of supply header.
 - 2) Return connection near top of return header.
 - 3) Furnish coil return **[and supply]**header with a vent connection at highest point on header.
 - f. Coils supply and return piping connections on same end of coil.
 - g. Coils shall be rated for system operating pressures and temperatures encountered by installation, but not less than **[200 psig (1379 kPa)][300 psig (2069 kPa)]<Insert pressure>**.
 - h. Coil selection criteria, unless otherwise indicated on Drawings, are as follows:
 - 1) Face Velocity: Maximum of **[500 fpm (2.5 m/s)]<Insert value>**.
 - 2) Fluid Tube Velocity (at Design Flow Rate):
 - a) Maximum: **[6 fps (1.8 m/s)]<Insert velocity>**.
 - b) Minimum: **[3 fps (0.9 m/s)]<Insert velocity>**.
 - 3) Fluid Header Velocity: Maximum of **[6 fps (1.8 m/s)]<Insert velocity>**.
 - a) Fin Height: Maximum of **[48 inches (1200 mm)]<Insert dimension>**.
 - b) Fin Spacing: Maximum of **[12 fins per inch (2.1 mm)]<Insert spacing>**.
 - i. Cooling coils shall have no moisture carryover at design conditions. Install moisture eliminators on discharge face of coil if it is necessary to eliminate moisture carryover.
7. Casing and Tube Sheets:
- a. Depth: Extend coil casing and tube sheets a minimum of **[1/2 inch (13 mm)]<Insert dimension>** beyond face of fins on both entering and leaving side.
 - b. Casing and Tube Sheet Materials:
 - 1) Cooling Coils: Stainless steel, ASTM A240/A240M or ASTM A480/A480M, **[Type 304L][or][Type 316L]**, No. 2D finish.
 - 2) Heating Coils:
 - a) Stainless steel, ASTM A240/A240M or ASTM A480/A480M, **[Type 304L][or][Type 316L]**, No. 2D finish.
 - b) Galvanized steel, ASTM A653/A653M, **G90 (Z275)** coating.

- c. Top and Bottom Casings:
 - 1) Flange face minimum of [1-1/2 inches (68 mm)]<Insert dimension>; double flange edge for rigidity and ease of removal with secondary flange face minimum of [1/2 inch (13 mm)]<Insert dimension>.
 - 2) Thickness:
 - a) Coils with Fin Length of up to [72 Inches (1800 mm)]<Insert dimension>: Minimum of [16 gauge (1.6 mm)][14 gauge (2.0 mm)][12 gauge (2.8 mm)] thick.
 - b) Coils with Fin Length Exceeding [72 Inches (1800 mm)]<Insert dimension>: Minimum of [16 gauge (1.6 mm)][14 gauge (2.0 mm)][12 gauge (2.8 mm)] thick.
 - d. End Tube Sheets:
 - 1) Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.
 - 2) Flange face minimum of [1-1/2 inches (68 mm)]<Insert dimension>.
 - 3) Thickness: Minimum of [16 gauge (1.6 mm)][14 gauge (2.0 mm)][12 gauge (2.8 mm)] thick.
 - e. Intermediate Tube Sheets:
 - 1) Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.
 - 2) Space intermediate tube sheets a maximum of [48 inches (1200 mm)]<Insert dimension> o.c. and locate to provide equal spacing between tube sheet across coil tube length.
 - 3) Flange face minimum of [1/2 inch (13 mm)]<Insert dimension>.
 - 4) Thickness: Minimum of [16 gauge (1.6 mm)]<Insert thickness> thick.
 - f. Holes: Include number, size, and location of holes in casing and end tube sheets required for coil installation.
8. Fins:
- a. Materials:
 - 1) Aluminum: [0.0060 inch (0.15 mm)][0.0075 inch (0.19 mm)][0.0095 inch (0.24 mm)]<Insert dimension> thick.
 - 2) Copper: [0.0060 inch (0.15 mm)][0.0075 inch (0.19 mm)][0.0095 inch (0.24 mm)]<Insert dimension> thick.
 - 3) 90/10 Cupronickel: [0.0060 inch (0.15 mm)][0.0075 inch (0.19 mm)][0.0095 inch (0.24 mm)]<Insert dimension> thick.
 - b. Collars: Full collars for accurate fin spacing and maximum tube contact while leaving no surface of tube exposed.
 - c. Fin Configuration: [Flat face fins without ripples][Flat face or enhanced ripple fins as required by performance].
9. Headers:
- a. Construct header of seamless copper, ASTM B75/B75M drawn temper of diameter and wall thickness based on coil size, flow rate, design pressure, design temperature, and circuiting.



- b. Tube-to Header Connections: Tube-to-header holes shall intrude inward so landed surface area is three times the core tube thickness, to provide enhanced header to tube joint integrity. Tubes shall evenly extend within the ID of the header no more than **0.12 inch (3 mm)**.
 - c. Header Top and Bottom Caps: End caps shall be die-formed and installed on the ID of header such that the landed surface area is three times the header wall thickness.
 - d. Drains: Include low point of **[supply][supply and return]** header with a **[NPS 1/2 (DN 13)]<Insert pipe size>** drain connection. Extend copper or **[red brass][carbon steel][stainless steel]<Insert material>** pipe through air-handling unit casing and terminate end with male national pipe threads (MNPT). Pipe shall be threaded on both ends to facilitate easy field removal and replacement.
 - e. Vents: Include high point of **[return][supply and return]** header with a **[NPS 1/2 (DN 13)]<Insert pipe size>** vent connection. Extend copper or **[red brass][carbon steel][stainless steel]<Insert material>** pipe through air-handling unit casing and terminate end with MNPT. Pipe shall be threaded on both ends to facilitate easy field removal and replacement.
 - f. Supply and Return Connections:
 - 1) Terminate ends with MNPT.
 - 2) Connections to header shall be either copper tube with brazed ASME B16.18 threaded male adapters or **[red brass][carbon steel][stainless steel]<Insert material>** pipe with machine-threaded MNPT connections. Pipe shall extend through air-handling unit casing and be threaded on both ends to facilitate easy field removal and replacement.
 - 3) Connections **[NPS 2-1/2 (DN 65)]<Insert pipe size>** and larger shall have a bronze ASME 16.24 threaded flanges attached to threaded connections to provide for a flanged field connection. Select flange class, Class 150 or Class 300, for system pressure and temperature encountered.
 - g. Protect openings of supply, return, vent, and drain connections with a threaded cap to prevent entry of dirt into the coil.
10. Tubes:
- a. Material: Copper, ASTM B75/B75M annealed temper or ASTM B280 drawn temper; **[90/10 cupronickel alloy, ASTM B122/B122M]**.
 - b. Tube Nominal Diameter: **1/2 or 5/8 inch (13 or 16 mm)** before expanding, selected to provide performance indicated.
 - c. Tube Nominal Wall Thickness: As required by performance, minimum of **[0.020 inch (0.5 mm)][0.025 inch (0.6 mm)][0.035 inch (0.9 mm)]<Insert dimension>** thick.
11. Tube Return Bends: 180-degree bends brazed to tubes; material[, **wall thickness,**] and nominal diameter to match tubes.
- a. Tube Return Bend Nominal Wall Thickness: As required by performance, minimum of **[0.020 inch (0.5 mm)][0.025 inch (0.6 mm)][0.035 inch (0.9 mm)]<Insert dimension>** thick.
12. Brazing: High-temperature brazing alloy with not less than 5 percent silver when brazing like non-ferrous materials together and more than 30 percent silver when brazing ferrous to non-ferrous materials.
13. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating. See Drawings for coils requiring a corrosion-resistant coating.
14. Coatings: Where indicated on Drawings, coat coils with one of the following coatings for additional corrosion protection:

- a. Baked phenolic.
 - b. Cathodic epoxy.
 - c. Water-based flexible epoxy polymer.
 - d. Water-based synthetic flexible polymer.
 - e. **<Insert coating type>**.
15. Hardware: Use hex-head bolts, nuts, and washers constructed of **[Type 304][or][Type 316]** stainless steel.
16. Nameplate: Aluminum or stainless steel nameplate with brass or stainless steel chain for each coil, with the following data engraved or embossed:
 - a. Manufacturer name, address, telephone number, and website address.
 - b. Manufacturer model number.
 - c. Serial number.
 - d. Manufacturing date.
 - e. Coil identification (indicated on Drawings).
 - f. Coil fin length.
 - g. Coil fin height.
 - h. Coil weight with fluid/without fluid.
 - i. Coil casing material and thickness.
 - j. Coil fin material and thickness.
 - k. Coil tube material and thickness.
 - l. Coil header material and thickness.
 - m. **<Insert requirements>**.
17. Cleaning: Residual manufacturing oils and solid contaminants shall be removed internally and externally by completely submersing the coil in an environmentally acceptable degreasing solution that is chemically compatible with the coil material.
18. Air-Handling Unit Factory Assembly:
 - a. Coil Connections: Extend each coil connection through casing access panel and terminate connections, approximately **[4 inches (100 mm)]<Insert dimension>** beyond exterior face of access panel, and seal each penetration as indicated. Casing access panels shall be removed and reinstalled with coils installed inside air-handling units.
 - b. Internal Access: Include each coil with internal access from **[downstream][and][upstream]** sides as indicated on Drawings.
 - c. Removal and Replacement: Each coil shall be independently removable and replaceable through a removable access panel installed in air-handling unit casing.
 - d. Supports for Coils:
 - 1) Construct a freestanding and self-supporting structural framework to support each coil individually from and independent of adjacent coils.
 - 2) Construct framework for cooling coils, from aluminum or stainless steel **[structural shapes]**.
 - 3) Construct frame work for heating coils from aluminum[, **galvanized steel,**] or stainless steel **[structural shapes]**.
- O. Refrigerant Coils:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Aerofin]**
 - b. **[Coilmaster Corporation]**

- c. **[Modine Manufacturing Company]**
 - d. **[Super Radiator Coils]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Aerofin]**
 - b. **[Coilmaster Corporation]**
 - c. **[Modine Manufacturing Company]**
 - d. **[Super Radiator Coils]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain coils from single source from single manufacturer.
4. General: Provide air-handling units with refrigerant coils where indicated on Drawings.
5. Description: Plate fin coils constructed of staggered tubes mechanically expanded into continuous collars that are die formed into plate fins. Coils shall be counterflow circuited and equipped with pressure-type distributors. Distributor tubes shall be of equal length to ensure equal distribution of refrigerant to each circuit.
6. Circuiting: **[Face][Row][Interlaced][Interlaced and face control][Indicated on Drawings]<Insert circuiting type>**.
7. Performance:
 - a. Capacities, face area, and number of rows indicated on Drawings are minimum acceptable.
 - b. Air pressure drop, fin spacing, and face velocity indicated on Drawings are the maximum acceptable.
 - c. Rate coils in accordance with AHRI 410 when tested in accordance with ASHRAE 33.
 - d. Coil performance variables and selection procedures shall be in accordance with AHRI 410.
 - e. Coils piping connections on same end of coil.
 - f. Coils shall be rated for system operating flows, pressures, and temperatures encountered by installation.
 - g. Coil selection criteria, unless otherwise indicated on Drawings, are as follows:
 - 1) Face Velocity: Maximum of **[500 fpm (2.5 m/s)]<Insert value>**.
 - 2) Fin Height: Maximum of **[48 inches (1200 mm)]<Insert dimension>**.
 - 3) Fin Spacing: Maximum of **[12 fins per inch (2.1 mm)]<Insert spacing>**.
 - h. Cooling coils shall have no moisture carryover at design conditions. Install moisture eliminators on discharge face of coil if it is necessary to eliminate moisture carryover.
8. Casing and Tube Sheets:
 - a. Depth: Extend coil casing and tube sheets a minimum of **[1/2 inch (13 mm)]<Insert dimension>** beyond face of fins on both entering and leaving side.
 - b. Casing and Tube Sheet Materials: Stainless steel, ASTM A240/A240M or ASTM A480/A480M, **[Type 304L][or][Type 316L]**, No. 2D finish.
 - c. Top and Bottom Casings:
 - 1) Flange face minimum of **[1-1/2 inches (68 mm)]<Insert dimension>**; double flange edge for rigidity and ease of removal with secondary flange face minimum of **[1/2 inch (13 mm)]<Insert dimension>**.
 - 2) Thickness: Minimum of **[16 gauge (1.6 mm)][14 gauge (2.0 mm)][12 gauge (2.8**

mm)] thick.

d. End Tube Sheets:

- 1) Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.
- 2) Flange face minimum of [1-1/2 inches (68 mm)]<Insert dimension>.
- 3) Thickness: Minimum of [16 gauge (1.6 mm)][14 gauge (2.0 mm)][12 gauge (2.8 mm)] thick.

e. Intermediate Tube Sheets:

- 1) Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.
- 2) Space intermediate tube sheets a maximum of [48 inches (1200 mm)]<Insert dimension> o.c. and locate to provide equal spacing between tube sheet across coil tube length.
- 3) Flange face minimum of [1/2 inch (13 mm)]<Insert dimension>.
- 4) Thickness: Minimum of [16 gauge (1.6 mm)]<Insert thickness> thick.

f. Holes: Include number, size, and location of holes in casing and end tube sheets required for coil installation.

9. Fins:

- a. Collars: Full collars for accurate fin spacing and maximum tube contact while leaving no surface of tube exposed.
- b. Configuration: [Flat face fins without ripples][Flat face or enhanced ripple fins as required by performance].
- c. Materials:
 - 1) Aluminum: [0.0060 inch (0.15 mm)][0.0075 inch (0.19 mm)][0.0095 inch (0.24 mm)]<Insert dimension> thick.
 - 2) Copper: [0.0060 inch (0.15 mm)][0.0075 inch (0.19 mm)][0.0095 inch (0.24 mm)]<Insert dimension> thick.
 - 3) 90/10 Cupronickel: [0.0060 inch (0.15 mm)][0.0075 inch (0.19 mm)][0.0095 inch (0.24 mm)]<Insert dimension> thick.

10. Headers:

- a. Construct header of seamless copper, ASTM B75/B75M drawn temper of diameter and wall thickness based on coil size, flow rate, design pressure, design temperature, and circuiting.
- b. Tube-to-Header Connections: Tube-to-header holes shall intrude inward so landed surface area is three times the core tube thickness to provide enhanced header to tube joint integrity. Tubes shall evenly extend within the ID of the header no more than 0.12 inch (3 mm).
- c. Header Top and Bottom Caps: End caps shall be die-formed and installed on the ID of header such that the landed surface area is three times the header wall thickness.
- d. Protect openings to prevent entry of dirt into the coil.

11. Tubes:

- a. Material: Copper, ASTM B75/B75M annealed temper or ASTM B280 drawn temper.
- b. Tube Nominal Diameter: Selected for performance indicated.
- c. Tube Nominal Wall Thickness: As required by performance, minimum of [0.020 inch (0.5

mm)][0.025 inch (0.6 mm)][0.035 inch (0.9 mm)]<Insert dimension> thick.

12. Tube Return Bends: 180-degree bends brazed to tubes; material, wall thickness, and nominal diameter to match tubes.
13. Brazing: High-temperature brazing alloy with not less than 5 percent silver.
14. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating. See Drawings for coils requiring a corrosion-resistant coating.
15. Coatings: Where indicated on Drawings, coat coils with one of the following coatings for additional corrosion protection:
 - a. Baked phenolic.
 - b. Cathodic epoxy.
 - c. Water-based flexible epoxy polymer.
 - d. Water-based synthetic flexible polymer.
 - e. <Insert coating type>.
16. Hardware: Use hex-head bolts, nuts, and washers constructed of [Type 304][or][Type 316] stainless steel.
17. Nameplates: Aluminum or stainless steel nameplate with brass or stainless steel chain for each coil, with the following data engraved or embossed:
 - a. Manufacturer name, address, telephone number, and website address.
 - b. Manufacturer model number.
 - c. Serial number.
 - d. Manufacturing date.
 - e. Coil identification (indicated on Drawings).
 - f. Coil fin length.
 - g. Coil fin height.
 - h. Coil weight.
 - i. Coil casing material and thickness.
 - j. Coil fin material and thickness.
 - k. Coil tube material and thickness.
 - l. Coil header material and thickness.
 - m. <Insert requirements>.
18. Cleaning: Residual manufacturing oils and solid contaminants shall be removed internally and externally by completely submersing the coil in an environmentally acceptable degreasing solution that is chemically compatible with the coil material.
19. Air-Handling Unit Factory Assembly:
 - a. Coil Connections: Extend each coil connection through casing access panel and terminate connections, approximately [4 inches (100 mm)]<Insert distance> beyond exterior face of the access panel, and seal each penetration as indicated. Casing access panels shall be removed and reinstalled with coils installed inside air-handling units.
 - b. Internal Access: Provide each coil with internal access from [downstream][and][upstream] sides as indicated on Drawings.
 - c. Removal and Replacement: Each coil shall be independently removable and replaceable through a removable access panel installed in air-handling unit casing.
 - d. Supports for Coils:
 - 1) Construct a freestanding and self-supporting structural framework to support each coil individually from and independent of adjacent coils.
 - 2) Construct framework for cooling from aluminum or stainless steel[structural shapes].

P. Steam Coils:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Aerofin]**
 - b. **[Coilmaster Corporation]**
 - c. **[Modine Manufacturing Company]**
 - d. **[Super Radiator Coils]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Aerofin]**
 - b. **[Coilmaster Corporation]**
 - c. **[Modine Manufacturing Company]**
 - d. **[Super Radiator Coils]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain coils from single source from single manufacturer.
4. General: Provide air-handling units with refrigerant coils where indicated on Drawings.
5. Description: Plate fin coils constructed of tubes mechanically expanded into continuous collars that are die formed into plate fins and specially designed for thermal expansion and contraction of the tubes during coil operation.
 - a. Distributing-type steam coils of a tube-in-tube design for uniform steam distribution along the entire length of each tube to ensure a consistent temperature rise across the full coil face and accelerate condensate removal.
 - b. Non-distributing-type steam coils of a single tube design for uniform steam distribution across the entire header and each tube.
6. Design and Performance:
 - a. Capacities, face area, and number of rows indicated on Drawings are minimum acceptable.
 - b. Air pressure drop, fin spacing, and face velocity indicated on Drawings are the maximum acceptable.
 - c. Design coils to be drainable.
 - 1) Coils shall have all circuits drainable when coils are installed in horizontal position and level.
 - 2) Coil headers shall be furnished with a drain connection at lowest point on header.
 - d. Vents: Vent connection at highest point on header.
 - e. Coils supply and return piping connections on same end of coil.
 - f. Coils shall be rated for system operating pressures and temperatures encountered by installation, but not less than **<Insert pressure>**.
 - g. Coil selection criteria, unless otherwise indicated on Drawings, are as follows:
 - 1) Face Velocity: Maximum of **[500 fpm (2.5 m/s)]<Insert value>**.
 - 2) Fin Height: Maximum of **[48 inches (1200 mm)]<Insert dimension>**.
 - 3) Fin Spacing: Maximum of **[12 fins per inch (2.1 mm)]<Insert spacing>**.

7. Casing and Tube Sheets:

- a. Depth: Extend coil casing and tube sheets a minimum of [1/2 inch (13 mm)]<Insert dimension> beyond face of fins on both entering and leaving side.
- b. Casing and Tube Sheet Materials:
 - 1) Stainless steel, ASTM A240/A240M or ASTM A480/A480M, [Type 304L][or][Type 316L], No. 2D finish.
 - 2) Galvanized steel, ASTM A653/A653M, **G90 (Z275)** coating.
- c. Top and Bottom Casings:
 - 1) Flange face minimum of [1-1/2 inches (68 mm)]<Insert dimension>; double flange edge for rigidity and ease of removal with secondary flange face minimum of [1/2 inch (13 mm)]<Insert dimension>.
 - 2) Thickness:
 - a) Coils with Fin Length of up to [72 Inches (1800 mm)]<Insert dimension>: Minimum of [16 gauge (1.6 mm)][14 gauge (2.0 mm)][12 gauge (2.8 mm)] thick.
 - b) Coils with Fin Length Exceeding [72 Inches (1800 mm)]<Insert dimension>: Minimum of [16 gauge (1.6 mm)][14 gauge (2.0 mm)][12 gauge (2.8 mm)] thick.
- d. End Tube Sheets:
 - 1) Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.
 - 2) Flange face minimum of [1-1/2 inches (68 mm)]<Insert dimension>.
 - 3) Thickness: Minimum of [16 gauge (1.6 mm)][14 gauge (2.0 mm)][12 gauge (2.8 mm)] thick.
- e. Intermediate Tube Sheets:
 - 1) Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.
 - 2) Space intermediate tube sheets a maximum of [48 inches (1200 mm)]<Insert dimension> o.c. and locate to provide equal spacing between tube sheet across coil tube length.
 - 3) Flange face minimum of [1/2 inch (13 mm)]<Insert dimension>.
 - 4) Thickness: Minimum of [16 gauge (1.6 mm)]<Insert thickness> thick.
- f. Holes: Include number, size, and location of holes in casing and end tube sheets required for coil installation.

8. Fins:

- a. Materials:
 - 1) Aluminum: [0.0060 inch (0.15 mm)][0.0075 inch (0.19 mm)][0.0095 inch (0.24 mm)]<Insert dimension> thick.
 - 2) Copper: [0.0060 inch (0.15 mm)][0.0075 inch (0.19 mm)][0.0095 inch (0.24 mm)]<Insert dimension> thick.
 - 3) 90/10 Cupronickel: [0.0060 inch (0.15 mm)][0.0075 inch (0.19 mm)][0.0095 inch (0.24 mm)]<Insert dimension> thick.

- b. Collars: Full collars for accurate fin spacing and maximum tube contact while leaving no surface of tube exposed.
 - c. Fin Configuration: **[Flat face fins without ripples][Flat face or enhanced ripple fins as required by performance]**.
- 9. Headers:
 - a. Construct header of seamless copper, ASTM B75/B75M drawn temper of diameter and wall thickness based on coil size, flow rate, design pressure, design temperature, and circuiting.
 - b. Tube-to-Header Connections: Tube-to-header holes shall intrude inward so landed surface area is three times the core tube thickness to provide enhanced header to tube joint integrity. Tubes shall evenly extend within the ID of the header no more than **0.12 inch (3 mm)**.
 - c. Header Top and Bottom Caps: End caps shall be die-formed and installed on the ID of header such that the landed surface area is three times the header wall thickness.
 - d. Drains: Include low point of headers with a **[NPS 1/2 (DN 13)]<Insert pipe size>** drain connection. Extend copper or **[red brass][carbon steel][stainless steel]<Insert material>** pipe through air-handling unit casing and terminate end with MNPT. Pipe shall be threaded on both ends to facilitate easy field removal and replacement.
 - e. Vents: Include high point of headers with a **[NPS 1/2 (DN 13)]<Insert pipe size>** vent connection. Extend copper or **[red brass][carbon steel][stainless steel]<Insert material>** pipe through air-handling unit casing and terminate end with MNPT. Pipe shall be threaded on both ends to facilitate easy field removal and replacement.
 - f. Supply and Return Connections:
 - 1) Terminate ends with MNPT.
 - 2) Connections to header shall be either copper tube with brazed ASME B16.18 threaded male adapters or **[red brass][carbon steel][stainless steel]<Insert material>** pipe with machine-threaded MNPT connections. Pipe shall extend through air-handling unit casing and be threaded on both ends to facilitate easy field removal and replacement.
 - 3) Connections **[NPS 2-1/2 (DN 65)]<Insert pipe size>** and larger shall have a bronze ASME 16.24 threaded flanges attached to threaded connections to provide for a flanged field connection. Select flange class, Class 150 or Class 300, for system pressure and temperature encountered.
 - g. Protect openings of supply, return, vent, and drain connections with a threaded cap to prevent entry of dirt into the coil.
- 10. Tubes:
 - a. Material: Copper, ASTM B75/B75M annealed temper or ASTM B280 drawn temper; **[90/10 cupronickel alloy, ASTM B122/B122M]**.
 - b. Tube Nominal Diameter: **5/8 or 1 inch (16 or 25 mm)** before expanding, selected to provide performance indicated.
 - c. Tube Nominal Wall Thickness: As required by performance, minimum of **[0.035 inch (0.9 mm)][0.049 inch (1.2 mm)]<Insert dimension>** thick.
- 11. Tube Return Bends: 180-degree bends brazed to tubes; material[, **wall thickness,**] and nominal diameter to match tubes.
 - a. Tube Return Bend Nominal Wall Thickness: As required by performance, minimum of **[0.020 inch (0.5 mm)][0.025 inch (0.6 mm)][0.035 inch (0.9 mm)]<Insert dimension>** thick.

12. Brazing: High-temperature brazing alloy with not less than 5 percent silver when brazing like non-ferrous materials together and more than 30 percent silver when brazing ferrous to non-ferrous materials.
13. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating. See Drawings for coils requiring a corrosion-resistant coating.
14. Coatings: Where indicated on Drawings, coat coils with one of the following coatings for additional corrosion protection:
 - a. Baked phenolic.
 - b. Cathodic epoxy.
 - c. Water-based flexible epoxy polymer.
 - d. Water-based synthetic flexible polymer.
 - e. **<Insert coating type>**.
15. Hardware: Use hex-head bolts, nuts, and washers constructed of **[Type 304][or][Type 316]** stainless steel.
16. Nameplate: Aluminum or stainless steel nameplate with brass or stainless steel chain for each coil, with the following data engraved or embossed:
 - a. Manufacturer name, address, telephone number, and website address.
 - b. Manufacturer model number.
 - c. Serial number.
 - d. Manufacturing date.
 - e. Coil identification (indicated on Drawings).
 - f. Coil fin length.
 - g. Coil fin height.
 - h. Coil weight with fluid/without fluid.
 - i. Coil casing material and thickness.
 - j. Coil fin material and thickness.
 - k. Coil tube material and thickness.
 - l. Coil header material and thickness.
 - m. **<Insert requirements>**.
17. Cleaning: Residual manufacturing oils and solid contaminants shall be removed internally and externally by completely submersing the coil in an environmentally acceptable degreasing solution that is chemically compatible with the coil material.
18. Air-Handling Unit Factory Assembly:
 - a. Coil Connections: Extend each coil connection through casing access panel and terminate connections, approximately **[4 inches (100 mm)]<Insert dimension>** beyond exterior face of the access panel as seal each penetration as indicated. Casing access panels shall be removed and reinstalled with coils installed inside air-handling units.
 - b. Internal Access: Include each coil with internal access from **[downstream][and][upstream]** sides as indicated on Drawings.
 - c. Removal and Replacement: Each coil shall be independently removable and replaceable through a removable access panel installed in air-handling unit casing.
 - d. Supports for Coils:
 - 1) Construct a freestanding and self-supporting structural framework to support each coil individually from and independent of adjacent coils.
 - 2) Construct frame work from aluminum[, **galvanized steel**,] or stainless steel[**structural shapes**].

Q. Heating Coils With Integral Face-and-Bypass Dampers:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [LJ Wing; a Mestek Technology, Inc. company]
 - b. [Marlo Heat Transfer Solutions; part of Leonardo DRS, Inc.]
 - c. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [LJ Wing; a Mestek Technology, Inc. company]
 - b. [Marlo Heat Transfer Solutions; part of Leonardo DRS, Inc.]
 - c. <Insert manufacturer's name>
3. Source Limitations: Obtain coils from single source from single manufacturer.
4. General: Provide air-handling units with heating coils with integral face-and-bypass dampers where indicated on Drawings.
5. Description: Horizontal or vertical tube arrangement as indicated on Drawings with integral face-and-bypass dampers and controls installed to control modulating dampers to achieve discharge air temperature set point.
 - a. Each coil consisting of multiple finned heating elements, each with bypasses and interlocking dampers controlled by electric actuators and a discharge airstream thermostat.
6. Performance:
 - a. Each coil able to maintain constant discharge air temperature regardless of variations in entering-air temperature with constant [steam][and][water] flow through coil.
 - b. Portioning of air across and around the heating element shall result in a uniform temperature within **5 deg F (3 deg C)** of average temperature when measured anywhere across a vertical plane located [24 inches (600 mm)][36 inches (900 mm)] downstream of leaving face of coil.
7. Casing: [Galvanized steel][or][Type 304 stainless steel], minimum of **16 gauge (1.6 mm)** thick. Standard casing shall be extended if required air-handling unit manufacturer to accommodate installation arrangement inside of the air-handling unit.
8. Fins: Rectangular shape, constructed of **0.010-inch- (0.25-mm-)** thick aluminum with spacing not closer than **12 fins per inch (2.1 mm)**.
9. Headers: [Carbon steel][or][copper], of thickness selected by manufacturer for flow, pressure, and temperature encountered; drain connections at low points, vent connections at high points, and supply and return connections located on discharge face of coil.
 - a. Insulation: Insulate headers with mineral-fiber insulation covered by a metal jacket.
 - b. Supply and Return Connections:
 - 1) Terminate ends with MNPT.
 - 2) Connections [NPS 2-1/2 (DN 65)]<Insert pipe size> and larger shall have thread-on flanges. Select flange class, Class 150 or Class 300, for system pressure and temperature encountered.
10. Tubes:
 - a. Materials: [Copper][90/10 cupronickel][or][carbon steel].

- b. Nominal Diameter: **5/8 inch (16 mm)**.
 - c. Nominal Tube Wall Thickness: As required by performance, minimum of **[0.035 inch (0.9 mm)][0.049 inch (1.2 mm)]** thick.
- 11. Dampers: Clamshell design arranged to modulate airflow across or around individual heating elements. Constructed of **[galvanized steel][or][Type 304 stainless steel]**, minimum of **16 gauge (1.6 mm)** thick.
 - 12. Damper Actuators: **[Face][or side]** mounted; electric motor for proportional control, failing in last position.
 - 13. Brazing: High-temperature brazing alloy with not less than 5 percent silver when brazing like non-ferrous materials together and more than 30 percent silver when brazing ferrous to non-ferrous materials.
 - 14. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating. See Drawings for coils requiring a corrosion-resistant coating.
 - 15. Coatings: Where indicated on Drawings, coat coil casings and damper assemblies with **[air-dried alkyd enamel][or][baked-epoxy]** corrosion-resistant coating.
 - 16. Hardware: Use hex-head bolts, nuts, and washers constructed of **[zinc-plated carbon steel][or][Type 304 stainless steel]**.
 - 17. Nameplate: Aluminum or stainless steel nameplate with brass or stainless steel chain for each coil, with the following data engraved or embossed:
 - a. Manufacturer name, address, telephone number, and website address.
 - b. Manufacturer model number.
 - c. Serial number.
 - d. Manufacturing date.
 - e. Coil identification (indicated on Drawings).
 - f. **<Insert requirements>**.
 - 18. Air-Handling Unit Factory Assembly:
 - a. Coil Connections: Extend each coil connection through casing access panel and terminate connections, approximately **[4 inches (100 mm)]<Insert dimension>** beyond exterior face of the access panel as seal each penetration as indicated. Casing access panels shall be removed and reinstalled with coils installed inside air-handling units.
 - b. Internal Access: Include each coil with internal access from **[downstream][and][upstream]** sides as indicated on Drawings.
 - c. Removal and Replacement: Each coil shall be independently removable and replaceable through a removable access panel installed in air-handling unit casing.
 - d. Supports for Coils:
 - 1) Construct a freestanding and self-supporting structural framework to support each coil individually from and independent of adjacent coils.
 - 2) Construct frame work from aluminum[, **galvanized steel,**] or stainless steel[**structural shapes**].

R. Drain Pans:

- 1. General:
 - a. Include a drain pan for each cooling[**and heating**] coil and at other locations indicated.
 - b. Continuously weld drain pan seams, joints, and mitered corners to make the assembled drain pan watertight.
 - c. Drain pans shall be located under the entire coil and provide full coil coverage including coil return bends and headers.
 - d. Slope drain pans in multiple directions toward low point drain connection at a uniform slope

- of at least [1][2] percent from high point to low point.
 - e. Include stainless steel blank-offs to prevent air from bypassing around coil.
- 2. Intermediate Drain Pans:
 - a. Where multiple individual horizontally mounted coils are vertically stacked to make a coil bank, install intermediate drain pans under each stacked coil in the coil bank.
 - b. Material: [Type 304L][Type 316L][300 series] stainless steel ASTM A240/A240M or ASTM A480/A480M, a minimum of [16 gauge (1.6 mm)]<Insert value> thick.
 - c. Minimum Depth: [1.0 inch (25 mm)][1.5 inches (38 mm)]<Insert dimension>.
 - d. Extend drain pan beyond air entering face of coil casing at least [3 inches (75 mm)]<Insert distance>.
 - e. Extend drain pan beyond air leaving face of coil casing at least [6 inches (150 mm)]<Insert distance>.
 - 1) Where moisture eliminators are required to prevent moisture carryover, extend drain pan beyond leaving face of moisture eliminator in lieu of leaving face of coil.
 - f. Drain Pan Connection:
 - 1) Stainless steel threaded coupling welded to underside of drain pan at lowest point.
 - 2) Minimum Nominal Connection Size: [NPS 1 (DN 25)][NPS 1.5 (DN 40)][NPS 2 (DN 50)]<Insert pipe size>.
 - g. Drain Pipe:
 - 1) Air-handling unit manufacturer to connect full-size drain pipe to each drain pan connection. Option to use one of following pipe materials:
 - a) Copper tube with a bronze threaded male adapter, brazed or solder to end.
 - b) Aluminum pipe with threaded MNPT ends.
 - c) Stainless steel pipe with threaded MNPT ends.
 - 2) Extend drain pipe to top of drain pan immediately below.
 - 3) Include a removable stainless steel support to secure bottom of drain pipe from drain pan below to prevent lateral movement.
 - 4) In applications where multiple drain pans are stacked, align stacked drains pan connections and pipes for clear vertical flow.
- 3. Bottom Drain Pans:
 - a. Mounting Location, Recessed in Floor: Air-handling unit manufacturer has option to recess bottom drain pan into the floor or install drain pan above air-handling unit floor walking surface.
 - b. Mounting Location, Above Floor: Bottom drain pan shall be installed above air-handling unit floor walking surface. Do not recess drain pan into unit base.
 - c. Grating: Install removable stainless steel grating on top of drain pan.
 - d. Double-Wall Construction: Double-wall sheet with space between walls filled with [1-inch (25-mm)]<Insert thickness> insulation.
 - e. Material: [Type 304L][Type 316L][300 series] stainless steel ASTM A240/A240M or ASTM A480/A480M, a minimum of [16 gauge (1.6 mm)]<Insert value> thick.
 - f. Minimum Depth: [1.5 inches (38 mm)]<Insert depth>.
 - g. Extend drain pan beyond air entering face of coil casing at least [3 inches (75 mm)]<Insert distance>.
 - h. Extend drain pan beyond air leaving face of coil casing at least [12 inches (150 mm)]<Insert distance>.

- 1) Where moisture eliminators are required to prevent moisture carryover, extend drain pan beyond leaving face of moisture eliminator in lieu of the leaving face of coil.
- i. Drain Pan Connection:
 - 1) Stainless steel threaded half-coupling welded to lowest point of drain pan.
 - 2) Location: **[one end][both ends][See Drawings]<Insert requirement>**.
 - 3) Minimum Nominal Connection Size: **[NPS 1 (DN 25)][NPS 1.5 (DN 40)][NPS 2 (DN 50)]<Insert pipe size>**.
- j. Drain Pipe:
 - 1) Air-handling unit manufacturer to connect full size drain pipe to each drain pan connection. Option to use one of following pipe materials:
 - a) Copper tube with threaded male adapter, brazed or soldered to ends.
 - b) Aluminum pipe with threaded MNPT ends.
 - c) Stainless steel pipe with threaded MNPT ends.
 - 2) Extend drain pipe and terminate **[3 inches (75 mm)]<Insert distance>** beyond exterior face of casing.

S. Electric Heaters:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Brasch Manufacturing Co., Inc]**
 - b. **[Chromalox, Inc.]**
 - c. **[INDEECO]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Brasch Manufacturing Co., Inc]**
 - b. **[Chromalox, Inc.]**
 - c. **[INDEECO]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain heaters from single source from single manufacturer.
4. General:
 - a. Provide air-handling units with electric heaters where indicated on Drawings.
 - b. NRTL listed for zero clearance to combustible surface, regardless of heater capacity.
5. Design and Performance:
 - a. Heaters and installation shall comply with NFPA 70.
 - b. Scheduled capacity (kW) is minimum acceptable.
 - c. Air pressure drop and face velocity are maximum acceptable.
 - d. Rate heaters output capacity at voltage, phase, and hertz indicated on Drawings.

- e. Arrange capacity control to minimize stratification.
 - f. Equally balance heater electrical load for each step across all three phases.
 - g. Part-Load Operation: Include multiple heaters configured in a **[series][or][parallel]** arrangement with operation staged if required for uninterrupted heater operation over the full range of air-handling unit airflow down to the minimum airflow indicated.
 - 1) Where multiple heaters positioned in a parallel arrangement are required for operation over the full range of air-handling unit airflow, include an automatic isolation damper at the **[inlet][or][discharge]** of inactive heaters to isolate airflow across inactive heaters while other heaters are operating.
6. Heating Elements:
- a. Open Elements:
 - 1) Open-coil resistance wire of 80 percent nickel and 20 percent chromium; supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in a frame.
 - 2) Safety Screens: Install safety screens to protect operators from accidentally coming in direct connect with elements.
 - b. Finned Tubular Elements:
 - 1) Coiled resistance wire of 80 percent nickel and 20 percent chromium; center-mounted and surrounded by compacted magnesium-oxide powder in tubular-steel sheath; with spiral-wound, copper-plated, steel fins continuously brazed to sheath.
 - 2) Finish finned tubular elements with a baked-on aluminum paint, and mount in a frame.
 - 3) Each element individually removable from terminal box.
 - 4) Use threaded stainless steel element terminals and hardware.
7. Frame: **[Galvanized][or][stainless]** steel; include intermediate element support brackets equally spaced at a maximum of **[36 inches (900 mm)]<Insert distance>** o.c. across heater element length.
8. Terminal Box/Control Panel: **[Unit mounted][Remote mounted][Unit or remote mounting arrangement indicated on Drawings]**; with disconnection means and overcurrent protection.
- a. Enclosure: NEMA 250, **[Type 1][or][Type 12]** enclosure complying with UL 50.
 - b. Full face hinged door **[with lock and key latching device(s)]**.
 - c. Factory insulate base of terminal box to prevent condensation from occurring within box.
 - d. Mount terminal box control panel on exterior surface of air-handling unit casing. Gasket and seal air-handling unit cabinet penetrations.
 - e. Install a laminated elementary wiring diagram on inside face of heater control panel door or in another protected location than visible be service personnel. Wiring diagram shall match installation.
9. Controls:
- a. Safety Controls: Each heater with following factory-mounted safety controls:
 - 1) Disk-type thermal cutout switch with automatic reset.
 - 2) Primary linear thermal limit cutout switch with automatic reset.
 - 3) Secondary linear thermal limit cutout switch with local manual reset.
 - 4) Airflow Proving Switch: Diaphragm-operated pressure differential type; with pressure range selected to ensure reliable operation throughout full range of air-handling unit airflow down to minimum airflow indicated.

- b. Staging Control: Magnetic contactors for switching stages of heat except for air-handling units located in occupied spaces, include mercury contactors for switching stages of heat.
 - c. SCR Control: Silicon-controlled rectifier (SCR) for 100 percent stepless capacity control.
 - d. Remote Monitoring and Control: Include control devices necessary to interface with remote-control signals including the following:
 - 1) Heater on/off control.
 - 2) Monitoring heater on/off status.
 - 3) High-temperature alarm.
 - 4) Low-airflow alarm.
 - 5) Heater capacity control.
 - 6) **<Insert requirements>**.
10. Electrical:
- a. Single-Point Field Power Connection: Install and wire the heater to accommodate a single field electrical connection for electrical power.
 - b. Disconnecting Means: Provide each heater with a main electrical power, door mounted and interlocking, and disconnecting means to prevent access into panel, unless switched in the off position.
 - 1) **[Fused disconnect switch][Nonfused disconnect switch][Circuit breaker]** with lockable handle.
 - 2) Minimum Short-Circuit Current Rating: As required by electrical power distribution system, but not less than **[42,000][65,000]<Insert value> A**.
 - c. Factory install and wire branch circuit fusing, or circuit breakers in accordance with NFPA 70.
 - d. Pilot Lights: Include labeled pilot lights on face of control panel for the following:
 - 1) Power on.
 - 2) Low-airflow alarm.
 - 3) High-temperature alarm.
 - 4) One for each stage on.
 - 5) **<Insert requirement>**.
 - e. Terminations: Wire terminations and field interface terminations to labeled terminal strips.
 - f. Control Transformer: Size control circuit transformer for required load, plus 75 VA.
 - g. Labeling: Label each electrical device with a laminated phenolic tag.
 - h. Use only NRTL-labeled electrical components.
11. Nameplate: Include the following data:
- a. Manufacturer name, address, telephone number, and website address.
 - b. Manufacturer model number.
 - c. Serial number.
 - d. Manufacturing date.
 - e. Coil identification (indicated on Drawings).
 - f. **<Insert requirements>**.
12. Air-Handling Unit Factory Assembly:
- a. Support individual heater assemblies within unit from a structural framework constructed of **[aluminum][galvanized steel][or][stainless steel]**.
 - b. Provide each heater assembly with access from **[downstream][and][or][upstream]** sides.

- c. Make provisions in arrangement and installation to mitigate uneven airflow patterns within unit for proper heater operation.
- T. Direct-Steam-Injection Panel Distribution Manifold Humidifiers:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Armstrong International, Inc]**
 - b. **[DriSteem]**
 - c. **[Nortec Industries Inc.]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Armstrong International, Inc]**
 - b. **[DriSteem]**
 - c. **[Nortec Industries Inc.]**
 - d. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain humidifiers from single source from single manufacturer.
 4. Description: Prefabricated, direct-steam panel distribution manifold specially designed for steam dispersion in a short distance.
 - a. **[Horizontal][or][vertical]** header with multiple **[vertical][or][horizontal]**, **[nonsteam][steam]**-jacketed tubes.
 - b. **[Nozzles/metered orifices in conjunction with nonsteam-jacketed manifolds][or][punched orifices/no nozzles in conjunction with steam-jacketed manifolds]** spaced evenly along manifold tubes and providing dry and uniform steam distribution.
 5. Design and Performance:
 - a. Absorption distance within **[12 inches (300 mm)][18 inches (450 mm)][24 inches (600 mm)]<Insert dimension>**.
 - b. Air Pressure Drop: Less than **0.1 inch wg (25 Pa)** at design velocity.
 - c. Suitable for pressurized steam applications.
 6. Headers and Distribution Tubes:
 - a. Material: **[Stainless steel][Stainless steel, Type 304][Stainless steel, Type 316]**.
 - b. Insulation: **[Uninsulated][Insulated][Insulated, minimum R-0.5]**.
 7. Steam Separator: External separator, or separator/baffles integral to header, to provide condensate-free steam to the distribution tubes.
 - a. Material: **[Stainless steel][Stainless steel, Type 304][Stainless steel, Type 316]**.
 8. Steam Trap:
 - a. Material: **[Cast iron][Stainless steel][Stainless steel, Type 304][Stainless steel, Type 316]**.

- b. Type: **[Inverted bucket][or][float and thermostatic]**.
- c. Capacity: Sized for a minimum of **[3]<Insert number>** times the maximum rated condensate flow of humidifier at **[1/2-psig (3.4-kPa)]<Insert value>** differential pressure.

9. Air-Handling Unit Factory Installation:

- a. Air-handling unit manufacturer shall furnish and install humidifiers with the size and capacities indicated on Drawings.
- b. Extend humidifier piping through the air-handling unit casing and terminate the connections approximately **[4 inches (100 mm)]<Insert distance>** beyond the exterior face.
- c. Drain Pans: Install condensate drain pans to collect and drain water to exterior of air-handling unit casing.
- d. Provide each humidifier with access for inspection, service, and replacement.
- e. Each humidifier shall be removable for replacement through a removable access panel in the air-handling unit casing or an access door.
- f. Include a freestanding and self-supporting structural **[aluminum or]**stainless steel framework to support each humidifier.

U. Bag Filters:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[AAF International]**
 - b. **[Camfil Farr Inc.]**
 - c. **[Flanders Corporation]**
 - d. **[Koch Filter Corporation]**
 - e. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[AAF International]**
 - b. **[Camfil Farr Inc.]**
 - c. **[Flanders Corporation]**
 - d. **[Koch Filter Corporation]**
 - e. **<Insert manufacturer's name>**
- 3. Source Limitations: Obtain filters from single source from single manufacturer.
- 4. Description: Factory-fabricated, dry, extended-surface, unsupported filters with header frames.
- 5. Performance:
 - a. Filtration Efficiency, ASHRAE 52.2 MERV Rating:
[11][11A][13][13A][14][14A][15][15A][See Drawings].
 - b. Energy Cost Index: Five star rating.
 - c. Initial Air Pressure Drop: With face velocity of **500 fpm (2.5 m/s)**, pressure drop shall not exceed the following:
 - 1) MERV 11 and MERV 11A:
 - a) Depth 12 Inches (300 mm): **0.28 inch wg (70 Pa)**.
 - b) Depth 15 Inches (375 mm): **0.26 inch wg (65 Pa)**.

- c) Depth 22 Inches (550 mm): **0.24 inch wg (60 Pa)**.
 - d) Depth 30 Inches (750 mm): **0.23 inch wg (58 Pa)**.
 - 2) MERV 13 and MERV 13A:
 - a) Depth 12 Inches (300 mm): **0.52 inch wg (130 Pa)**.
 - b) Depth 15 Inches (375 mm): **0.48 inch wg (120 Pa)**.
 - c) Depth 22 Inches (550 mm): **0.38 inch wg (95 Pa)**.
 - d) Depth 30 Inches (750 mm): **0.34 inch wg (85 Pa)**.
 - 3) MERV 14 and MERV 14A:
 - a) Depth 12 Inches (300 mm): **0.67 inch wg (168 Pa)**.
 - b) Depth 15 Inches (375 mm): **0.55 inch wg (138 Pa)**.
 - c) Depth 22 Inches (550 mm): **0.45 inch wg (113 Pa)**.
 - d) Depth 30 Inches (750 mm): **0.41 inch wg (103 Pa)**.
 - 4) MERV 15 and MERV 15A:
 - a) Depth 15 Inches (375 mm): **0.81 inch wg (203 Pa)**.
 - b) Depth 22 Inches (550 mm): **0.62 inch wg (155 Pa)**.
 - c) Depth 30 Inches (750 mm): **0.53 inch wg (133 Pa)**.
 - d. Manufacturer-Recommended Final Air Pressure Drop: **[1.0 inch wg (250 Pa)]<Insert pressure drop>**.
 - e. Pressure Differential without Failure: **[10 inches wg (2500 Pa)]<Insert pressure drop>**.
 - f. Temperature Rating: **[158 deg F (70 deg C)]<Insert temperature>**.
- 6. Certification:
 - a. AHRI: Tolerances in accordance with AHRI 850 (I-P) and AHRI 851 (SI).
 - b. ASHRAE: Tested and rated in accordance with ASHRAE 52.2.
 - c. UL: UL 900 listed.
- 7. Size:
 - a. Nominal size of individual filters indicated on Drawings:
 - b. Nominal Filter Size:
 - 1) Face: **[24 by 24 inches (600 by 600 mm)]<Insert dimensions>**.
 - 2) Depth: **[12 inches (300 mm)][15 inches (375 mm)][22 inches (550 mm)][30 inches (750 mm)]<Insert dimension>**.
 - c. Actual Filter Size: Suitable for installation in an industry-standard filter holding frame.
- 8. Filter Media Surface Area: Each filter shall contain the following minimum media surface area for a filter with a nominal **24-by-24-inch (600-by-600-mm)** face:
 - a. Depth 12 Inches (300 mm): **39 sq. ft. (3.6 sq. m)**.
 - b. Depth 15 Inches (375 mm): **49 sq. ft. (4.5 sq. m)**.
 - c. Depth 22 Inches (550 mm): **71 sq. ft. (6.6 sq. m)**.
 - d. Depth 30 Inches (750 mm): **97 sq. ft. (9.0 sq. m)**.
- 9. Construction:

- a. Media: Glass-fiber material constructed so individual pockets are maintained in tapered form under rated-airflow conditions by flexible internal supports. **[Coat media with an antimicrobial agent.]**
 - 1) Synthetic mesh backing to provide media protection and support.
 - 2) Multiple stitched pockets sealed to eliminate air bypass through stitch points.
- b. Header: Filter face with ABS plastic or corrosion-resistant metal header designed for rigidity and to eliminate racking.
- c. Adhesive: Fire-retardant bonding adhesive where bonding media to header.

V. Cartridge Filters:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[AAF International]**
 - b. **[Camfil Farr Inc.]**
 - c. **[Flanders Corporation]**
 - d. **[Koch Filter Corporation]**
 - e. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[AAF International]**
 - b. **[Camfil Farr Inc.]**
 - c. **[Flanders Corporation]**
 - d. **[Koch Filter Corporation]**
 - e. **<Insert manufacturer's name>**
- 3. Source Limitations: Obtain filters from single source from single manufacturer.
- 4. Description: Factory-fabricated, dry, extended-surface, disposable, air filters with media formed in mini-pleats and arranged in a V-shape pattern.
- 5. Performance:
 - a. Filtration Efficiency, ASHRAE 52.2 MERV Rating: **[11][11A][13][13A][14][14A][16][16A][See Drawings].**
 - b. Energy Cost Index: Five star rating.
 - c. Initial Air Pressure Drop: With face velocity of **500 fpm (2.5 m/s)**, clean filter pressure drop shall not exceed the following:
 - 1) MERV 11 and MERV 11A: **0.21 inch wg (53 Pa).**
 - 2) MERV 13 and MERV 13A: **0.25 inch wg (63 Pa).**
 - 3) MERV 14 and MERV 15A: **0.27 inch wg (68 Pa).**
 - 4) MERV 16 and MERV 16A: **0.60 inch wg (150 Pa).**
 - d. Manufacturer-Recommended Final Air Pressure Drop: **[1.5 inches wg (375 Pa)]<Insert pressure drop>**.
 - e. Pressure Differential without Failure: **[10 inches wg (2500 Pa)]<Insert pressure drop>**.
 - f. Temperature Rating: **[175 deg F (79 deg C)]<Insert temperature>**.

6. Certification:
 - a. AHRI: Tolerances in accordance with AHRI 850 (I-P) and AHRI 851 (SI).
 - b. ASHRAE: Tested and rated in accordance with ASHRAE 52.2.
 - c. UL: UL 900 listed.
7. Size:
 - a. Nominal size of individual filters indicated on Drawings:
 - b. Nominal Filter Size:
 - 1) Face: **[24 by 24 inches (600 by 600 mm)]<Insert dimensions>**.
 - 2) Depth: **12 inches (300 mm)**.
 - c. Actual Filter Size: Suitable for installation in an industry-standard filter holding frame.
8. Filter Media Surface Area: Each filter shall contain at least **[200 sq. ft. (18.6 sq. m)]<Insert area>** for a filter with a nominal **24-by-24-inch (600-by-600-mm)** face.
9. Construction:
 - a. Media: Microfine glass media formed into mini-pleats and arranged in V-shape patterns.
 - b. Media Frame: Plastic or corrosion-resistant metal.
 - c. Adhesive: Fire-retardant bonding adhesive where bonding media to frame.

W. Pleated Panel Filters:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[AAF International]**
 - b. **[Camfil Farr Inc.]**
 - c. **[Flanders Corporation]**
 - d. **[Koch Filter Corporation]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[AAF International]**
 - b. **[Camfil Farr Inc.]**
 - c. **[Flanders Corporation]**
 - d. **[Koch Filter Corporation]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain filters from single source from single manufacturer.
4. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters.
5. Performance:
 - a. Filtration Efficiency, ASHRAE 52.2 MERV Rating: **[8][8A][9][9A][See Drawings]**.
 - b. Energy Cost Index: Five star rating.
 - c. Initial Air Pressure Drop: With face velocity of **500 fpm (2.5 m/s)**, clean filter pressure drop shall not exceed the following:

- 1) MERV 8 and MERV 8A:
 - a) Depth 1 Inch (25 mm): **0.23 inch wg (58 Pa)**.
 - b) Depth 2 Inches (50 mm): **0.31 inch wg (78 Pa)**.
 - c) Depth 4 Inches (100 mm): **0.27 inch wg (68 Pa)**.
- 2) MERV 9 and MERV 9A:
 - 3) Depth 2 Inches (50 mm): **0.30 inch wg (75 Pa)**.
 - 4) Depth 4 Inches (100 mm): **0.27 inch wg (68 Pa)**.
- d. Manufacturer-Recommended Final Air Pressure Drop: **[1.0 inch wg (250 Pa)]<Insert pressure drop>**.
- e. Pressure Differential without Failure: **[2 inches wg (500 Pa)]<Insert pressure drop>**.
- f. Temperature Rating: **[200 deg F (93 deg C)]<Insert temperature>**.
6. Certification:
 - a. AHRI: Tolerances in accordance with AHRI 850 (I-P) and AHRI 851 (SI).
 - b. ASHRAE: Tested and rated in accordance with ASHRAE 52.2.
 - c. UL: UL 900 listed.
7. Size:
 - a. Nominal size of individual filters indicated on Drawings:
 - b. Nominal Filter Size:
 - 1) Face: **[24 by 24 inches (600 by 600 mm)]<Insert dimensions>**.
 - 2) Depth: **[1 inch (25 mm)][2 inches (50 mm)][4 inches (100 mm)]**.
 - c. Actual Filter Size: Suitable for installation in an industry-standard filter holding frame.
8. Filter Media Surface Area: Each filter shall contain the following minimum media surface area for a filter with a nominal **24-by-24-inch (600-by-600-mm)** face:
 - a. Depth 1 Inch (25 mm): **9.8 sq. ft. (0.9 sq. m)**.
 - b. Depth 2 Inches (50 mm): **17.3 sq. ft. (1.6 sq. m)**.
 - c. Depth 4 Inches (100 mm): **27.7 sq. ft. (2.6 sq. m)**.
9. Construction:
 - a. Media: **[Glass or][Cotton and]** synthetic blend of fibers arranged in a series of pleats attached to and supported by a corrosion-resistant welded-wire grid. **[Coat media with an antimicrobial agent.]**
 - b. Filter Media Casing: High wet strength (28-point) beverage board that is bonded around the periphery to eliminate air bypass.
 - 1) Diagonal support members across upstream and downstream filter face constructed of same material as casing shall ensure pleat spacing and stability.
 - c. Adhesive: Fire-retardant bonding adhesive where bonding media to casing.
- X. ASHRAE-Rated Filter Holding Frames:
 1. Filter Holding Frames for ASHRAE-Rated Filters:

- a. Fabricate filter holding frames with mitered corners and reinforce frame to maintain a durable, rugged, true square shape.
 - b. Construct frames of **[galvanized][or][stainless]** steel. Use stainless steel frames in applications exposed to corrosive airstreams.
 - c. For applications with pre-filter and final filters sharing the same filter holding frame, frames shall be suitable for supporting and holding both pre-filter and final filters in frame with both filters serviceable from upstream (entering air) side.
 - d. Frame Depth: At least **[2.75 inches (70 mm)]<Insert dimension>**.
 - e. Gaskets: Continuous, suitable for same operating temperature as filters.
 - f. Filter Clips: Each filter holding frame with spring clip fasteners at each corner. Spring clips shall allow filters to be removed and replaced without use of tools.
 - g. Frames shall be industry-standard size to provide interchangeability of filters from other manufacturers.
2. Air-Handling Unit Factory Installation:
- a. Air-handling unit manufacturer shall furnish filters and provide filter holding frames, retaining clips, and filter support structures.
 - b. Furnish filter quantity, size, type, and performance indicated on Drawings.
 - c. Install filter frames in a flat vertical position for horizontal airflow.
 - d. Install holding frames in accordance with manufacturer's written instructions and to prevent passage of unfiltered air. Include additional gaskets as necessary.
 - e. Secure individual holding frames together to build a multiple filter bank.
 - f. Construct **[aluminum][galvanized-steel][or][stainless steel]** support structure to hold frames and filters.
 - 1) Design support structure for maximum system operating pressures encountered equal to fan shutoff pressure.
 - 2) Design and fabricate support structure to limit deflection across filter bank to 1/360 of the span when subjected to a **[200-lb (890-N)]<Insert value>** lateral force applied at any point on the filter holding frame assembly.

Y. Absolute Filters:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[AAF International]**
 - b. **[Camfil Farr Inc.]**
 - c. **[Flanders Corporation]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[AAF International]**
 - b. **[Camfil Farr Inc.]**
 - c. **[Flanders Corporation]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain filters from single source from single manufacturer.
4. Description: Factory-fabricated, disposable, packaged high-efficiency particulate air filters consisting of an anodized aluminum hold frame with media formed into mini-pleats and arranged

- in a V-shape pattern.
5. Performance:
- a. Filtration Efficiency:
 - 1) Rating indicated on Drawings.
 - 2) IEST Rating at 0.3-micron Size: **[95][99.99][99.999]<Insert number>** percent.
 - b. Energy Cost Index: Five star rating.
 - c. Initial Air Pressure Drop: With face velocity of **500-fpm (2.5-m/s)**, clean filter pressure drop shall not exceed the following:
 - 1) Gasket Seal Filters:
 - a) 95 Percent Efficiency: **0.50 inch wg (125 Pa)**.
 - b) 99.99 Percent Efficiency: **1.0 inch wg (250 Pa)**.
 - c) 99.999 Percent Efficiency: **1.1 inches wg (275 Pa)**.
 - 2) Gel Seal Filters:
 - a) 95 Percent Efficiency: **0.70 inch wg (175 Pa)**.
 - b) 99.99 Percent Efficiency: **0.9 inch wg (225 Pa)**.
 - c) 99.999 Percent Efficiency: **1.1 inches wg (250 Pa)**.
 - d. Manufacturer-Recommended Final Air Pressure Drop: **[2.0 inches wg (500 Pa)]<Insert pressure drop>**.
 - e. Pressure Differential without Failure: **[10 inches wg (2500 Pa)]<Insert pressure drop>**.
 - f. Temperature Rating:
 - 1) Gasket Seal: **[175 deg F (79 deg C)]<Insert temperature>**.
 - 2) Gel Seal: **[155 deg F (68 deg C)]<Insert temperature>**.
6. Certification:
- a. IEST: Tested and rated in accordance with IEST's "Recommended Practice for Testing HEPA Filters."
 - 1) Comply with IEST-RP-CC001.6.
 - 2) Comply with IEST-RP-CC034.
 - b. UL: UL 900 listed.
7. Size:
- a. Nominal Face Size: **[24 by 24 inches (600 by 600 mm)][See Drawings]<Insert size>**.
 - b. Depth: **12 inches (300 mm)**.
 - c. Actual Filter Size: Suitable for installation in an industry-standard filter holding frame.
8. Filter Media Surface Area: Each filter shall contain the following minimum media surface area for a filter with a nominal **24-by-24-inch (600-by-600-mm)** face:
- a. Gasket Seal:
 - 1) 95 Percent Efficiency: **390 sq. ft. (36.2 sq. m)**.

- 2) 99.99 Percent Efficiency: **390 sq. ft. (36.2 sq. m).**
 - 3) 99.999 Percent Efficiency: **431 sq. ft. (40.0 sq. m).**
 - b. Gel Seal:
 - 1) 95 Percent Efficiency: **401 sq. ft. (37.2 sq. m).**
 - 2) 99.99 Percent Efficiency: **401 sq. ft. (37.2 sq. m).**
 - 3) 99.999 Percent Efficiency: **401 sq. ft. (37.2 sq. m).**
9. Construction for Gasket Seal Filters:
 - a. Media: Microfine glass media formed into mini-pleats and arranged in a V-shape pattern.
 - 1) Internal Separators: **[None]<Insert type>.**
 - 2) Media to Filter Frame Seal Material: **[Polyurethane]<Insert material>.**
 - 3) Faceguard Material: **[Aluminum][Stainless steel]<Insert material>.**
 - 4) Faceguard Location: **[None][upstream][and][downstream].**
 - b. Media-Holding Frame: Anodized aluminum enclosing frame with continuous seamless perimeter **[neoprene]<Insert gasket material>** gasket.
 - 1) Filter Frame to Mounting Frame Seal Location: **[Upstream][Downstream].**
 - c. Adhesive: Fire-retardant bonding adhesive where bonding media to frame.
10. Construction for Gel Seal Filters:
 - a. Media: Microfine glass media formed into mini-pleats and arranged in a V-shape pattern.
 - 1) Internal Separators: **[None]<Insert type>.**
 - 2) Media to Filter Frame Seal Material: **[Polyurethane]<Insert material>.**
 - 3) Faceguard Material: **[Aluminum][Stainless steel]<Insert material>.**
 - 4) Faceguard Location: **[None][upstream][and][downstream].**
 - b. Media-Holding Frame: Anodized aluminum enclosing frame with gel seal track and elastic **[silicone][urethane]<Insert material>** gel sealant.
 - c. Adhesive: Fire-retardant bonding adhesive where bonding media to frame.
- Z. Absolute Filter Holding Frame Assembly:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[AAF International]**
 - b. **[Camfil Farr Inc.]**
 - c. **[Flanders Corporation]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[AAF International]**



- b. [Camfil Farr Inc.]
 - c. [Flanders Corporation]
 - d. <Insert manufacturer's name>
3. Source Limitations: Obtain holding frame assembly from absolute filter manufacturer.
4. Description: Holding frame assembly with access for upstream (front) or downstream (back) filter servicing as indicated, specifically designed for absolute filter banks.
- a. Gasket Seal: Positive-sealing device to ensure seal between each gasket filter to prevent bypass of unfiltered air. Filter latching mechanism to seat each filter firmly against holding frame surface.
 - b. Gel Seal: Knife-edge to mate to each filter to prevent bypass of unfiltered air. Positive-locking mechanism for each filter to seat the knife edge into the gel during installation and to remove the filter from the knife edge during filter replacement.
5. Construction:
- a. Each filter bank with a factory-assembled filter holding framework consisting of a framework superstructure, a base, bracing, and removable swing bolt assemblies designed to accommodate the scheduled sizes and configuration of absolute filters.
 - b. Framework:
 - 1) Nominal **4 inches (100 mm)**, minimum **11-gauge- (3.1-mm)** thick-, [**galvanized-steel**][or][**stainless steel**] channels or tube.
 - 2) Continuously weld members. After assembly, grind and polish welds to provide a smooth uniform sealing surface.
 - c. Base:
 - 1) Continuously weld the framework to a minimum **11-gauge- (3.1-mm-)** thick, [**galvanized-steel**][or][**stainless steel**] base.
 - d. Filter Attachment:
 - 1) Equip framework with four swing bolts for each filter.
 - 2) Include each swing bolt with a bearing clamp and hex nut designed for applying a sufficiently uniform sealing pressure against the periphery of each filter.
 - 3) Swing bolts shall be constructed of at least **5/16-inch (8-mm)** [**zinc electroplated**][**galvanized**][or][**stainless**] steel.
 - 4) Hex nuts shall be capable of being torqued to provide at least 50 percent gasket compression.
 - 5) Swing bolt assembly shall provide individual sealing of filters.
 - e. Pre-Filter Frames:
 - 1) For filter banks with pre-filters attached on the air entering side of absolute filter, include an ASHRAE-rated filter holding frame.
 - 2) Pre-filter holding frames shall be held in place by swing bolts and allow for installation and removal of pre-filters without disturbing absolute filter seal.
6. Air-Handling Unit Factory Installation:
- a. Air-handling unit manufacturer shall furnish filters and provide filter holding frames, retaining clips, and filter support structures.
 - b. Furnish filter quantity, size, type, and performance indicated on Drawings.

- c. Install filter frames in a flat vertical position for horizontal airflow.
- d. Install holding frames in accordance with manufacturer's written instructions and to prevent passage of unfiltered air. Include additional gaskets as necessary.
- e. Construct aluminum[, **galvanized-steel**] or stainless steel support structure to hold frames and filters.
 - 1) Design support structure for maximum system operating pressures encountered equal to fan shutoff pressure.
 - 2) Design and fabricate support structure to limit deflection across filter bank to 1/360 of the span when subjected to a **[400-lb (1780-N)]<Insert value>** lateral force applied at any point on the filter holding frame assembly.

AA. Gas-Phase Filters:

1. Gas-Phase Panel-Style Filters:

- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[AAF International]**
 - 2) **[Camfil Farr Inc.]**
 - 3) **[Flanders Corporation]**
 - 4) **[Koch Filter Corporation]**
 - 5) **[Purafil, Inc.]**
 - 6) **<Insert manufacturer's name>**
- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[AAF International]**
 - 2) **[Camfil Farr Inc.]**
 - 3) **[Flanders Corporation]**
 - 4) **[Koch Filter Corporation]**
 - 5) **[Purafil, Inc.]**
 - 6) **<Insert manufacturer's name>**
- c. Source Limitations: Obtain filters from single source from single manufacturer.
- d. Description: Gas-phase panel filter for installation in a universal ASHRAE-rated filter holding frame.
- e. Performance:
 - 1) Initial Air Pressure Drop: Maximum **0.50 inch wg (125 Pa)** at a velocity of **500 fpm (2.5 m/s)**.
 - 2) Efficiency: 60 percent ozone-removal efficiency.
 - 3) Temperature: **155 deg F (68 deg C)**.
- f. Construction:
 - 1) Filters shall be plastic disposable, loose-fill sorbent[**or refillable**].
 - 2) Panel shall include perforated face.
 - 3) Each panel shall contain at least **12 lb (2.7 kg)** of sorbent.
- g. Nominal Panel Filter Size:

- 1) Face: **24 by 24 inches (600 by 600 mm)**.
- 2) Depth: **2 inches (50 mm)**.
- h. Media:
 - 1) Coconut shell activated carbon.
 - 2) Activated alumina impregnated with potassium permanganate.
 - 3) Blended activated carbon and alumina impregnated with potassium permanganate.
 - 4) **<Insert media types for specific applications>**.
- i. Pre-Installation Protection: Package each gas-phase filter in a sealed polyethylene bag to prevent unintentional adsorption before installation.
- j. Gas-Phase Panel-Style Filter Holding Frames: Use ASHRAE-rated filter holding frames.
2. Gas-Phase Canister-Style Filters:
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Camfil Farr Inc.]**
 - 2) **[Flanders Corporation]**
 - 3) **[Purafil, Inc.]**
 - 4) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Camfil Farr Inc.]**
 - 2) **[Flanders Corporation]**
 - 3) **[Purafil, Inc.]**
 - 4) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain filters from single source from single manufacturer.
 - d. Description: Factory-fabricated, dry, cylindrical canisters containing loose-fill adsorbent media.
 - e. Performance:
 - 1) Initial Air Pressure Drop: **0.60 inch wg (150 Pa)** at a velocity of **500 fpm (2.5 m/s)** when 16 cylinders, **24 inches (600 mm)** long are installed on frames.
 - 2) Efficiency: 95 percent removal efficiency at rated airflow.
 - 3) Temperature:
 - a) Plastic Construction: **105 deg F (41 deg C)**.
 - b) Stainless Steel Construction: **140 deg F (60 deg C)**.
 - f. Canister Construction:
 - 1) Material: **[Disposable ABS HDPE plastic][or][factory-refillable stainless steel]**.
 - 2) Perforations around cylinder surface area for air passage through media.
 - 3) Each canister shall include a mounting assembly with three integral bayonets for mounting to matching cylindrical mounting flange.
 - 4) Gasket seals.

- 5) Each canister with at least **1.5 lb (2.7 kg)** of sorbent per **6 inches (150 mm)** of canister length.
 - 6) Canister to mounting hardware procedure shall form a mechanical connection with a seal limiting air bypass across canister mounting assembly.
- g. Filter Size:
- 1) Nominal Holding Frame Face: **24 by 24 inches (600 by 600 mm)**.
 - 2) Nominal Canister Diameter: **6 inches (150 mm)**.
 - 3) Nominal Canister Length: **[18 inches (450 mm)][24 inches (600 mm)][Length indicated on Drawings]**.
- h. Media:
- 1) Activated carbon.
 - 2) Impregnated carbon for corrosive and acid gases.
 - 3) Activated alumina impregnated with 4 percent potassium permanganate.
 - 4) Blended activated carbon and activated alumina impregnated with potassium permanganate.
 - 5) **<Insert media types for specific applications>**.
- i. Pre-Installation Protection: Package each gas-phase filter in a sealed polyethylene bag to prevent unintentional adsorption before installation.
- j. Canister-Style Gas-Phase Filter Holding Frames:
- 1) Holding frames shall be **14-gauge (2-mm)** stainless steel with cylindrical sorbent cylinder mounting perforations.
 - 2) Frame shall be assembled from a single piece of metal and welded at junctures to assure a rigid and durable frame assembly.
 - 3) Each frame shall hold 16 canisters.
 - 4) Frame with prepunched mounting holes for cylindrical filter fastener attachment and open airflow paths.
 - 5) Frame designed for front or back loading.
 - 6) Frame surface shall have a flat sealing surface to ensure a secure sorbent canister mount when matched with sorbent cylinders and sealing gasket.
 - 7) Cylinder to mounting hardware procedure shall form a mechanical connection forming a tight seal that minimizes air bypass.
3. Air-Handling Unit Factory Installation:
- a. Air-handling unit manufacturer shall furnish filters and provide filter holding frames, retaining clips, and filter support structures.
 - b. Furnish filter quantity, size, type, and performance indicated on Drawings.
 - c. Install filter frames in a flat vertical position for horizontal airflow.
 - d. Install holding frames in accordance with manufacturer's written instructions and to prevent passage of unfiltered air. Include additional gaskets as necessary.
 - e. Construct stainless steel support structure to hold frames and filters.
- 1) Design support structure for weight of gas-phase filters and maximum system operating pressures encountered equal to fan shutoff pressure.
 - 2) Design and fabricate support structure to limit deflection across filter bank to 1/360 of the span when subjected to a **[800-lb (3559-N)]<Insert value>** lateral force applied at any point on the filter holding frame assembly.

BB. Filter Gauges:

1. Basis-of-Design Product: Subject to compliance with requirements, provide the following:
 - a. Gauge: **<Insert manufacturer's name; product name or designation>**.
 - b. Vent Valves: **<Insert manufacturer's name; product name or designation>**.
 - c. Static Pressure Sensors: **<Insert manufacturer's name; product name or designation>**.
 - d. Tubing Compression Fittings: **<Insert manufacturer and product name or designation>**.
2. Provide a gauge to indicate pressure differential between entering and leaving side of each filter bank. Panel filter bank separate from cartridge filter bank.
 - a. Where multiple filters share a common frame, include a separate gauge for each filter bank.
 - b. Include a metal spacer constructed of same material as filter frame for one of the filters installed in filter bank to accommodate pressure differential measure across both upstream and downstream filters.
3. Gauge shall have a nominal **4-inch- (100-mm-)** diameter face.
4. Select range of gauge to be approximately **[twice][three times]<Insert range>** the dirty filter pressure drop.
5. Provide each gauge with vent valves to allow for re-zeroing the gauge without removing tubing connections.
6. Include static pressure sensors on entering and leaving side of each filter bank.
7. Air-Handling Unit Factory Assembly:
 - a. Mount each filter gauge on exterior surface of unit casing near associated filter sections.
 - b. Mount center of gauges **[60 inches (1500 mm)]<Insert distance>** above bottom of air-handling unit structural base.
 - c. Connect static pressure sensors to filter gauges using **[aluminum][copper][or][stainless steel]** tubing and compression type fittings.
 - d. Support tubing at intervals not greater than **[60 inches (1500 mm)]<Insert distance>** o.c.

CC. Automatic Dampers:

1. General: Provide air-handling units with automatic dampers where indicated on Drawings.
 - a. Unless otherwise indicated, use parallel-blade configuration for two-position control, for equipment isolation service, and when mixing two airstreams. For other applications, use opposed-blade configuration.
 - b. Factory assemble multiple damper sections to provide a single damper assembly of size required by application.
 - c. Damper actuator shall be factory installed by damper manufacturer as integral part of damper assembly. Coordinate actuator location and mounting requirements with damper manufacturer.
2. Rectangular Dampers with Aluminum Blades:
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - 2) **[Greenheck Fan Corporation]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **[TAMCO (T. A. Morrison & Co. Inc.)]**

- 5) <Insert manufacturer's name>
- b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1) [American Warming and Ventilating (AWV); Mestek, Inc.]
 - 2) [Greenheck Fan Corporation]
 - 3) [Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]
 - 4) [TAMCO (T. A. Morrison & Co. Inc.)]
 - 5) <Insert manufacturer's name>
- c. Source Limitations: Obtain dampers from single source from single manufacturer.
- d. Performance:
 - 1) Leakage: AMCA 511, Class 1A. Leakage shall not exceed **3 cfm/sq. ft. (15.2 L/s per sq. m)** against **1-inch wg (250-Pa)** differential static pressure.
 - 2) Pressure Drop: **0.05 inch wg (12.5 Pa)** at **1500 fpm (7.6 m/s)** across a **24-by-24-inch (600-by-600-mm)** damper when tested in accordance with AMCA 500-D, figure 5.3.
 - 3) Velocity: Up to **[4000 fpm (20 m/s)][6000 fpm (30 m/s)]**.
 - 4) Temperature: **Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C)**.
 - 5) Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.
 - 6) Damper shall have AMCA seal for both air leakage and air performance.
- e. Construction:
 - 1) Frame:
 - a) Material: ASTM B211, Alloy 6063 T5 extruded-aluminum profiles, **0.07 inch (1.8 mm)** thick.
 - b) Hat-shaped channel with integral flange(s). Flange mating face shall be a minimum of **1 inch (25 mm)**.
 - c) Width not less than **5 inches (125 mm)**.
 - 2) Blades:
 - a) Hollow, airfoil, extruded aluminum.
 - b) Parallel- or opposed-blade configuration as required by application.
 - c) Material: ASTM B211, Alloy 6063 T5 aluminum, **0.07 inch (1.8 mm)** thick.
 - d) Width not to exceed **6 inches (150 mm)**.
 - e) Length as required by close-off pressure, not to exceed **48 inches (1200 mm)**.
 - 3) Seals:
 - a) Blades: Replaceable, mechanically attached extruded silicone, vinyl, or plastic composite.
 - b) Jamb: Stainless steel, compression type; **or replaceable, mechanically attached extruded silicone**.
 - 4) Axles: **0.5-inch- (13-mm-)** diameter, **[plated][or][stainless]** steel, mechanically attached to blades.
 - 5) Bearings:



- a) Molded synthetic or stainless steel sleeve mounted in frame.
 - b) Where blade axles are installed in vertical position, include thrust bearings.
- 6) Linkage:
 - a) Concealed in frame.
 - b) Constructed of aluminum and **[plated][or][stainless]** steel.
 - c) Hardware: Stainless steel.
- 7) Additional Corrosion Protection for Corrosive Environments:
 - a) Include anodized finish for aluminum surfaces in contact with airstream. Anodized finish shall be a minimum of **0.0007 inch (0.018 mm)** thick.
 - b) Axles, damper linkage, and hardware shall be constructed of Type 316L grade stainless steel.
- f. Airflow Measurement: Where indicated, include damper assembly with integral airflow monitoring.
 - 1) Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - b) **<Insert manufacturer's name>**
 - 2) Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - b) **<Insert manufacturer's name>**
 - 3) Source Limitations: Obtain damper applications from single source from single manufacturer.
 - 4) Performance:
 - a) Zero- to 10-V dc or 4- to 20-mA scaled output signal for remote monitoring of actual airflow.
 - b) Accuracy shall be within 5 percent of actual flow rate between the range of minimum and design airflow. For applications with a large variation in range between the minimum and design airflow, configure damper sections and flow measurement assembly as required to comply with stated accuracy over the entire modulating range.
 - c) Include a straightening device as part of flow measurement assembly to achieve the specified accuracy with configuration indicated.
 - d) Suitable for operation in untreated and unfiltered air.
 - e) Include temperature and altitude compensation and correction to maintain accuracy over temperature range encountered at site altitude.
 - f) Include automatic zeroing feature.
- g. Airflow Control: Where indicated, provide damper assembly with integral airflow measurement and control.

- 1) Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - b) **<Insert manufacturer's name>**
- 2) Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - b) **<Insert manufacturer's name>**
- 3) Source Limitations: Obtain damper assembly from single source from single manufacturer.
- 4) Performance:
 - a) A factory-furnished and -calibrated controller shall be programmed, in nonvolatile EPROM, with application-specific airflow set point and range.
 - b) Controller and actuator shall communicate to control the desired airflow.
 - c) Controller shall receive a zero- to 10-V dc input signal and report a zero- to 20-mA output signal that is proportional to airflow.
 - d) Airflow measurement and control range shall be suitable for operation between **150 to 2000 fpm (0.8 to 10 m/s)**.
 - e) Ambient Operating Temperature Range: **Minus 40 to plus 140 deg F (Minus 40 to plus 60 deg C)**.
 - f) Ambient Operating Humidity Range: 5 to 95 percent relative humidity, noncondensing.
 - g) Provide unit with control transformer rated for not less than 85 VA. Include transformer with primary and secondary protection and primary disconnecting means. Coordinate requirements with field power connection.
 - h) Include screw terminals for interface to field wiring.
 - i) Factory mount electronics within a NEMA 250, Type 1 painted steel enclosure.
3. Rectangular Dampers with Insulated Aluminum Blades:
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - 2) **[Greenheck Fan Corporation]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **[TAMCO (T. A. Morrison & Co. Inc.)]**
 - 5) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - 2) **[Greenheck Fan Corporation]**

- 3) [Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]
 - 4) [TAMCO (T. A. Morrison & Co. Inc.)]
 - 5) <Insert manufacturer's name>
- c. Source Limitations: Obtain dampers from single source from single manufacturer.
- d. General: Unless otherwise indicated on Drawings, install insulated aluminum blade dampers in applications where dampers close to outdoors.
- e. Performance:
- 1) Leakage: AMCA 511, Class 1A. Leakage shall not exceed **3 cfm/sq. ft. (15.2 L/s per sq. m)** against **1-inch wg (250-Pa)** differential static pressure and shall not exceed **4.9 cfm/sq. ft. (25 L/s per sq. m)** against **4-inch wg (1000-Pa)** differential static pressure at **minus 40 deg F (minus 40 deg C)**.
 - 2) Pressure Drop: **0.1 inch wg (25 Pa)** at **1500 fpm (7.6 m/s)** across a **24-by-24-inch (600-by-600-mm)** damper when tested in accordance with AMCA 500-D, figure 5.3.
 - 3) Velocity: Up to **4000 fpm (20 m/s)**.
 - 4) Temperature: **Minus 100 to plus 185 deg F (Minus 73 to plus 85 deg C)**.
 - 5) Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.
 - 6) Damper shall have AMCA seal for both air leakage and air performance.
- f. Construction:
- 1) Frame:
 - a) Material: ASTM B211, Alloy 6063 T5 extruded-aluminum profiles, **0.08 inch (2.0 mm)** thick.
 - b) C-shaped channel with integral flange(s). Mating face shall be a minimum of **1 inch (25 mm)**.
 - c) Width not less than **4 inches (100 mm)**.
 - d) Entire frame shall be thermally broken by means of polyurethane resin pockets, complete with thermal cuts.
 - 2) Blades:
 - a) Hollow shaped, extruded aluminum.
 - b) Blades shall be internally insulated with expanded polyurethane foam and shall be thermally broken. Complete blade shall have an insulating factor of R-2.29 and a temperature index of 55.
 - c) Parallel- or opposed-blade configuration as required by application.
 - d) Material: ASTM B211, Alloy 6063 T5 aluminum, **0.08 inch (2.0 mm)** thick.
 - e) Width not to exceed **6 inches (150 mm)**.
 - f) Length as required by close-off pressure, not to exceed **48 inches (1200 mm)**.
 - 3) Seals: Blade and frame seals shall be of flexible silicone and secured in an integral slot within the aluminum extrusions. [**Option to use stainless steel compression-type frame seals.**].
 - 4) Axles: **0.44-inch- (11-mm-)** diameter [plated][or][stainless] steel, mechanically attached to blades.
 - 5) Bearings:
 - a) Bearings shall be composed of a celcon inner bearing fixed to axle, rotating within a polycarbonate outer bearing inserted in the frame, resulting in no metal-to-metal or metal-to-plastic contact.

- b) Where blade axles are installed in vertical position, include thrust bearings.
- 6) Linkage:
 - a) Concealed in frame.
 - b) Constructed of aluminum and **[plated][or][stainless]** steel.
 - c) Hardware: Stainless steel.
- 7) Additional Corrosion Protection for Corrosive Environments:
 - a) Include anodized finish for aluminum surfaces in contact with airstream. Anodized finish shall be a minimum of **0.0007 inch (0.018 mm)** thick.
 - b) Axles, damper linkage, and hardware shall be constructed of Type 316L stainless steel.
- 4. Industrial-Duty Rectangular Dampers with Steel Airfoil Blades:
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - 2) **[Greenheck Fan Corporation]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - 2) **[Greenheck Fan Corporation]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain dampers from single source from single manufacturer.
 - d. Performance:
 - 1) Leakage: Leakage shall not exceed **3 cfm/sq. ft. (15.2 L/s per sq. m)** against **1-inch wg (250-Pa)** differential static pressure.
 - 2) Pressure Drop: **0.06 inch wg (15 Pa)** at **2000 fpm (10 m/s)** across a **48-by-48-inch (1200-by-1200-mm)** damper when tested in accordance with AMCA 500-D, figure 5.3.
 - 3) Velocity: Up to **4000 fpm (20 m/s)**.
 - 4) Temperature: **Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C)**.
 - 5) Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length, minimum **10 inches wg (2500 Pa)**.
 - e. Construction:
 - 1) Frame:
 - a) Material: **[Galvanized steel][Type 304 stainless steel][or][Type 316L stainless steel]**, minimum **0.11 inch (2.8 mm)** thick.

- b) C-shaped channel with mating face minimum of **1 inch (25 mm)**.
 - c) Width not less than **[3 inches (75 mm)][blade width plus 2 inches (50 mm)]**.
 - 2) Blades: Hollow, airfoil shape; constructed of **[galvanized steel][Type 304 stainless steel][Type 316L stainless steel]**, minimum **0.06 inch (1.6 mm)** thick.
 - a) Width not to exceed **[6 inches (150 mm)][8 inches (200 mm)]**.
 - b) Length not to exceed **[36 inches (900 mm)][48 inches (1200 mm)][60 inches (1500 mm)]**.
 - 3) Seals:
 - a) Blades: Replaceable, mechanically attached EPDM or extruded silicone.
 - b) Jams: Stainless steel, double compression type.
 - 4) Axles: **0.5- or 0.75-inch- (13- or 19-mm-)** diameter **[plated][Type 304 stainless][or][Type 316 stainless]** steel, mechanically attached to blades **[and continuous from end to end]**.
 - 5) Bearings:
 - a) Stainless steel sleeve type mounted in frame.
 - b) Where blade axles are installed in vertical position, provide thrust bearings.
 - 6) Linkage:
 - a) Face linkage exposed to airstream.
 - b) Constructed of **[plated steel][Type 304 stainless steel][or][Type 316 stainless steel]**.
 - c) Hardware: **[Type 304][or][Type 316]** stainless steel.
- 5. Damper Actuators:
 - a. General:
 - 1) Actuators shall operate related damper(s) with sufficient reserve power to provide smooth modulating action or two-position action and proper speed of response at velocity and pressure conditions to which damper is subjected.
 - 2) Actuators shall produce sufficient power and torque to close off against the maximum system pressures encountered. Actuators shall be sized to close off against the fan shutoff pressure as a minimum requirement.
 - 3) Total damper area operated by an actuator shall not exceed 80 percent of manufacturer's maximum area rating.
 - 4) Include one actuator for each damper assembly where possible. Multiple actuators required to drive a single damper assembly shall operate in unison.
 - 5) Avoid use of excessively oversized actuators, which could overdrive and cause linkage failure when the damper blade has reached either its full open or closed position.
 - 6) Use jackshafts and shaft couplings in lieu of blade-to-blade linkages when driving axially aligned damper sections.
 - 7) Include mounting hardware and linkages for connecting actuator to damper.
 - 8) Select actuators to fail in desired position in the event of a power failure.
 - 9) Actuator Fail Positions: **[See Drawings.][As indicated below:]**
 - a) Exhaust Air: **[Close][Last position][Open]**.
 - b) Outdoor Air: **[Close][Last position][Open]**.

- c) Supply Air: **[Close][Last position][Open]**.
 - d) Return Air: **[Close][Last position][Open]**.
 - e) **<Insert system and fail position>**.
- b. Type: Motor operated, with or without gears, electric and electronic.
- c. Voltage:
 - 1) **[See Drawings][Voltage selection is delegated to professional designing control system][24 V][120 V]<Insert requirement>**.
 - 2) Actuator shall deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.
 - 3) Actuator shall function properly within a range of 85 to 120 percent of nameplate voltage.
- d. Construction:
 - 1) Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.
 - 2) 100 up to 400 W: Gears ground steel, oil immersed, shaft-hardened steel running in bronze, copper alloy, or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel, or cast-aluminum housing.
 - 3) Greater Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.
- e. Field Adjustment:
 - 1) Spring return actuators shall be easily switchable from fail open to fail closed in the field without replacement.
 - 2) Provide gear-type actuators with an external manual adjustment mechanism to allow manual positioning of the damper when actuator is not powered.
- f. Two-Position Actuators: Single direction, spring return, or reversing type.
- g. Modulating Actuators:
 - 1) Capable of stopping at all points across full range, and starting in either direction from any point in range.
 - 2) Control Input Signal:
 - a) Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for **[0- to 10-][or][2- to 10-]V dc [and][4- to 20-mA]** signals.
 - b) Pulse-Width Modulation (PWM): Actuator drives to a specified position in accordance with a pulse duration (length) of signal from a dry-contact closure, triac sink, or source controller.
 - c) Programmable Multifunction:
 - d) Control input, position feedback, and running time shall be factory or field programmable.
 - e) Diagnostic feedback of hunting or oscillation, mechanical overload, mechanical travel, and mechanical load limit.
 - f) Service data, including at a minimum, number of hours powered, and number of hours in motion.
- h. Position Feedback:
 - 1) **[Equip][Where indicated, equip]** two-position actuators with limits switches or other positive means of a position indication signal for remote monitoring of

- 2) [open][and][close] position.
 - 2) [Equip][Where indicated, equip] modulating actuators with a position feedback through [current][or][voltage] signal for remote monitoring.
 - 3) Include a position indicator and graduated scale on each actuator indicating open and closed travel limits.
- i. Fail-Safe:
- 1) Where indicated, provide actuator to fail to an end position.
 - 2) Internal spring return mechanism to drive-controlled device to an end position (open or close) on loss of power.
 - 3) Batteries, capacitors, and other non-mechanical forms of fail-safe operation are acceptable only where uniquely indicated.
- j. Integral Overload Protection:
- 1) Provide against overload throughout the entire operating range in both directions.
 - 2) Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.
- k. Damper Attachment:
- 1) Unless otherwise required for damper interface, provide actuator designed to be directly coupled to damper shaft without need for connecting linkages.
 - 2) Attach actuator to damper drive shaft in a way that ensures maximum transfer of power and torque without slippage.
 - 3) Bolt and setscrew method of attachment is acceptable only if included with at least two points of attachment.
- l. Temperature and Humidity:
- 1) Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of [minus 20 to plus 120 deg F (minus 29 to plus 49 deg C)]<Insert temperature range>.
 - 2) Humidity: Suitable for humidity range encountered by application; minimum operating range shall be from [5 to 95]<Insert numbers> percent relative humidity, noncondensing.
- m. Enclosure:
- 1) Suitable for ambient conditions encountered by application.
 - 2) Provide actuator enclosure with a heater and controller where required by application.
 - 3) NEMA 250, Type 2 for all applications except <Insert applications>.
 - 4) NEMA 250, Type 4 or Type 4X for <Insert applications> applications.
- n. Stroke Time: Select operating speed to be compatible with equipment and system operation.
- 1) Operate damper from fully closed to fully open within [15][60][75][90][150]<Insert number> seconds.
 - 2) Operate damper from fully open to fully closed within [15][60][75][90][150]<Insert number> seconds.
 - 3) Move damper to failed position within [5][15][30]<Insert number> seconds.
 - 4) Actuators operating in smoke-control systems shall comply with governing code and

NFPA requirements.

o. Sound:

- 1) Spring Return: 62 dBA.
- 2) Non-Spring Return: 45 dBA.

DD. Manual Balancing Dampers:

1. General: Air-handling unit manufacturer shall furnish and factory install manual balancing dampers inside air-handling units where indicated on Drawings.
2. Rectangular Manual Balancing Dampers with Aluminum Airfoil Blades:
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) **[Greenheck Fan Corporation]**
 - 2) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 3) **[TAMCO (T. A. Morrison & Co. Inc.)]**
 - 4) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Greenheck Fan Corporation]**
 - 2) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 3) **[TAMCO (T. A. Morrison & Co. Inc.)]**
 - 4) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain dampers from single source from single manufacturer.
 - d. Performance:
 - 1) Leakage: AMCA 511, Class 1A. Leakage shall not exceed **3 cfm/sq. ft. (15.2 L/s per sq. m)** against **1-inch wg (250-Pa)** differential static pressure.
 - 2) Pressure Drop: **0.05 inch wg (12.5 Pa)** at **1500 fpm (7.6 m/s)** across a **24-by-24-inch (600-by-600-mm)** damper when tested in accordance with AMCA 500-D, figure 5.3.
 - 3) Velocity: Up to **6000 fpm (30 m/s)**.
 - 4) Temperature: **Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C)**.
 - 5) Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.
 - 6) Damper shall have AMCA seal for both air leakage and air performance.
 - e. Construction:
 - 1) Frame:
 - a) Material: ASTM B211, Alloy 6063 T5 extruded-aluminum profiles, **0.07 inch (1.8 mm)** thick.
 - b) Hat-shaped channel with integral flange(s). Flange mating face shall be a minimum of **1 inch (25 mm)**.
 - c) Width not less than **5 inches (125 mm)**.

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- 2) Blades:
 - a) Hollow, airfoil, extruded aluminum.
 - b) Parallel- or opposed-blade configuration as required by application.
 - c) Material: ASTM B211, Alloy 6063 T5 aluminum, **0.07 inch (1.8 mm)** thick.
 - d) Width not to exceed **6 inches (150 mm)**.
 - e) Length as required by close-off pressure, not to exceed **48 inches (1200 mm)**.
 - 3) Seals:
 - a) Blades: Replaceable, mechanically attached extruded silicone, vinyl, or plastic composite.
 - b) Jams: Stainless steel, compression type.
 - 4) Axles: **0.5-inch- (13-mm-)** diameter **[plated][or][stainless]** steel, mechanically attached to blades.
 - 5) Bearings:
 - a) Molded synthetic or stainless steel sleeve mounted in frame.
 - b) Where blade axles are installed in vertical position, include thrust bearings.
 - 6) Linkage:
 - a) Concealed in frame.
 - b) Constructed of aluminum and **[plated][or][stainless]** steel.
 - c) Hardware: Stainless steel.
 - 7) Locking Regulator:
 - a) Aluminum or stainless steel standoff with locking regulator mounted to frame in an accessible location for manual adjustment of damper blades.
 - 8) Additional Corrosion Protection for Corrosive Environments:
 - a) Provide anodized finish for aluminum surfaces in contact with airstream. Anodized finish shall be a minimum of **0.0007 inch (0.018 mm)** thick.
 - b) Axles, damper linkage, and hardware shall be constructed of Type 316L stainless steel.
 3. Industrial-Duty Manual Balancing Dampers with Airfoil Blades:
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - 2) **[Greenheck Fan Corporation]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- 1) **[American Warming and Ventilating (AWV); Mestek, Inc.]**
 - 2) **[Greenheck Fan Corporation]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **<Insert manufacturer's name>**
- c. Source Limitations: Obtain dampers from single source from single manufacturer.
- d. Performance:
- 1) Leakage: Leakage shall not exceed **3 cfm/sq. ft. (15.2 L/s per sq. m)** against **1-inch wg (250-Pa)** differential static pressure.
 - 2) Pressure Drop: **0.06 inch wg (15 Pa)** at **2000 fpm (10 m/s)** across a **48-by-48-inch (1200-by-1200-mm)** damper when tested in accordance with AMCA 500-D, figure 5.3.
 - 3) Velocity: Up to **4000 fpm (20 m/s)**.
 - 4) Temperature: **Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C)**.
 - 5) Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length, minimum **10 inches wg (2500 Pa)**.
- e. Construction:
- 1) Frame:
 - a) Material: **[Galvanized steel][Type 304 stainless steel][or][Type 316L stainless steel]**, minimum **0.11 inch (2.8 mm)** thick.
 - b) C-shaped channel with mating face minimum of **1 inch (25 mm)**.
 - c) Width not less than **[3 inches (75 mm)][blade width plus 2 inches (50 mm)]**.
 - 2) Blades: Hollow, airfoil shape; constructed of **[galvanized steel][Type 304 stainless steel][Type 316L stainless steel]**, minimum **0.06 inch (1.6 mm)** thick.
 - a) Width not to exceed **[6 inches (150 mm)][8 inches (200 mm)]**.
 - b) Length not to exceed **[36 inches (900 mm)][48 inches (1200 mm)][60 inches (1500 mm)]**.
 - 3) Seals:
 - a) Blades: Replaceable, mechanically attached EPDM or extruded silicone.
 - b) Jams: Stainless steel, double compression type.
 - 4) Axles: **0.5- or 0.75-inch- (13- or 19-mm-)** diameter **[plated][Type 304 stainless][or][Type 316 stainless]** steel, mechanically attached to blades **[and continuous from end to end]**.
 - 5) Bearings:
 - a) Stainless steel sleeve type mounted in frame.
 - b) Where blade axles are installed in vertical position, provide thrust bearings.
 - 6) Linkage:
 - a) Face linkage exposed to airstream.
 - b) Constructed of **[plated steel][Type 304 stainless steel][or][Type 316 stainless steel]**.
 - c) Hardware: **[Type 304][or][Type 316]** stainless steel.
 - 7) Locking Regulator:

- a) Stainless steel standoff with locking regulator mounted to frame in an accessible location for manual adjustment of damper blades.

EE. Smoke Dampers:

1. General: Air-handling unit manufacturer shall furnish and factory install smoke dampers inside air-handling units where indicated on Drawings.
2. Rectangular Smoke Dampers with Aluminum Blades:
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) **[Greenheck Fan Corporation]**
 - 2) **[Nailor Industries Inc]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **[TAMCO (T. A. Morrison & Co. Inc.)]**
 - 5) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Greenheck Fan Corporation]**
 - 2) **[Nailor Industries Inc]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **[TAMCO (T. A. Morrison & Co. Inc.)]**
 - 5) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain dampers from single source from single manufacturer.
 - d. General: Air-handling unit manufacturer shall furnish and factory install smoke dampers inside air-handling units where indicated on Drawings.
 - e. Performance:
 - 1) Leakage: In accordance with UL 555S, Class 1.
 - 2) Pressure Drop: **0.05 inch wg (12.5 Pa) at 1500 fpm (7.6 m/s)** across a **24-by-24-inch (600-by-600-mm)** damper when tested in accordance with AMCA 500-D, figure 5.3.
 - 3) Velocity: Up to **4000 fpm (20 m/s)**.
 - 4) Temperature: **250 deg F (121 deg C)**.
 - 5) Pressure Rating: **8.0 inches wg (2000 Pa)**.
 - f. Certification: NRTL listed and labeled in accordance with UL 555S, Class 1.
 - g. Construction:
 - 1) Frame:
 - a) Material: ASTM B211, Alloy 6063 T5 extruded-aluminum profiles, **0.07 inch (1.8 mm)** thick.
 - b) Hat-shaped channel with integral flange(s). Flange mating face shall be a minimum of **1 inch (25 mm)**.
 - c) Width not less than **5 inches (125 mm)**.
 - 2) Blades:

- a) Hollow, extruded airfoil shape.
 - b) Material: ASTM B211, Alloy 6063 T5 aluminum, **0.07 inch (1.8 mm)** thick.
 - c) Width not to exceed **6 inches (150 mm)**.
 - d) Length as required by close-off pressure, not to exceed **48 inches (1200 mm)**.
 - 3) Seals:
 - a) Blades: Replaceable, mechanically attached extruded silicone.
 - b) Jambs: Stainless steel, compression type.
 - 4) Axles: **0.5-inch- (13-mm-)** diameter **[plated][or][stainless]** steel, mechanically attached to blades.
 - 5) Bearings:
 - a) Molded synthetic or stainless steel sleeve mounted in frame.
 - b) Where blade axles are installed in vertical position, include thrust bearings.
 - 6) Linkage:
 - a) Concealed in frame.
 - b) Constructed of aluminum and **[plated][or][stainless]** steel.
 - c) Hardware: Stainless steel.
3. Rectangular Smoke Dampers with Galvanized-Steel Blades:
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Greenheck Fan Corporation]**
 - 2) **[Nailor Industries Inc]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Greenheck Fan Corporation]**
 - 2) **[Nailor Industries Inc]**
 - 3) **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - 4) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain dampers from single source from single manufacturer.
 - d. General: Air-handling unit manufacturer shall furnish and factory install smoke dampers inside air-handling units where indicated on Drawings.
 - e. Performance:
 - 1) Leakage: In accordance with UL 555S, Class 1.
 - 2) Pressure Drop: **0.07 inch wg (17.5 Pa)** at **1500 fpm (7.6 m/s)** across a **24-by-24-inch (600-by-600-mm)** damper when tested in accordance with AMCA 500-D, figure 5.3.
 - 3) Velocity: Up to **4000 fpm (20 m/s)**.
 - 4) Temperature: **250 deg F (121 deg C)**.

- 5) Pressure Rating: **8.0 inches wg (2000 Pa)**.
- f. Certification: NRTL listed and labeled in accordance with UL 555S, Class 1.
- g. Construction:
 - 1) Frame:
 - a) Material: Galvanized steel, minimum **0.06 inch (1.6 mm)** thick.
 - b) Hat-shaped channel with integral flange(s). Flange mating face shall be a minimum of **1 inch (25 mm)**.
 - c) Width not less than **5 inches (125 mm)**.
 - 2) Blades:
 - a) Hollow, airfoil shape.
 - b) Material: Galvanized steel, minimum **0.06 inch (1.6 mm)** thick.
 - c) Width not to exceed **6 inches (150 mm)**.
 - d) Length as required by close-off pressure, not to exceed **48 inches (1200 mm)**.
 - 3) Seals:
 - a) Blades: Replaceable, mechanically attached extruded silicone.
 - b) Jambs: Stainless steel, compression type.
 - 4) Bearings:
 - a) Stainless steel sleeve type mounted in frame.
 - b) Where blade axles are installed in vertical position, include thrust bearings.
 - 5) Linkage:
 - a) Concealed in frame.
 - b) Constructed of galvanized steel.
 - c) Hardware: Steel with corrosion-resistant finish.
- h. Actuator:
 - 1) Type: Electric, with electrical characteristics compatible with field power supply.
 - 2) Action: **[See Drawings][modulating][or][two position]**.
 - 3) Control Signal: Individual damper assemblies with multiple actuators shall be factory wired to operate in unison from a single control signal.
 - 4) Fail Position: Closed or open, as indicated on Drawings.
 - 5) Mounting on Damper: External.
 - 6) Quantity: Provide each damper assembly with least number of actuators possible for application.
 - 7) Speed of Response:
 - a) Damper blade operation shall have a controlled movement of at least 5 seconds when travelling from open to close to reduce the potential for damage to duct system and connected equipment.
 - b) Damper closure shall not be instantaneous under any condition.
 - c) Operating time for completion of 90-degree damper travel, from open to close, or from close to open, shall not exceed the more stringent of the following: NFPA references indicated, governing codes, **[15 seconds]<Insert time>**.

i. Blade Position Switches:

- 1) Provide damper assemblies with limit switches to provide remote indication of damper blade positions.
- 2) Provide separate limit switches for remote indication of damper blade open position and damper blade closed position.
- 3) Actuators equipped with remote position indication as an integral part of actuator is acceptable in lieu of separate limit switches only if actuator with integral remote position indication is NRTL listed in accordance with UL 555S.

FF. Duct Silencers:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Dynasonics]**
 - b. **[IAC Acoustics]**
 - c. **[Price Industries Limited]**
 - d. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - e. **[Vibro-Acoustics]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Dynasonics]**
 - b. **[IAC Acoustics]**
 - c. **[Price Industries Limited]**
 - d. **[Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.]**
 - e. **[Vibro-Acoustics]**
 - f. **<Insert manufacturer's name>**
3. Duct Silencer Sourcing Option: In lieu of sourcing duct silencers from a specialty duct silencer manufacturer, air-handling unit manufacturer has option to furnish in-house silencers that achieve equal or better performance while complying with other requirements indicated.
 - a. Full-height duct silencers baffles shall span from floor to roof of air-handling unit air tunnel and consist of multiple baffles aligned to fill the entire cross-sectional area of air-handling unit air tunnel. In this alternative, the air-handling unit casing shall serve as the duct silencer casing.
4. General: Air-handling unit manufacturer shall furnish and install duct silencers and associated support structures inside air-handling units where indicated on Drawings.
 - a. Unless otherwise indicated on Drawings, select face area of silencers to fill the entire cross-sectional area of air-handling unit air tunnel.
 - b. Silencer Type: **[Dissipative][Reactive (packless)][Type, either dissipative or reactive (packless), indicated on Drawings]**.
 - c. Factory fabricated.
 - d. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials with flame-spread index not exceeding 25 and smoke-developed index not exceeding 50; ASTM E84.
 - e. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in

ASHRAE 62.1.

5. Ratings and Performance:
 - a. Duct silencer manufacturer shall publish performance for dynamic insertion loss (DIL), self-noise power levels, and airflow static pressure loss based on results of performance testing indicated.
 - b. Duct silencer manufacturer shall test duct silencers in accordance with ASTM E477 in a qualified nationally recognized independent testing laboratory or manufacturer's National Voluntary Lab Accreditation Program accredited laboratory.
 - 1) Conduct tests with air flowing through duct silencers at not less than three different flow rates and with no airflow.
 - 2) Test methods shall eliminate effects due to end reflection, vibration, flanking transmission, and standing waves in the test chamber.
 - c. DIL is not less than values indicated on Drawings.
 - d. Silencer self-generated noise shall not increase system sound level.
 - e. Static pressure loss not to exceed values indicated on Drawings.
 - f. Structural Performance:
 - 1) Design casing for differential air pressure of **8 inches wg (2000 Pa)** between.
 - 2) Reinforce duct silencer casing to limit deflection to 1/200 of span.
6. Construction: Fabricate rectangular silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations. Do not use mechanical fasteners for individual unit assemblies.
 - a. Casing:
 - 1) Unless otherwise indicated, construct outer casing in accordance with ASHRAE and SMACNA standards for construction of high-pressure rectangular ductwork.
 - 2) Casing seams and joints shall be lock formed and mastic filled, or continuously welded.
 - 3) Materials and Thicknesses, Aluminum, ASTM B209 (ASTM B209M) Alloy 3003-1114, Smooth Finish:
 - a) Outer Casing: Solid, minimum **[0.040 inch (1.0 mm)][0.063 inch (1.6 mm)]<Insert dimension>** thick.
 - b) Baffles: Perforated, minimum **[0.032 inch (0.8 mm)][0.040 inch (1.0 mm)]<Insert dimension>** thick for sizes through **[24 inches (600 mm)]<Insert dimension>** tall and **[0.040 inch (1.0 mm)][0.063 inch (1.6 mm)]<Insert dimension>** thick for larger sizes.
 - 4) Materials and Thicknesses, Galvanized Steel, ASTM A653/A653M, G60 (Z180) or G90 (Z275) Finish:
 - a) Outer Casing: Solid, minimum **[20 gauge (1.0 mm)][22 gauge (0.8 mm)]<Insert thickness>** thick.
 - b) Baffles: Perforated, minimum **[24 gauge (0.7 mm)][26 gauge (0.5 mm)]<Insert thickness>** for sizes through **[24 inches (600 mm)]<Insert dimension>** tall and **[20 gauge (1.0 mm)][22 gauge (0.8 mm)]<Insert thickness>** for larger sizes.
 - 5) Materials and Thicknesses, Stainless Steel, ASTM A240/A240M or ASTM

A480/A480M:

- a) Outer Casing: Solid, minimum [20 gauge (1.0 mm)][22 gauge (0.8 mm)]<Insert thickness> thick.
 - b) Baffles: Perforated, minimum [24 gauge (0.6 mm)][26 gauge (0.5 mm)]<Insert thickness> for sizes through [24 inches (600 mm)]<Insert dimension> tall and [20 gauge (1.0 mm)][22 gauge (0.8 mm)]<Insert thickness> for larger sizes.
- 6) Duct Silencer Material Applications:
- a) Exhaust Air, General: [Aluminum][Galvanized steel][Type 304L stainless steel][or][Type 316L stainless steel].
 - b) Exhaust Air, Hazardous: [Aluminum][Galvanized steel][Type 304L stainless steel][or][Type 316L stainless steel].
 - c) Mixed Air: [Aluminum][Galvanized steel][Type 304L stainless steel][or][Type 316L stainless steel].
 - d) Outdoor Air: [Aluminum][Galvanized steel][Type 304L stainless steel][or][Type 304 stainless steel].
 - e) Return Air: [Aluminum][Galvanized steel][Type 304L stainless steel][or][Type 316L stainless steel].
 - f) Supply Air: [Aluminum][Galvanized steel][Type 304L stainless steel][or][Type 316L stainless steel].
 - g) <Insert material application>.
- b. Dissipative-Type Duct Silencer Fill Materials:
- 1) Inert, vermin-proof, and moisture-proof inorganic mineral or glass fiber of a density sufficient to obtain the acoustic performance indicated. Fiber-free fill materials are an acceptable alternative to fiber fill materials if complying with other requirements.
 - 2) Pack fill under not less than [5]<Insert number> percent compression.
 - 3) Fill material and coverings shall not exceed the following values when tested in accordance with ASTM E84, NFPA 255, and UL 723:
 - a) Flame-Spread Index: 25.
 - b) Smoke-Developed Index: 50.
 - c) Fuel Contribution: 20.
 - 4) Protective Coverings for Fiber Fill Materials:
 - a) Except for silencers used in exhaust applications completely cover silencer fiber fill materials with a protective covering, such as a tightly woven fiberglass fabric, to prevent particle contamination of airstream without degrading silencer acoustical performance.
 - b) For silencers located in airstreams filtered by absolute filters and where located in potentially hazardous exhaust airstreams, enclose the fiber fill material in a polymer sheeting to prevent contaminating air stream without impacting air cleanliness and hygiene. Offset polymer sheeting with honeycomb standoff to prevent polymer sheeting from coming in direct contact with perforated baffles.
- c. Reactive-Type (Packless) Duct Silencer Baffles: Controlled impedance membranes and broadly tuned resonators without absorptive fill material.
- d. Removable Baffles: Design and construct baffles to be easily removable for purposes of cleaning and replacement.

7. Factory Assembly:

- a. Install duct silencers in correct direction with respect to airflow.
- b. Manufacturer's written installation instructions shall not be compromised.
- c. Seal penetrations through duct silencer baffles using a sealant.
- d. Install duct silencers with baffles oriented in the vertical position.
- e. Duct silencer banks consisting of multiple individual duct silencers shall be as follows:
 - 1) Structurally reinforced to support loading and limit deflection to 1/200 of span.
 - 2) Provided with a continuous nosing to cover all joints of adjoining duct silencers. Nosing shall be constructed of same material as duct silencers and attached by friction fit, crimping, or button punch.
 - 3) Fastened together using **[zinc-plated][or][stainless]** steel sheet metal screws that are spaced at not more than **[6 inches (150 mm)]<Insert dimension>** apart, starting at corners.

8. Cleaning:

- a. After assembly, clean duct silencers with HEPA-filtered vacuum machines and then wipe all surfaces with a cleaning agent, using clean rags.

GG. Antimicrobial Ultraviolet (UV) Lamp Systems:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American Ultraviolet]**
 - b. **[Steril-Aire, Inc.]**
 - c. **[UV Resources]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Ultraviolet]**
 - b. **[Steril-Aire, Inc.]**
 - c. **[UV Resources]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain UV lamp systems from single source from single manufacturer.
4. Description: UV-C lamp system consisting of power supply, wiring, lamp(s), plug(s), and holder(s) used for ultraviolet germicidal irradiation (UVGI) of cooling coil and condensate drain pan.
 - a. Factory assembled and engineered by a qualified design professional.
5. Certification: NRTL listed and labeled in accordance with UL 153, UL 1598, and UL 1995; UL Category Code ABQK; HVAC accessories; air-duct mounted.
6. Performance:
 - a. Operating Conditions: Suitable for operation in extreme conditions of the airstream encountered.

- 1) Relative humidity range not less than 5 to 100 percent.
 - 2) Temperature range not less than [34 to 158 deg F (1 to 70 deg C)]<Insert temperature range>.
 - 3) Velocity range not less than [0 to 600 fpm (0 to 3 m/s)]<Insert velocity range>.
- b. Irradiation Intensity:
- 1) Install sufficient quantity of UV-C lamps to provide an average irradiation intensity of [500][1000][2000]<Insert value> microwatts/sq. cm over coil face and exposed surfaces of drain pan.
 - 2) Install sufficient quantity of UVGI fixtures to provide an average irradiation intensity indicated on the Drawings.
 - 3) Submit calculations indicating high, low, and average irradiation intensity level across coil face area and drain pan.
 - 4) Take irradiation intensity measurements of factory assembly before air-handling unit shipment to determine results and confirm compliance with requirements. Document and submit measurement results confirming compliance.
 - 5) Intensity calculations shall be based on an average output over a lamp life of [9000]<Insert number> hours and account for light output degradation over the lamp life.
- c. Lamp Life: Minimum of [9000]<Insert number> hours.
- d. Light Output Degradation: Reduction in light output shall not exceed [15][20]<Insert number> percent of initial lamp output over the rated lamp life.
7. Construction:
- a. Lamps:
- 1) Type: High output, hot cathode; non-ozone producing.
 - 2) Output: UV-C energy, primarily at the 254-nm wavelength with a 360-degree energy distribution.
 - 3) Protective Sleeve: Hermetically sealed to provide protection against lamp breakage and to ensure that lamp contents from a broken lamp are contained.
 - 4) Labeling: Lamp wattage and model number visibly printed on all lamps.
 - 5) Mercury Content: Less than 8 Mg of mercury in each lamp.
 - 6) Lamp Sourcing: Commercially sourced from more than one manufacturer for future replacement. Proprietary lamps available from only one manufacturer are unacceptable.
- b. Lamp Holders:
- 1) UV- and moisture-resistant materials designed to connect the lamp to the plug and ensure a watertight connection.
 - 2) Adjustable positioning.
- c. Wiring Loom: UV-C-resistant jacket materials with internal aluminum/Mylar shield.
- 1) Conduit: Loom covered with NRTL-listed flexible metal conduit, aluminum or stainless steel.
- d. Power Supply: NRTL listed, single phase, 120 or 277 V ac as indicated, with a programmed rapid start.
- 1) Power Factor: High power factor, Class P, Sound Rated A, Type 1 Outdoor, and with inherent thermal protection and without polychlorinated biphenyl.



- 2) Wiring Harness: Plug and play.
 - 3) Electrical Connection: Single electrical connection[**with service disconnect**].
 - e. Enclosures: NEMA 250, [Type 1][Type 4] constructed of [painted carbon steel][stainless steel]<Insert material>.
8. Air-Handling Unit Factory Assembly:
- a. Install UV-C lamp systems in accordance with manufacturer's written instructions.
 - b. Location: Install UV-C lamp system array [immediately downstream of cooling coil bottom drain pan][at locations indicated on Drawings]<Insert location within air-handling unit>.
 - c. UV-C Lamp System Support Assembly: [Aluminum][or][300 series grade stainless steel] framework rigidly attached to air-handling unit casing and adequately braced to provide ridge support of UV-C lamp systems that will not move or damage when leaned on or bumped into by operators.
 - d. Service Access: Lamps shall be easily replaceable from inside the air-handling unit.
 - 1) Install access door(s) with window to access UV light. Treat each window and test to confirm UV emitted through the window is below the threshold limits of NIOSH and ACGIH.
 - 2) If adequate space is unavailable inside air-handling unit, install UV-C lamp systems on a slide out rail to allow lamp replacement from one exterior side of air-handling unit.
 - e. Factory wire UV-C lamp systems internally and terminate at a disconnecting switch on the exterior of the air-handling unit casing.
 - 1) Switch to include a lock-out/tag-out feature.
 - 2) In addition to disconnecting switch, provide each access door accessible to UV-C lamp systems with a position limit switch wired into UV-C lamp systems power circuit to de-energize power to UV-C lamp systems when door is opened.
 - f. Install a caution nameplate at each UV-C lamp systems disconnecting switch that reads: "DANGER, UV LIGHTS - Turn off before entering."
 - g. Protection from UV Damage: Materials in direct or indirect (reflected) contact with UV shall be tested and certified as UV tolerant. Any material not certified shall be completely shielded from UV using a certified UV-tolerant material such as metal. UV tolerance shall be capable of performing intended duty for a minimum of [20]<Insert number> years.
 - h. Shipping: Remove UV-C lamps after factory testing; package and ship UV-C lamps in protective containers for field installation.
 - 1) Label exterior of enclosures with detailed description of container contents, including air-handling unit designation.
 - 2) Ship UV-C lamps for each air-handling unit in separate containers.
9. UV-C Lamp System Irradiance Monitoring:
- a. Sourcing: Furnished by UV-C lamp system manufacturer with UV-C lamp systems.
 - b. General: UVGI monitoring consisting of sensor(s) and controller to measure and locally display UV output irradiance in [absolute output (microwatts/sq. cm)][and][user-defined percentage of relative output]
 - c. Measurement Range: Suitable for highest measured irradiance encountered by application, but not less than [10,000][20,000]<Insert value> microwatts/sq. cm.
 - d. NIST traceable calibration.

- e. Remote Monitoring Signal: 4- to 20-mA output signal for remote monitoring.
10. UV-C Lamp System Status Monitoring:
- a. Sourcing: Furnished by UV-C lamp system manufacturer with UV-C lamp systems.
 - b. Monitors operating status of UV-C lamps by measuring change in electrical current.
 - c. On/off status of lamps displayed by LED lights on face of local display unit.
 - d. Remote Monitoring Signal: On/off status relays for remote monitoring.

HH. Heat Wheels:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Innergy Tech, Inc.]**
 - b. **[SEMCO, LLC; part of FlaktGroup]**
 - c. **[Thermotech Enterprises, Inc.]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Innergy Tech, Inc.]**
 - b. **[SEMCO, LLC; part of FlaktGroup]**
 - c. **[Thermotech Enterprises, Inc.]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain heat wheels from single source from single manufacturer.
4. Performance:
 - a. Heat wheels shall be engineered by manufacturer to provide a highly reliable, low-maintenance product for use under continuous operation over an extended operating period of not less than **[20][25]<Insert number>** years. Provide supporting documentation if requested to show how features of product design comply with performance indicated.
 - b. Products with ratings that exceed indicated pressure drop, fall short of sensible and latent recovery performance indicated, or transfer contaminants in excess of requirements indicated are unacceptable and should not be submitted for review and approval.
 - c. Fully-assembled and -installed heat wheel shall be suitable for use in air systems that supply air to tenant occupied space and shall comply with NFPA 90A and governing building codes.
5. Testing and Certification:
 - a. Thermal Performance: Certification by a qualified independent testing organization documenting the following:
 - 1) Sensible and latent recovery efficiencies conducted in accordance with ASHRAE 84 with results presented in accordance with ASHRAE 84 and AHRI 1060 (I-P) and AHRI 1061 (SI).
 - 2) Sensible, latent, and pressure loss performance over a range of operating points as required by ASHRAE 84 and specifically for actual airflow conditions required by Project.

- b. Cross Contamination: Cross-contamination performance reports to validate compliance with requirements indicated.
 - 1) Independent test report shall document desiccant-coated transfer media exhibits [3][or][4] Angstrom behavior and does not transfer pollutants typically encountered in indoor air environment having room operations and functions indicated.
 - 2) Testing shall be performed in a test facility complying with ASHRAE 84 for tracer gas testing.
 - 3) Challenge gases used for testing shall include chemicals that represent contaminants typically encountered and include at least the following: acetaldehyde, methanol, methyl isobutyl ketone, propane, and xylene <Insert contaminate>.
 - c. Flame and Smoke: NRTL test report listing flame-spread index and smoke-developed index of media when tested in accordance with ASTM E84 to comply with requirements indicated.
 - d. Microbial Resistance: Test report documenting ability of wheel faces and transfer media to actively limit microbial growth.
 - 1) Testing completed by a qualified research institution or testing laboratory using common live bacterial cultures to document antimicrobial performance with 95 percent mortality effectiveness.
 - e. Corrosion Resistance: Test report summarizing acid resistance effectiveness of media face coating completed in accordance with ASTM corrosion-test methodologies.
6. Rotors:
- a. Construct rotor media of aluminum base material precoated with a desiccant before forming into honeycomb media structure consisting of circular spiral layers.
 - b. Aluminum base material shall be at least [0.0015 inch (0.0381 mm)]<Insert dimension> thick before coating.
 - c. Media layers shall be joined together using adhesive to bond between flat and corrugated media layers.
 - d. Media Coating:
 - 1) Coat media surfaces with a non-migrating solid adsorbent desiccant layer before forming into the structure to ensure that all surfaces are coated.
 - 2) Desiccant coating shall be inorganic and use a [3][or][4] Angstrom molecular sieve to achieve desired [3][or][4] Angstrom selectivity, excluding contaminants larger than [3][or][4] Angstroms while effectively transferring water vapor.
 - 3) In addition to desiccant coating applied to aluminum substrate, cover two faces of rotor with a two-part polymer coating specifically chosen for chemical resistance and corrosion protection. Coating shall be selected to provide life expectancy indicated when exposed to airstreams encountered.
 - 4) Media exposed to airstream shall exhibit effective antimicrobial action to protect against development and spread of microbial contaminants.
 - 5) Rotor media with applied coatings and adhesive shall have a flame-spread index of [0]<Insert value> and a smoke-developed index of [5]<Insert value> when tested in accordance with ASTM E84.
 - e. Media depth shall be determined by heat wheel manufacturer to achieve performance indicated.
 - f. Media shall not transfer pollutants typically encountered in an indoor air environment having room operations and functions indicated.
 - g. Media shall be cleanable without degrading performance over time.

- h. Dry particles up to 800 microns shall pass freely through the media.
 - i. Provide segmented rotor media to allow for field installation and replacement of one section at a time without requiring side access. Removal and replacement shall be made while facing rotor media face.
 - j. Rotor media shall be held in place by a rigid structural spoke system made of extruded aluminum.
 - k. Coat exposed surfaces of aluminum spoke system for corrosion protection.
 - l. Rotor structural spoke system shall be designed and manufactured to provide for field installation of media without possibility of media deformation or misfit.
 - m. Media shall be secured within structural spoke system by mechanical means, relying on a formed friction fit without use of adhesives or silicone.
 - n. Rotors that cannot be installed in air-handling units as a single complete factory assembly coming from heat wheel manufacturer shall be remotely assembled by trained factory service personnel that are employed by heat wheel manufacturer.
7. Purge Sector:
- a. Factory-set, field-adjustable purge sector designed to limit cross contamination to less than **[0.04]<Insert number>** percent of that of exhaust airstream concentration into supply airstream.
 - b. Factory-set, field-adjustable purge sector designed to eliminate cross contamination of exhaust airstream into supply airstream.
8. Seals:
- a. Maintenance-free "non-contact" type to eliminate wear, excessive drag, and resulting added horsepower required for motor drive system, while still being capable of resisting high-pressure differences.
 - b. Equip rotor with labyrinth seals, which at no time shall make contact with any rotating surface of rotor face.
 - 1) Seals shall be field adjustable and set to within factory-specified tolerances.
 - 2) Provide multi-pass seals with four labyrinth stages for optimum performance or alternative design with documented test results showing comparable performance.
 - c. Seal shall be secured to housing either by an extruded-aluminum strip with adjustment slots for fastening bolts to the casing frame or by using adjustable clips. Clips shall be made of stainless steel or other noncorrosive material to resist corrosion and possible damage to transfer media.
9. Shafts:
- a. Shaft supporting rotor between bearings shall be one piece, solid steel, accurately turned, ground, polished, and ring gauged for accuracy.
 - b. Machine and polish shaft within bearing contact area to comply with bearing manufacturer's written recommended tolerances.
 - c. Use a dial indicator to inspect shafts for roundness and straightness.
 - d. Coat exposed surfaces of shaft with a corrosion-inhibitive coating.
 - e. Shaft shall be machined to provide a shoulder against bearings for a positive locked position to eliminate any lateral movement of rotor due to axial bearing loads.
10. Bearings:
- a. Support rotor shaft by two pillow block **[tapered roller]** bearings designed for an ABMA 11 L-10 life of at least **[200,000][1,000,000]** hours.
 - b. Bearings shall be maintainable and replaceable without removal of rotor from its casing or

- media from spoke support system.
 - c. Grease fittings for each bearing shall be easily accessible and within view of bearing.
 - d. Reverse Rotation: Clutch bearing and extended shaft, or equivalent alternative, to prevent reverse rotation and ensure that wheel can only rotate in direction commensurate with effective purge operation.
11. Frame and Housing:
- a. Design frame to limit deflection of rotor due to air pressure loss to less than **[0.03125 inch (0.79375 mm)]<Insert deflection>**, **[as measured at the outer radius, during maximum rated airflow condition]** when exposed to a wheel pressure differential of **[25]<Insert number>** percent above design conditions.
 - b. Construct rigid frame of welded structural **[aluminum][galvanized steel][painted steel][or][stainless steel]**.
 - c. Designed and manufactured in one, two, or more sections as required by application to provide a rigid structure, when completely assembled, capable of supporting rotor.
 - 1) For horizontal airflow applications, support rotor at each end only with no additional support under center.
 - 2) For vertical airflow applications, provide one additional bottom center support.
 - 3) Clearly mark each section of multiple section units for easy installation.
 - d. Construct housing of **[galvanized-steel][painted steel][aluminum][or][stainless steel]** formed sheets designed to prevent corrosion.
 - e. Housing shall be reinforced as required to provide a solid mounting surface of peripheral and radial seals, to maintain a fixed distance between rotor surface and any housing part.
 - f. There shall be no special requirement to provide air-handling unit casing side access for future rotor removal and service. All rotor service shall be performed from inside air-handling unit at face of rotor.
 - g. Requirements for Painted Frame and Housing:
 - 1) Comply with painting manufacturer's written preparation and application requirements.
 - 2) Treat galvanized steel that is not phosphatized with a phosphate rinse to ensure that paint adheres.
 - 3) Apply rust-inhibiting primer before applying finishing coats.
 - 4) Apply multiple coats to achieve dry film thickness required for protection indicated.
 - 5) Finish coat color to be **[manufacturer's standard]<Insert color>**.
 - 6) Painted products shall have no deterioration when subjected to the following:
 - a) Salt spray test in accordance with ASTM B117 with 5 percent salt solution fog at 95 deg F for a period of **[500][1000][2000]<Insert number>** hours.
 - b) Acid-resistance test in accordance with ASTM D3260 with 15-minute exposure to 10 percent hydrochloric acid at room temperature.
12. Motor and Drive Assembly:
- a. Motor Enclosure: Totally enclosed.
 - b. Motor nameplate horsepower shall exceed maximum load of driven assembly.
 - c. Multiple belt-drive assembly shall be automatically tensioned and arranged to eliminate any side-to-side movements and slippage.
 - d. Motor and drive assembly shall be easily accessible and visible for inspection and maintenance.
 - e. Drive assembly, except motor, shall have a life expectancy of **[45,000][90,000]<Insert number>** hours.

13. Variable-Frequency Controller:
 - a. Variable-speed control of rotor through a variable-frequency controller.
 - b. Digital programming with a manual-speed adjustment on the front face of controller.
 - c. Rotor drive system shall allow for a turndown ratio of 80:1 (20 to 0.25 rpm).
 - d. Controller with switchable control either locally on front of controller or remotely by a control system.
 - e. Controller with a motor-rated disconnect switch or circuit breaker having a withstanding rating greater than that required by field electrical power system, but not less than **[42,000][65,000]<Insert value> A**.
 - f. Controller mounted in a NEMA 250, **[Type 1][Type 4][Type 4X][or][Type 12]** enclosure.
14. Rotation Sensor: Proximity-type rotation sensor and target to provide **[rotational speed (rpm) analog signal and]**wheel stop digital alarm signal for interface to remote-control system.
15. Monitoring and Control:
 - a. Single-Source Responsibility: Heat wheel manufacturer shall provide a complete monitoring and control package for heat wheel with controller, local display, operator interface, sensors, switches, transmitters, accessories, components, devices, and programming for a complete and operating heat wheel to ensure that responsibility for heat wheel and its operation resides with one source.
 - b. Enclosure:
 - 1) House controller and control devices in a NEMA 250, **[Type 1][Type 4][Type 4X][or][Type 12]** enclosure.
 - 2) Enclosure with LCD screen to allow viewing and changing parameters.
 - 3) Enclosure with full front face hinged door and lockable handle.
 - 4) Air-handling unit manufacturer shall mount enclosure of outside of air-handling unit casing in vicinity of heat wheel.
 - c. DDC with the following:
 - 1) Conversion of temperature and relative humidity readings into grains, dew point, and enthalpy.
 - 2) Calculation and reporting of real-time unit effectiveness.
 - 3) Calculation and reporting of accumulation of energy (Btu) recovered over time.
 - 4) With user input of energy costs, calculation and accumulation of dollars saved over time.
 - 5) An alarm output if wheel is not rotating and not rotating in correct direction.
 - 6) Programming for integration of enthalpy-based summer-winter change over, frost prevention and supply temperature control such that they also function correctly as the wheel speed is modulated.
 - 7) Communications and data transfer for remote monitoring and control through ASHRAE 135 (BACnet) interface.
 - 8) Option to achieve conversion and calculations indicated is for heat wheel manufacturer to employ building controls provider, to provide a field-installed DDC with LCD to be mounted directly adjacent to heat wheel manufacturer monitoring and control enclosure.
 - d. Four, field-mounted, high-precision dry-bulb temperature and either wet-bulb temperature or humidity sensors shall be provided by heat wheel manufacturer to air-handling unit manufacturer for factory mounting in accordance with heat wheel manufacturer's written instructions to measure dry-bulb temperature and either wet-bulb temperature or humidity at each of four energy wheel airstreams.
 - 1) Sensors shall be wired to controller or controller expander board located within

enclosure.

- e. Wheel Rotation: Rotation detector module to detect a rotating wheel, and correct direction of rotation[**and speed**].
- f. Active Monitoring and Control of Purge: Manufacturer's standard method to ensure that proper purge operation is maintained actively in response to changes in system airflows and pressures that normally occurs with a variable-volume system and where pressure changes appreciably due to filter loading and damper modulation.

16. Air-Handling Unit Factory Assembly:

- a. Internal Access: Provide each heat wheel with internal access from **[downstream][and][upstream]** sides as indicated on Drawings.
- b. Removal and Replacement: Each heat wheel shall be independently removable and replaceable through a removable access panel installed in air-handling unit casing.
- c. Drain Pans: In applications capable of formation of frost, install condensate drain pans to collect and drain water to exterior of air-handling unit casing.
- d. Supports for Heat Wheel:
 - 1) Construct a freestanding and self-supporting structural framework to support each heat wheel individually from and independent of adjacent heat wheels.
 - 2) Construct frame work from aluminum[, **galvanized-steel,**] or stainless steel[**structural shapes**].
- e. Comply with heat wheel manufacturer's written installation instructions.

II. Fixed Plate Heat Exchangers:

1. Fixed Plate Sensible Heat Exchangers:

- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Heatex, Inc.]**
 - 2) **[Innergy Tech, Inc.]**
 - 3) **[Klingenburg]**
 - 4) **<Insert manufacturer's name>**
- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Heatex, Inc.]**
 - 2) **[Innergy Tech, Inc.]**
 - 3) **[Klingenburg]**
 - 4) **<Insert manufacturer's name>**
- c. Source Limitations: Obtain heat exchangers from single source from single manufacturer.
- d. Description: A device for purpose of transferring only sensible energy from one airstream to another with no moving parts. Design may incorporate parallel, cross- or counterflow construction or a combination of these to achieve the energy transfer.
- e. Performance: Indicated on Drawings with no cross contamination between exhaust and supply airstreams.

- 1) Maximum Pressure Differential: Suitable for maximum [6 inches wg (1500 Pa)]<Insert pressure>.
 - 2) Maximum Temperature: Suitable for maximum [194 deg F (90 deg C)]<Insert temperature>.
- f. Casing: [Aluminum][Galvanized steel]<Insert material>.
- g. Plates: Evenly spaced, sealed, and arranged for [counter][cross] airflow.
- 1) Plate Material: [Embossed aluminum][Stainless steel][High-density plastic]<Insert material>.
 - 2) Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating. See Drawings for heat exchangers requiring a corrosion-resistant coating.
 - 3) Aluminum Plate Coating: [None][Epoxy]<Insert coating>. See Drawings for heat exchangers requiring a corrosion-resistant coating.
2. Fixed Plate Total Heat Exchangers:
- a. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
- 1) [CORE Energy Recovery Solutions]
 - 2) [Dais Analytic Corporation]
 - 3) [Innergy Tech, Inc.]
 - 4) <Insert manufacturer's name>
- b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- 1) [CORE Energy Recovery Solutions]
 - 2) [Dais Analytic Corporation]
 - 3) [Innergy Tech, Inc.]
 - 4) <Insert manufacturer's name>
- c. Source Limitations: Obtain heat exchangers from single source from single manufacturer.
- d. Description: A device for purpose of transferring total energy (sensible and latent) from one airstream to another with no moving parts. Design may incorporate parallel, counterflow construction to achieve the energy transfer.
- e. Performance: Indicated on Drawings with no cross contamination between exhaust and supply airstreams.
- 1) Maximum Pressure Differential: Suitable for maximum [6 inches wg (1500 Pa)]<Insert pressure>.
 - 2) Maximum Temperature: Suitable for maximum [194 deg F (90 deg C)]<Insert temperature>.
- f. Casing: [Aluminum][Galvanized steel]<Insert material>.
- g. Plates: Evenly spaced, sealed, and arranged for counter airflow.
- 1) Plate Material and Coating: Chemically treated paper, or polymer on [aluminum]<Insert material>, with selective hydroscopicity, moisture permeability, and gas barrier properties.
3. Air-Handling Unit Factory Assembly:

- a. Internal Access: Provide each fixed plate heat exchanger with internal access from **[downstream][and][upstream]** sides as indicated on Drawings.
- b. Removal and Replacement: Each fixed plate heat exchanger shall be independently removable and replaceable through a removable access panel or door installed in air-handling unit casing.
- c. Drain Pans: In applications capable of formation of frost, install condensate drain pans to collect and drain water to exterior of air-handling unit casing.
- d. Supports for Fixed Plate Heat Exchanger:
 - 1) Construct a freestanding and self-supporting structural framework to support heat exchangers.
 - 2) Construct frame work from aluminum[, **galvanized-steel,**] or stainless steel[**structural shapes**].
- e. Comply with fixed plate heat exchanger manufacturer's written installation instructions.

JJ. Heat Pipe Heat Exchangers:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Engineered Air]**
 - b. **[Heat Pipe Technology, Inc.]**
 - c. **[Innergy Tech, Inc.]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Engineered Air]**
 - b. **[Heat Pipe Technology, Inc.]**
 - c. **[Innergy Tech, Inc.]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain heat exchangers from single source from single manufacturer.
4. Description: Air-to-air energy recovery heat exchanger employing tubes charged with a fluid for purpose of transferring sensible energy from one airstream to another through the vaporization of fluid.
5. Performance: Indicated on Drawings with no cross contamination between exhaust and supply airstreams.
6. Certification: Rated[, **listed and labeled**] in accordance with AHRI 1060 (I-P) and AHRI 1061 (SI).[**NRTL listed in accordance with UL 207.**]
7. Casing and Tube Sheets: **[Galvanized-steel][or][stainless steel]** flanged casing minimum **[16 gauge (1.6 mm)]<Insert thickness>** thick, with airtight **[single][double][foam-filled double]** partition between exhaust and supply airstreams.
8. Fluid in Sealed Tubes: Selected by heat pipe heat exchanger manufacturer and classified as Safety Group A1 in accordance with ASHRAE 34.
9. Tubes:
 - a. Tube Diameter: Selected by heat pipe heat exchanger manufacturer; not less than nominal **1/2 inch (13 mm)** and not more than nominal **1 inch (25 mm)** in diameter.
 - b. Tube Material: **[Aluminum][or][copper]<Insert material>**; minimum thickness required for

- fluid pressure and temperature encountered.
 - c. Number of Tube Rows: As required by performance; not to exceed [8]<Insert number>.
- 10. Fins: **[Aluminum][or][copper]<Insert material>**.
 - a. Fin Configuration: **[Extruded][plate][or][spiral]**.
 - b. Fin Spacing: As required by performance; not to exceed **12 fins per inch (2.1 mm)**.
 - c. Fin and Tube Bond: **[Mechanical expanded into collared fins and tube sheets][Silver brazed]**.
- 11. Coating: **[None][Flexible epoxy polymer E-coating][Baked phenolic]<Insert coating>**; apply to supply and exhaust.
- 12. Control:
 - a. Integral plenum containing heat pipe coil and gasketed, face-and-bypass, opposed-blade dampers with rods extended outside casing for damper operator and linkage.
 - b. Pivot center of bottom of heat pipe coil on shaft and bearings to tilt coil. Include tilt controls with electronic controller, electric actuator and linkage, thermostats, sensors, and polyester-fabric-coated flexible connector for automatic supply temperature regulation, summer/winter changeover, and frost protection.
- 13. Air-Handling Unit Factory Assembly:
 - a. Internal Access: Provide each heat pipe heat exchanger with internal access from **[downstream][and][upstream]** sides as indicated on Drawings.
 - b. Removal and Replacement: Each heat pipe heat exchanger shall be independently removable and replaceable through a removable access panel installed in air-handling unit casing.
 - c. Drain Pans: In applications capable of formation of frost, install condensate drain pans to collect and drain water to exterior of air-handling unit casing.
 - d. Supports for Heat Pipe Heat Exchanger:
 - 1) Construct a freestanding and self-supporting structural framework to support each heat pipe heat exchangers individually from and independent of adjacent heat pipe heat exchangers.
 - 2) Construct frame work from aluminum[, **galvanized-steel,**] or stainless steel[**structural shapes**].
 - e. Comply with heat pipe heat exchanger manufacturer's written installation instructions.

KK. Air Blenders:

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

- b. **[Kees, Inc]**
- c. **<Insert manufacturer's name>**
- 3. Source Limitations: Obtain blenders from single source from single manufacturer.
- 4. Description: Static air mixing devices fabricated in assemblies consisting of multidirectional vanes that are designed to reduce stratification of multiple mixed airstreams and improve uniformity of the air tunnel velocity profile located downstream of air mixer.
- 5. Performance:
 - a. Certification: Documented performance verified by tests performed by an independent agency **[or][factory tests witnessed by a professional engineer that is not a company employee]**.
 - b. Mixing: Uniform mixed airstream within **[6 deg F (3 deg C)]<Insert temperature>** of the theoretical average temperature of two or more airstreams.
 - c. Indicated on Drawings.
- 6. Construction:
 - a. Configuration: Indicated on Drawings.
 - b. Material: **[Aluminum][galvanized steel][Type 304 stainless steel][or][Type 316 stainless steel]**.
 - c. Thickness: **[0.080 inch (2.06 mm)][0.125 inch (3.18 mm)]<Insert dimension>**.
 - d. Attachment: Integral mounting flange for attachment to mounting substrate.
 - e. Welding: Stitch or continuous welds. Filler metals matched to welded materials.
 - f. Hardware: **[Stainless][Zinc-plated carbon]** steel.
 - g. OEM Factory Assembly: Single-piece assembly for sizes through **96 inches (2400 mm)**. For larger sizes, air mixers shall be fabricated in two pieces, bolted together to ensure proper fit and alignment and then disassembled for shipment.
 - h. Finish: **[Anodized]<Insert requirements>**.
- 7. Air-Handling Unit Factory Assembly:
 - a. Internal Access: Provide each air mixer with internal access from **[downstream][and][upstream]** sides as indicated on Drawings.
 - b. Install air mixer assemblies in an internal separating wall reinforced to limit deflection to **[L/200]<Insert value>** when subjected to a horizontal force of **[200 lb (900 N)]<Insert value>** at any point on the air mixer assembly.
 - c. Blank-off and seal assembly to prevent leakage and air bypass around air mixer.
 - d. Operating Clearance: Maintain upstream and downstream operating clearances in accordance with manufacturer's written installation requirements.

LL. Close-Coupled, In-Line Centrifugal Pumps:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Armstrong International, Inc]**
 - b. **[Bell & Gossett; a Xylem brand]**
 - c. **[GRUNDFOS CBS Inc.]**
 - d. **[Taco Comfort Solutions]**
 - e. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert**

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

- a. **[Armstrong International, Inc]**
 - b. **[Bell & Gossett; a Xylem brand]**
 - c. **[GRUNDFOS CBS Inc.]**
 - d. **[Taco Comfort Solutions]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain pumps from single source from single manufacturer.
 4. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally or vertically.
 5. Pump Construction:
 - a. Casing: Radially split, cast iron, with threaded gauge tapings at inlet and outlet[, **replaceable bronze wear rings,**] and threaded **[companion-flange][or][union-end]** connections.
 - b. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.
 - c. Pump Shaft: **[Steel, with copper-alloy shaft sleeve][Stainless steel]**.
 - d. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless steel spring, and **[Buna-N][EPT][FKM]<Insert material>** bellows and gasket. Include water slinger on shaft between motor and seal.
 6. Motor: Rigidly mounted to pump casing.
 - a. Enclosure: **[ODP][or][TEFC][totally enclosed, nonventilated]**.
 - b. Enclosure Materials: **[Cast iron][or][rolled steel]**.
 - c. Motor Bearings: **[Permanently lubricated][or][grease-lubricated]** ball bearings.
 - d. Efficiency: NEMA Premium efficient.
 - e. NEMA Design: **<Insert designation>**.
 - f. Service Factor: **[1.15]<Insert value>**.

MM. Air-Handling Unit Factory Drain Piping and Piping Insulation:

1. General:
 - a. Air-handling unit manufacturer to factory install piping inside air-handling units.
 - b. If more than one material is listed, material selection is by air-handling unit manufacturer.
2. Aluminum Piping:
 - a. Pipe: Aluminum ASTM B241/B241M, Grade 1061, Temper T6, seamless longitudinal joints with beveled or plain ends; and wall thickness as indicated under applications.
 - b. Fittings: Cast aluminum, ASTM B26/B26M, Grade 356, Temper T6, ASME B16.1 Class 150; threaded ends.
 - c. Flanges: Cast aluminum, ASTM B26/B26M, Grade 356, Temper T6, ASME B16.1, Class 150 including bolts, nuts, washers, and gaskets of the following end connections and facings:
 - 1) Threaded end connections for threaded joints, welding-neck with butt-joint for welded joints, and blinds for use with flanged joints requiring close-off.
 - d. Unions: Cast aluminum, ASTM B26/B26M, Grade 356, Temper T6, hexagonal-stock body;

female NPT threaded ends.

3. Copper Tubing:

- a. Tubing: Drawn-temper, **[ASTM B88, Type L (ASTM B88M, Type B)][ASTM B88, Type M (ASTM B88M, Type C)][or][Type DWV in accordance with ASTM B306]**.
- b. Fittings: Wrought-copper and copper alloy, ASME B16.22, pressure fittings.
- c. Unions: Cast-copper-alloy, MSS SP-123, hexagonal-stock body; female NPT threaded ends
- d. Solder Filler Metals: ASTM B32, lead-free alloys, and water-flushable flux in accordance with ASTM B813.

4. Stainless Steel Piping:

- a. Pipe: ASME B36.19/ASME B36.19M, stainless steel ASTM A312/A312M, with beveled or plain ends; seamless **[or welded]** longitudinal joints, Grade TP316L, and wall thickness as indicated under applications.
- b. Fittings, Threaded: MSS SP-114, Class 150, stainless steel ASTM A351/A351M, Grade CF8M.
- c. Fittings, Welded: ASME B16.9, stainless steel ASTM A403/A403M, Grade WP316L, seamless, wall thickness to match adjoining pipe.
- d. Flanges: Stainless steel ASTM A182/A182M, Grade F316L, ASME B16.5, Class 150 including bolts, nuts, washers, and gaskets of the following material group, end connections, and facings:
 - 1) Material Group: 2.2.
 - 2) Threaded end connections for threaded joints, welding-neck with butt-joint for welded joints, and blinds for use with flanged joints requiring close-off.
- e. Unions: MSS SP-114, Class 150, stainless steel ASTM A351/A351M, Grade CF8M; female NPT threaded ends.

5. Floor Drain Piping:

- a. **[Schedule 40]<Insert pipe schedule or wall thickness>** aluminum or stainless steel pipe with threaded ends **[or][copper tube with soldered threaded male adapters]**.
- b. Factory install a dedicated drain pipe for each floor drain and extend pipe to access side of air-handling unit.
 - 1) Terminate pipe with a threaded pipe cap **[3 inches (75 mm)]<Insert dimension>** beyond exterior face of air-handling unit casing. Threaded pipe cap material to match pipe material.
 - 2) Pipe size to match size of floor drain connection.

6. Fan Drain Piping:

- a. **[Schedule 40]<Insert pipe schedule or wall thickness>** aluminum or stainless steel pipe with threaded ends **[or][copper tube with soldered threaded male adapters]**.
- b. Factory install a dedicated drain pipe for each housed centrifugal fan with a drain connection and extend pipe to access side of air-handling unit.
 - 1) Terminate pipe with a threaded pipe cap **[3 inches (75 mm)]<Insert dimension>** beyond exterior face of air-handling unit casing. Threaded pipe cap material to match pipe material.
 - 2) Install a twin sphere **[EPDM][or][neoprene]** pipe connector in the pipe between the

- fan connection and the pipe penetration through the air-handling unit casing.
- 3) Pipe size to match size of fan drain connection.
- 4) Install a threaded union or thread-on flange in drain pipe at connection to fan.

7. Drain Pan Piping:

- a. **[Schedule 40]<Insert pipe schedule or wall thickness>** aluminum or stainless steel pipe with threaded ends **[or][copper tube with soldered threaded male adapters]**.
- b. Factory install drain piping for drain pan(s). Install a dedicated drain pipe for each drain pan serving different air-handling unit internal components. Where multiple drain pans serve like components interconnect drain piping to a single drain pipe for field connection.
 - 1) Where interconnecting cooling coil condensate drain pans from upstream and downstream sides of cooling coil, provide pipe with a water seal trap configured to prevent air bypass.
 - 2) Terminate pipe with a threaded pipe cap **[3 inches (75 mm)]<Insert dimension>** beyond exterior face of air-handling unit casing. Threaded pipe cap material to match pipe material.
 - 3) Drain pipe size to match size of drain pan connection.

8. Piping Insulation:

- a. Factory insulate bottom cooling coil drain pan pipe with **[1-inch- (25-mm-)]<Insert dimension>** thick, flexible elastomeric insulation where pipe is located under and outside of the air-handling unit casing but within the air-handling unit base.
- b. Factory insulate steam and steam condensate piping located inside of air-handling with **[2-inch- (25-mm-)]<Insert dimension>** thick, preformed mineral-fiber pipe insulation.
- c. Cover pipe insulation with a factory-applied aluminum or stainless steel jacket.

NN. Air-Handling Unit Factory Hydronic Piping and Piping Insulation:

1. Chilled-Water Piping:

- a. Design Pressure and Temperature: **[See Drawings]<Insert pressure and temperature>**.
- b. Pipe: ASME B36.10M, carbon steel ASTM A53/A53M, with beveled or plain ends; **[electric resistance weld][or][seamless]** longitudinal joints, Grade B; standard weight.
- c. Fittings, Threaded: Malleable iron, ASME B16.3; **[Class 150][or][Class 300]**.
- d. Fittings, Butt Welded: ASME B16.9, wrought-steel ASTM A234/A234M, Grade WPB, seamless or welded, wall thickness to match adjoining pipe.
- e. Flanges, Weld: Weld-neck, forged carbon steel, ASME B16.5; **[Class 150][or][Class 300]**.
- f. Unions, Threaded: Malleable iron, ASME B16.39; **[Class 150][or][Class 300]**.
- g. Strainers: Y-pattern; body and cap constructed of cast-iron, ASTM A126, Class B, removable basket constructed of **[Type 304][or][Type 316]** stainless steel with openings not larger than **0.032 inch (0.8 mm)**; **[Class 125][or][Class 250]**.
- h. Valves:
 - 1) Ball: Two-piece with threaded ends, MSS SP-110, 600 WOG; cast-bronze or forged copper-alloy body, stainless steel vented ball, corrosion-resistant plastic-coated handle, extended stem, and stationary outer sleeve to protect insulation vapor seal.
 - 2) Butterfly: Lugged body; MSS SP-67; cast-iron, ductile-iron, or cast-steel body; stainless steel disk, EPDM seat, and **[lever][or][gear]** operator; rated for system pressure, but not less than **[250-psig (1724-kPa)]<Insert value>** bi-directional dead-end shutoff with downstream flange removed.
 - 3) Check: Globe-style, MSS SP-125; cast-iron ASTM A126 body, stainless steel spring, and bronze seat; **[Class 125][or][Class 250]**.
 - 4) **<Insert valve type>**.

- i. Vents: Cast-iron body, stainless steel float, **NPS 1/2 (DN 15)** or larger inlet connection.
 - j. Flow Meters: In-line electromagnetic type with integral display and accuracy within 3 percent of reading.
 - k. Pressure Gauges: Bourdon-tube, ASME B40.100 with **[Grade A][or][Grade B]** accuracy; metal case with nominal **[4-1/2-inch (114-mm)][6-inch (152-mm)]<Insert dimension>** shatter-resistant glass face and **NPS 1/2 (DN 15)** threaded brass connection.
 - l. Test Plugs: Brass or stainless steel body with core inserts and gasketed and threaded cap, extension for insulation; threaded **NPS 1/2 (DN 15)** connection.
 - m. Thermometers: Bi-metal actuated, ASME B40.200 with 1 percent accuracy; adjustable-angle stainless steel case with nominal **[5-inch (125-mm)]<Insert dimension>** shatter-resistant glass face. Include thermometers with stainless steel extended-neck thermowells.
 - n. Air-Handling Unit Factory Assembly: Factory install a complete piping system inside air-handling units as indicated on Drawings.
 - 1) **NPS 2 (DN 50)** and smaller with threaded fittings, strainers, and valves. Larger sizes with welded joints, fittings, and flanges for valves and strainers.
 - 2) Arrange piping with sufficient clearance between piping and other components to accommodate removal and replacement of installed components.
 - 3) Gradually slope piping for venting and drainage.
 - 4) Include threaded drain connections and ball valves with threaded hose-end, cap, and chain at all low points in piping.
 - 5) Comply with requirements indicated on Drawings.
 - 6) Make connections to coils with a **[flange][or][union]**.
 - 7) Connect to each coil inlet with shutoff valve, test plug, **[strainer][pressure gauge][and][thermometer]**.
 - 8) Connect to each coil outlet with balancing valve, test plug, **[pressure gauge][thermometer][flow meter][and][shutoff valve]**.
 - 9) Connect each coil drain connection with a drain valve, which is full size of drain connection.
 - 10) Connect each coil vent connection with **[automatic][or][manual]** vent, which is full size of vent connection.
 - 11) Connect to each pump inlet with flange or union, shutoff valve, test plug, strainer **and pressure gauge**.
 - 12) Connect to each pump outlet with flange or union, check valve, balancing valve, test plug, **[pressure gauge][flow meter][and][shutoff valve]**.
 - 13) Include with each strainer a blowdown connection consisting of a nipple and threaded ball valve with threaded hose-end, cap, and chain.
2. Chilled-Water Piping Insulation and Identification:
- a. Insulation: Preformed, **[cellular glass][phenolic foam][or][flexible elastomeric]<Insert material>**; minimum **[2 inches (50 mm)]<Insert dimension>** thick.
 - b. Adhesive: Compatible with insulation material and recommended in writing by insulation manufacturer.
 - c. Jacket: **[None][ASJ][PVC, color selected by Architect, 20 mils (0.5 mm) thick][Aluminum, smooth, 0.020 inch (0.51 mm) thick]<Insert jacket>**.
 - d. Air-Handling Unit Factory Assembly: Continuously insulate and vapor seal piping system throughout its entire length. Insulate all surface capable of forming condensation.
 - 1) Install high-density insulation insert products, consisting of two 180-degree halves, at pipe hangers and supports. Material density sufficient to accommodate loading without deformation.
 - 2) Insulation thickness determined by air-handling unit manufacturer to comply with governing codes, ASHRAE/IES 90.1, and minimum thickness indicated and to prevent condensation.

- 3) Insulate piping system only after successful completion of pressure tests.
- 4) Install adhesive-backed acrylic identification labels indicating [pipe size]service and direction of flow at multiple locations sufficient for operators to easily follow the flow path. Each branch pipe should have at least one label.

3. Heating Water Piping:

- a. Design Pressure and Temperature: **[See Drawings]<Insert pressure and temperature>**.
- b. Pipe: ASME B36.10M, carbon steel ASTM A53/A53M, with beveled or plain ends; **[electric resistance weld][or][seamless]** longitudinal joints, Grade B; standard weight.
- c. Fittings, Threaded: Malleable iron, ASME B16.3; **[Class 150][or][Class 300]**.
- d. Fittings, Butt Welded: ASME B16.9, wrought-steel ASTM A234/A234M, Grade WPB, seamless or welded, wall thickness to match adjoining pipe.
- e. Flanges, Weld: Weld-neck, forged carbon steel, ASME B16.5; **[Class 150][or][Class 300]**.
- f. Unions, Threaded: Malleable iron, ASME B16.39; **[Class 150][or][Class 300]**.
- g. Strainers: Y-pattern; body and cap constructed of cast-iron, ASTM A126, Class B, removable basket constructed of **[Type 304][or][Type 316]** stainless steel with openings not larger than **0.032 inch (0.8 mm)**; **[Class 125][or][Class 250]**.
- h. Valves:
 - 1) Ball: Two-piece with threaded ends, MSS SP-110, 600 WOG; cast-bronze or forged copper-alloy body, stainless steel vented ball, corrosion-resistant plastic-coated handle, and extended stem.
 - 2) Butterfly: Lugged body; MSS SP-67; cast-iron, ductile-iron, or cast-steel body; stainless steel disk, EPDM seat, and **[lever][or][gear]** operator; rated for system pressure, but not less than **[250-psig (1724-kPa)]<Insert pressure>** bi-directional dead-end shutoff with downstream flange removed.
 - 3) Check: Globe-style, MSS SP-125; cast-iron ASTM A126 body, stainless steel spring, and bronze seat; **[Class 125][or][Class 250]**.
 - 4) **<Insert valve type>**.
- i. Vents: Cast-iron body, stainless steel float, **NPS 1/2 (DN 15)** or larger inlet connection.
- j. Flow Meters: In-line electromagnetic type with integral display and accuracy within 3 percent of reading.
- k. Pressure Gauges: Bourdon-tube, ASME B40.100 with **[Grade A][or][Grade B]** accuracy; metal case with nominal **[4-1/2-inch (114-mm)][6-inch (152-mm)]<Insert dimension>** shatter-resistant glass face and **NPS 1/2 (DN 15)** threaded brass connection.
- l. Test Plugs: Brass or stainless steel body with core inserts and gasketed and threaded cap, extension for insulation; threaded **NPS 1/2 (DN 15)** connection.
- m. Thermometers: Bi-metal actuated, ASME B40.200 with 1 percent accuracy; adjustable-angle stainless steel case with nominal **[5-inch (125-mm)]<Insert dimension>** shatter-resistant glass face. Include thermometers with stainless steel extended-neck thermowells.
- n. Air-Handling Unit Factory Assembly: Factory install a complete piping system inside air-handling units as indicated on Drawings.
 - 1) **NPS 2 (DN 50)** and smaller with threaded fittings, strainers, and valves. Larger sizes with welded joints, fittings, and flanges for valves and strainers.
 - 2) Arrange piping with sufficient clearance between piping and other components to accommodate removal and replacement of installed components.
 - 3) Gradually slope piping for venting and drainage.
 - 4) Include threaded drain connections and ball valves with threaded hose-end, cap, and chain at all low points in piping.
 - 5) Comply with requirements indicated on Drawings.
 - 6) Make connections to coils with a **[flange][or][union]**.
 - 7) Connect to each coil inlet with shutoff valve, test plug, **[strainer][pressure gauge][and][thermometer]**.

- 8) Connect to each coil outlet with balancing valve, test plug, **[pressure gauge][thermometer][flow meter][and][shutoff valve]**.
- 9) Connect each coil drain connection with a drain valve, which is full size of drain connection.
- 10) Connect each coil vent connection with **[automatic][or][manual]** vent, which is full size of vent connection.
- 11) Connect to each pump inlet with flange or union, shutoff valve, test plug, strainer **and pressure gauge**.
- 12) Connect to each pump outlet with flange or union, check valve, balancing valve, test plug, **[pressure gauge][flow meter][and][shutoff valve]**.
- 13) Include each strainer with a blowdown connection consisting of a nipple and threaded ball valve with threaded hose-end, cap, and chain.

4. Heating Water Piping Insulation and Identification:

- a. Insulation: Preformed, **[cellular glass][mineral fiber][or][phenolic foam]<Insert material>**; minimum **[2 inches (50 mm)]<Insert dimension>** thick.
- b. Adhesive: Compatible with insulation material and recommended in writing by insulation manufacturer.
- c. Jacket: **[ASJ][PVC, color selected by Architect, 20 mils (0.5 mm) thick][Aluminum, smooth, 0.020 inch (0.51 mm) thick]<Insert jacket>**.
- d. Air-Handling Unit Factory Assembly: Continuously insulate and seal piping insulation system throughout its entire length.
 - 1) Install high-density insulation insert products, consisting of two 180-degree halves, at pipe hangers and supports. Material density sufficient to accommodate loading without deformation.
 - 2) Insulation thickness determined by air-handling unit manufacturer to comply with governing codes, ASHRAE/IES 90.1, and minimum thickness indicated and to prevent condensation.
 - 3) Insulate piping system only after successful completion of pressure tests.
 - 4) Install adhesive-backed acrylic identification labels indicating **[pipe size]** service and direction of flow at multiple locations sufficient for operators to easily follow the flow path. Each branch pipe should have at least one label.

5. Piping Hangers and Supports:

- a. Finish: Galvanized metallic coatings including pregalvanized, hot-dip galvanized, or electro-galvanized.
- b. Hangers: MSS-SP-58, Type 1.
- c. Supports: MSS-SP-58, Type 4, Type 24, or Type 37.
- d. Threaded Rods: Continuous-thread rod, nuts, and washer made of **[galvanized steel][or][stainless steel]<Insert material>**.
- e. Strut: MFMA-4, continuous slotted **[carbon steel][stainless steel, Type 304][stainless steel, Type 316][extruded-aluminum]<Insert material>** channel with intumed lips.
- f. Air-Handling Unit Factory Assembly:
 - 1) Ridgely support piping from internal structure in accordance with governing codes and MSS SP-58.

OO. Air-Handling Unit Factory Steam and Condensate Piping And Piping Insulation:

1. Steam Piping:

- a. Design Pressure and Temperature: **[See Drawings]<Insert pressure and temperature>**.

- b. Pipe: ASME B36.10M, carbon steel ASTM A53/A53M, with beveled or plain ends; **[electric resistance weld][or][seamless]** longitudinal joints, Grade B; standard weight.
- c. Fittings, Threaded: Cast iron, ASME B16.4; **[Class 125][or][Class 250]**.
- d. Fittings, Butt Welded: ASME B16.9, wrought-steel ASTM A234/A234M, Grade WPB, seamless or welded, wall thickness to match adjoining pipe.
- e. Flanges, Weld: Weld-neck, forged carbon steel, ASME B16.5; **[Class 150][or][Class 300]**.
- f. Unions, Threaded: MSS SP-83, Class 3000, ASTM A105/A105M.
- g. Strainers: Y-pattern; body and cap constructed of cast-iron, ASTM A126, Class B, removable basket constructed of **[Type 304][or][Type 316]** stainless steel with openings not larger than **0.032 inch (0.8 mm)**; **[Class 125][or][Class 250]**.
- h. Valves:
 - 1) Ball: Two-piece with threaded ends, MSS SP-110, 600 WOG; cast-bronze or forged copper-alloy body, stainless steel vented ball, corrosion-resistant plastic-coated handle, and extended stem.
 - 2) Check:
 - a) Bronze with Bronze Disc: MSS SP-80, Type 3; Class 150.
 - b) Iron with Metal Seats: MSS SP-71, Type I; **[Class 125][or][Class 250]**.
 - 3) Gate:
 - a) Bronze: **[MSS SP-80, Type 1][or][MSS SP-80, Type 2]**; Class 150.
 - b) Iron: MSS SP-70, Type I, **[NRS][OS & Y]**; **[Class 125][or][Class 250]**.
 - 4) Globe:
 - a) Bronze: MSS SP-80, Type 2; Class 150.
 - b) Iron: MSS SP-85, Type I; **[Class 125][or][Class 250]**.
- i. Flow Meters: Vortex-shedding type with integral display and accuracy within 5 percent of reading.
- j. Pressure Gauges: Bourdon-tube, ASME B40.100 with **[Grade A][or][Grade B]** accuracy; metal case with nominal **[4-1/2-inch (114-mm)][6-inch (152-mm)]<Insert dimension>** shatter-resistant glass face and **NPS 1/2 (DN 15)** threaded connection.
- k. Test Plugs: Brass or stainless steel body with core inserts and gasketed and threaded cap, extension for insulation; threaded **NPS 1/2 (DN 15)** connection.
- l. Thermometers: Bi-metal actuated, ASME B40.200 with 1 percent accuracy; adjustable-angle stainless steel case with nominal **[5-inch (125-mm)]<Insert dimension>** shatter-resistant glass face. Include thermometers with stainless steel extended-neck thermowells.
- m. Air-Handling Unit Factory Assembly: Factory install a complete piping system inside air-handling units as indicated on Drawings.
 - 1) **NPS 2 (DN 50)** and smaller with threaded fittings, strainers, and valves. Larger sizes with welded joints, fittings, and flanges for valves and strainers.
 - 2) Arrange piping with sufficient clearance between piping and other components to accommodate removal and replacement of installed components.
 - 3) Gradually slope piping for venting and drainage at not less than 2 percent.
 - 4) Include threaded drain connections and ball valves with threaded hose-end, cap, and chain at all low points in piping.
 - 5) Comply with requirements indicated on Drawings.
 - 6) Make connections to coils **and humidifiers** with a **[flange][or][union]**.
 - 7) Connect to each coil inlet with shutoff valve, test plug, vacuum breaker, **[strainer][flow meter][pressure gauge][and][thermometer]**.
 - 8) Connect to each humidifier inlet with shutoff valve, test plug, vacuum breaker **[strainer][flow meter][pressure gauge][and][thermometer]**.

- 9) Include each strainer with a blowdown connection consisting of a nipple and threaded gate valve with threaded hose-end, cap, and chain.

2. Steam Condensate Piping:

- a. Design Pressure and Temperature: **[See Drawings]<Insert pressure and temperature>**.
- b. Pipe: ASME B36.10M, carbon steel ASTM A53/A53M, with beveled or plain ends; **[electric resistance weld][or][seamless]** longitudinal joints, Grade B; Schedule 80.
- c. Fittings, Threaded: Cast iron, ASME B16.4; **[Class 125][or][Class 250]**.
- d. Fittings, Butt Welded: ASME B16.9, wrought-steel ASTM A234/A234M, Grade WPB, seamless or welded, wall thickness to match adjoining pipe.
- e. Flanges, Weld: Weld-neck, forged carbon steel, ASME B16.5; **[Class 150][or][Class 300]**.
- f. Unions, Threaded: MSS SP-83, Class 3000, ASTM A105/A105M.
- g. Strainers: Y-pattern; body and cap constructed of cast-iron, ASTM A126, Class B, removable basket constructed of **[Type 304][or][Type 316]** stainless steel with openings not larger than **0.032 inch (0.8 mm)**; **[Class 125][or][Class 250]**.
- h. Steam Traps:
 - 1) Material: **[Cast iron][Stainless steel][Stainless steel, Grade 304][Stainless steel, Grade 316]**.
 - 2) Type: **[Inverted bucket][or][float and thermostatic]**.
 - 3) Capacity: Sized for a minimum of **[3]<Insert number>** times the maximum rated condensate flow at **[1/2-psig (3.4-kPa)]<Insert value>** differential pressure.
- i. Valves:
 - 1) Ball: Two-piece with threaded ends, MSS SP-110, 600 WOG; cast-bronze or forged copper-alloy body, stainless steel vented ball, corrosion-resistant plastic-coated handle, and extended stem.
 - 2) Check:
 - a) Bronze with Bronze Disc: MSS SP-80, Type 3; Class 150.
 - b) Iron with Metal Seats: MSS SP-71, Type I; **[Class 125][or][Class 250]**.
 - 3) Gate:
 - a) Bronze: **[MSS SP-80, Type 1][or][MSS SP-80, Type 2]**; Class 150.
 - b) Iron: MSS SP-70, Type I, **[NRS][OS & Y]**; **[Class 125][or][Class 250]**.
 - 4) Globe:
 - a) Bronze: MSS SP-80, Type 2; Class 150.
 - b) Iron: MSS SP-85, Type I; **[Class 125][or][Class 250]**.
- j. Vents: Cast-iron body, stainless steel float, **NPS 1/2 (DN 15)** or larger inlet connection.
- k. Flow Meters: In-line electromagnetic type with integral display and accuracy within 3 percent of reading.
- l. Pressure Gauges: Bourdon-tube, ASME B40.100 with **[Grade A][or][Grade B]** accuracy; metal case with nominal **[4-1/2-inch (114-mm)][6-inch (152-mm)]<Insert dimension>** shatter-resistant glass face and **NPS 1/2 (DN 15)** threaded brass connection
- m. Test Plugs: Brass or stainless steel body with core inserts and gasketed and threaded cap, extension for insulation; threaded **NPS 1/2 (DN 15)** connection.
- n. Thermometers: Bi-metal actuated, ASME B40.200 with 1 percent accuracy; adjustable-angle stainless steel case with nominal **[5-inch (125-mm)]<Insert dimension>** shatter-resistant glass face. Include thermometers with stainless steel extended-neck thermowells.

- o. Air-Handling Unit Factory Assembly: Factory install a complete piping system inside air-handling units as indicated on Drawings.
 - 1) **NPS 2 (DN 50)** and smaller with threaded fittings, strainers, and valves. Larger sizes with welded joints, fittings, and flanges for valves and strainers.
 - 2) Arrange piping with sufficient clearance between piping and other components to accommodate removal and replacement of installed components.
 - 3) Gradually slope piping for venting and drainage at not less than 2 percent.
 - 4) Include threaded drain connections and valves with threaded hose-end, cap, and chain at all low points in piping.
 - 5) Comply with requirements indicated on Drawings.
 - 6) Make connections to coils **[and humidifiers]** with a **[flange][or][union]** .
 - 7) Connect to each coil outlet with strainer, steam trap, test plug, vent **[pressure gauge][thermometer][flow meter][and][shutoff valve]**.
 - 8) Connect to each humidifier outlet with strainer, steam trap, test plug, **[pressure gauge][thermometer][flow meter][and][shutoff valve]**.
 - 9) Connect each coil drain connection with a drain valve, which is full size of drain connection.
 - 10) Include each strainer with a blowdown connection consisting of a nipple and threaded ball valve with threaded hose-end, cap, and chain.
3. Steam and Condensate Piping Insulation:
 - a. Insulation: Preformed, **[cellular glass][or][mineral fiber]<Insert material>**; minimum **[3 inches (75 mm)][4 inches (100 mm)][5 inches (125 mm)]<Insert dimension>** thick.
 - b. Adhesive: Compatible with insulation material and recommended in writing by insulation manufacturer.
 - c. Jacket: **[ASJ][Aluminum, smooth, 0.020 inch (0.51 mm) thick]<Insert jacket>**.
 - d. Air-Handling Unit Factory Assembly: Continuously insulate and seal piping insulation system throughout its entire length.
 - 1) Install high-density insulation insert products, consisting of two 180-degree halves, at pipe hangers and supports. Material density sufficient to accommodate loading without deformation.
 - 2) Insulation thickness determined by air-handling unit manufacturer to comply with governing codes, ASHRAE/IES 90.1, and minimum thickness indicated and to prevent condensation.
 - 3) Insulate piping system only after successful completion of pressure tests.
 - 4) Install adhesive-backed acrylic identification labels indicating **[pipe size]** service and direction of flow at multiple locations sufficient for operators to easily follow the flow path. Each branch pipe should have at least one label.
4. Piping Supports:
 - a. Finish: Galvanized metallic coatings including pregalvanized, hot-dip galvanized, or electro-galvanized.
 - b. Hangers: MSS-SP-58, Type 1.
 - c. Supports: MSS-SP-58, Type 4, Type 24, or Type 37.
 - d. Threaded Rods: Continuous-thread rod, nuts, and washer made of **[galvanized steel][or][stainless steel]<Insert material>**.
 - e. Strut: MFMA-4, continuous slotted **[carbon steel][stainless steel, Type 304][stainless steel, Type 316][extruded-aluminum]<Insert material>** channel with inturned lips.
 - f. Air-Handling Unit Factory Assembly:
 - 1) Ridgely support piping from internal structure in accordance with governing codes and MSS SP-58.

PP. Drains:**1. Floor Drains:**

- a. Drain Body: Fabricate floor drain body of **NPS 4 (DN 100)** or larger aluminum or stainless pipe and weld a plate of same material to the bottom. Option to fabricate an aluminum or stainless steel rectangular box drain at least **4 by 4 inches (100 by 100 mm)** of material at least **0.1 inch (3 mm)** thick.
- b. Drain Connection: Weld a nominal **[NPS 2 (DN 50)]<Insert pipe size>** half coupling in side of drain body located within **1 inch (25 mm)** from bottom.
- c. Drain Cover: Perforated plate, at least **0.1 inch (3 mm)** thick, or grating, fabricated from aluminum or stainless steel. Drain cover shall be supported and secured in place by drain body, but not fastened to drain body with fasteners.
- d. Fluid Seal: **[Seal][Weld]** floor drain body to air-handling unit floor for a watertight installation.
- e. Mounting: Recess floor drain body into structural base. Top of floor drain to be slightly recessed below air-handling unit finished floor for unobstructed gravity flow from floor into drain.
- f. Application:
 - 1) Install floor drains in air-handling unit floors at locations indicated on Drawings.
 - 2) Install floor drains in air-handling unit floors of all sections.
 - 3) Install floor drains in air-handling unit floors of **[coil][coil and humidifier][coil, heat wheel, heat exchanger, humidifier][potentially wet]<Insert floor drain locations>** sections and associated access sections.

QQ. Factory-Assembled Electrical:

1. Factory install **[UV-C and switches],[service light fixtures and switches],[and][receptacles]** for each air-handling unit.
 - a. Locate in a convenient and field-accessible location.
 - b. Installation shall comply with NFPA 70.
 - c. Wire, Conduit, and Enclosures:
 - 1) Minimum Conduit Size: **[3/4 inch (20 mm)]<Insert dimension>**.
 - 2) Materials: **[Metal, with a corrosion-resistant finish][Aluminum or stainless steel][Stainless steel]**.
 - 3) Supports: Support conduits, boxes, and enclosures using corrosion-resistant fastening hardware **[constructed of stainless steel]**.
 - 4) Conduit: Locate conduit inside the air-handling unit casing. Conduit installed on exterior of air-handling unit casing is unacceptable.
 - 5) Wire: Copper, rated for 600 V, solid wire for size **[No. 10 AWG]<Insert wire size>** and smaller and stranded wire for larger sizes.
 - 6) Minimum Wire Size: **[No. 12 AWG]<Insert wire size>**.
 - 7) Each circuit shall have a ground wire.
 - 8) Install wire in conduit.
 - d. Boxes, Conduit Outlet Bodies, and Enclosures:
 - 1) Located in Airstream: NEMA 250, **[Type 4][Type 4X][or][Type 12]<Insert Type>**.
 - 2) Located in Service Corridor: NEMA 250, **[Type 1][Type 4][or][Type 12]<Insert Type>**.
 - 3) Located on Exterior of Air-Handling Unit Casing: NEMA 250, **[Type 3R][Type 4][or][Type 4X]<Insert Type>**.

- e. Seals: Seal pathways to prevent air leakage between air-handling unit exterior and interior, and between internal component sections.
- f. UV-C Lamp System Applications: Wire all UV-C lamp systems located in the same air tunnel to a single circuit.
- g. Service Lighting Applications:
 - 1) Provide quantity of 20-A branch circuits required to power service light fixtures.
 - 2) For air-handling units consisting of multiple stacked tiers, provide separate circuits for top and bottom tiers of air-handling units.
 - 3) Factory install a **[main disconnect switch][field power junction box]** for interfacing air-handling power for service lighting with single-point field power wiring connection.
- h. Receptacle Applications:
 - 1) For air-handling units consisting of multiple stacked tiers, provide separate circuits for top and bottom tiers of air-handling units.
 - 2) Factory wire receptacles to a **[main disconnect switch][field power junction box]** for interfacing air-handling power for receptacles with a single-point field power wiring connection.
- 2. Main Disconnect Switches: Factory-install main disconnect switch mounted on air-handling unit casing exterior for interface of factory power wiring with field power wiring.
 - a. Specification Grade: "Heavy Duty Type"; "quick-make," "quick-break" construction.
 - b. Three pole, **[fused][or][nonfused]**.
 - c. 600 V rated.
 - d. Minimum Short-Circuit Current Rating: As required by electrical power distribution system, but not less than **[42,000][65,000]<Insert value> A**.
 - e. Enclosure:
 - 1) Located in Service Corridor: NEMA 250, **[Type 1][Type 4][or][Type 12]<Insert Type>**.
 - 2) Located on Exterior of Air-Handling Unit Casing: NEMA 250, **[Type 3R][Type 4][or][Type 4X]<Insert Type>**.
 - f. Operating handle shall be of box-mounted type that directly drives switch mechanism.
 - g. Disconnect switch shall use a flange-operated visible blade that is close coupled to a vertical-lift-type handle that achieves a positive visible indication of disconnect with cover open or closed.
 - h. Disconnect switch shall have a defeatable, front-accessible, mechanical interlock to prevent opening of cover when switch is in "ON" position, and to prevent turning switch "ON" when the door is open.
 - i. Include a solid neutral as required by authorities having jurisdiction.
 - j. Disconnect switch shall have a ground lug for ground wire termination.
 - k. Operating handle shall be lockable in open position.
 - l. Horsepower rated.
 - m. Feed through or double lugged.
- 3. Field Power Junction Box: Factory-install junction box with internal wire terminal block mounted on air-handling unit casing exterior for interface of factory power wiring with field power wiring.
- 4. Exterior Service Light Fixtures:
 - a. LED Luminaires for Outdoors:
 - 1) Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert**

-
- manufacturer's name; product name or designation>.**
 - 2) Finish: Selected by Architect from available finishes offered by manufacturer.
 - 3) Mounting: Wall.
 - 4) Intended for direct exposure in outdoor locations and operation in cold- and hot-temperature extremes encountered; dust and moisture resistant.
 - 5) Light Color: **[4000][5000]** K.
 - 6) Light Output: **[3000][6000][8000]** lumens.
 - 7) Additional Protection: **[Vandal guard][or][wire guard]**.
 - 8) On/Off Operation: **[Local toggle switch][Photo cell with local override toggle switch]**.
 - b. Vaportight Fixtures:
 - 1) Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>.**
 - 2) Finish: Selected by Architect from available finishes offered by manufacturer.
 - 3) Mounting: Wall.
 - 4) Intended for direct exposure in outdoor locations and operation in cold- and hot-temperature extremes encountered; dust and moisture resistant.
 - 5) Cast-aluminum housing and guard with heat-resistant, tempered, clear glass globe.
 - 6) Incandescent Lamps: **[150][200][300]** W.
 - 7) LED A21 Series Lamps:
 - a) Light Color: **[3000][5000]** K.
 - b) Light Output: **[1700]<Insert value>** lumens.
 - c. Application:
 - 1) Provide service light fixtures where indicated on Drawings.
 - 2) Provide one service light fixture on each side of air-handling unit with access doors. Position fixture at midpoint of most remote access doors.
 - 5. Interior Service Light Fixtures:
 - a. Fluorescent Luminaires:
 - 1) Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>.**
 - 2) Suitable for wet locations and operation in cold- and hot-temperature extremes encountered; dust and moisture resistant.
 - 3) High-impact, UV-stabilized, fiberglass-reinforced polyester housing; high-impact acrylic lens.
 - 4) Two, cool white, T **[5][5HO][8][8HO]** lamps; and an electronic ballast.
 - b. LED Luminaires:
 - 1) Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>.**
 - 2) Suitable for wet locations and operation in cold- and hot-temperature extremes encountered; dust and moisture resistant.
 - 3) High-impact, UV-stabilized fiberglass housing and acrylic lens.
 - 4) Light Color: **[3500][4000][5000]** K.
 - 5) Light Output: **[2000][3000][4000]** lumens.
 - 6) Driver: 1 percent dimming.

c. Vaportight Fixtures:

- 1) Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>**.
- 2) Suitable for wet locations and operation in cold- and hot-temperature extremes encountered; dust and moisture resistant.
- 3) Cast-aluminum housing and guard with heat-resistant, tempered, clear glass globe.
- 4) Incandescent Lamps: **[150][200][300]** W.
- 5) LED A21 Series Lamps:
 - a) Light Color: **[3000][5000]** K.
 - b) Light Output: **[1700]<Insert value>** lumens.

d. Application:

- 1) Provide service light fixtures where indicated on Drawings.
- 2) Provide one service light fixture in each accessible section of air-handling units.
- 3) Provide one service light fixture in fan[, **coil**][**filter**]**<Insert section>** sections of air-handling units.

6. Toggle Switches for Service Light Fixtures:

- a. Single-Pole Switches, 120/277 V, 20 A: Comply with UL 20 and FS W-S-896.
- b. Two-Pole Switches, 120/277 V, 20 A: Comply with UL 20 and FS W-S-896.
- c. Three-Way Switches, 120/277 V, 20 A: Comply with UL 20 and FS W-S-896.
- d. Four-Way Switches, 120/277 V, 20 A: Comply with UL 20 and FS W-S-896.
- e. Lighted Single-Pole Switches, 120/277 V, 20 A: Comply with NEMA WD 1, UL 20, and FS W-S-896.
 - 1) Description: Handle illuminated when switch is on.
- f. Toggle Switch Box and Cover: Mount toggle switch in a **[metal][cast-aluminum]** outlet box with **[cast-aluminum][or][stainless steel]** cover. Weatherproof where exposed to outdoors.
- g. Application:
 - 1) Factory install switching configuration (single, three way, or four way) required to operate a single service light fixture or group of service light fixtures from any access door that opens to respective service light fixtures.
 - 2) Factory install service light switches at locations indicated on Drawings.
 - 3) Factory install a single service light switch to switch all service light fixtures from a single location.
 - 4) Factory install a service light switch for each service light fixture or group of service light fixtures accessible from a single access door adjacent to the access door.
- h. Switches with Lighted Handles Applications: Lighted handle feature may be omitted where on/off status of internal lights can be viewed through an access door window.

7. Receptacles:

- a. Isolated-Ground Duplex Receptacles, 125 V, 20 A:
 - 1) Description: Straight blade; equipment grounding contacts shall be connected only to green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts. Two pole, three wire, and self-grounding.

- 2) Configuration: NEMA WD 6, Configuration 5-20R.
 - 3) Standards: Comply with UL 498 and FS W-C-596.
- b. Duplex GFCI Receptacles, 125 V, 20 A:
- 1) Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding.
 - 2) Configuration: NEMA WD 6, Configuration 5-20R.
 - 3) Type: Non-feed through.
 - 4) Standards: Comply with UL 498, UL 943 Class A, and FS W-C-596.
- c. Receptacle Box and Cover: Mount receptacle in a **[metal][cast-aluminum]** outlet box with **[cast-aluminum][or][stainless steel]** cover. Weatherproof where exposed to outdoors.
- d. Applications: Factory install a receptacle in a convenient and field-accessible location on air-handling unit exterior of casing **[at locations indicated on Drawings][near access doors accessing fans][near access doors accessing electric heaters and fans][near access doors accessing energy wheels and fans][near access doors accessing electric heaters, energy wheels and fans]<Insert locations>**.
8. Power Supply to Fan Motors:
- a. As indicated on Drawings.
 - b. Factory install a **[disconnect switch][junction box][motor controller][variable-frequency controller]** for each fan motor.
 - 1) Locate in a convenient and field-accessible location on unit exterior.
 - 2) Installation shall comply with NFPA 70.
 - 3) Wire, Conduit, and Enclosures:
 - a) Minimum Conduit Size: **[3/4 inch (20 mm)]<Insert dimension>**.
 - b) Materials: Metal, corrosion resistant **[and constructed of stainless steel]**.
 - c) Motor Termination: Flexible conduit, NRTL listed, not to exceed **36 inches (900 mm)** long.
 - d) Supports: Support conduits, boxes, and enclosures using corrosion-resistant fastening hardware **constructed of stainless steel**.
 - e) Wire: Copper, rated for 600 V, solid wire for size **[No. 10 AWG]<Insert wire size>** and smaller and stranded wire for larger sizes.
 - f) Minimum Wire Size: **[No. 12 AWG]<Insert wire size>**.
 - g) Each circuit shall have a ground wire.
 - h) Install wire in conduit.
 - 4) Boxes, Conduit Outlet Boxes, and Enclosures:
 - a) Located in Airstream: NEMA 250, **[Type 4][Type 4X][or][Type 12]<Insert Type>**.
 - b) Located in Service Corridor: NEMA 250, **[Type 1][Type 4][or][Type 12]<Insert Type>**.
 - c) Located on Exterior of Air-Handling Unit Casing: NEMA 250, **[Type 3R][Type 4][or][Type 4X]<Insert Type>**.
9. Disconnect Switches:
- a. Specification Grade: "Heavy Duty Type"; "quick-make," "quick-break" construction.
 - b. Three pole, **[fused][or][nonfused]**.
 - c. 600 V rated.

- d. Minimum Short-Circuit Current Rating: As required by electrical power distribution system, but not less than [42,000][65,000]<Insert value> A.
 - e. Enclosure:
 - 1) Located in Service Corridor: NEMA 250, [Type 1][Type 4][or][Type 12]<Insert Type>.
 - 2) Located on Exterior of Air-Handling Unit Casing: NEMA 250, [Type 3R][Type 4][or][Type 4X]<Insert Type>.
 - f. Operating handle shall be of box-mounted type that directly drives switch mechanism.
 - g. Disconnect switch shall use a flange-operated visible blade that is close coupled to a vertical-lift-type handle that achieves a positive visible indication of disconnect with cover open or closed.
 - h. Disconnect switch shall have a defeatable, front-accessible, mechanical interlock to prevent opening of cover when switch is in "ON" position, and to prevent turning switch "ON" when the door is open.
 - i. Include a solid neutral as required by authorities having jurisdiction.
 - j. Disconnect switch shall have a ground lug for ground wire termination.
 - k. Operating handle shall be lockable in open position.
 - l. Horsepower rated.
 - m. Feed through or double lugged.
10. Motor Field Power Junction Box:
- a. Provide junction box with internal wire terminal block mounted on unit exterior for interface with field power wiring.
 - 1) Provide for each motor not installed with a factory disconnect or controller with integral disconnect.
 - b. Factory install internal wiring and conduit to motor.
11. Motor Controllers:
- a. NEMA ICS 2, Class A, full-voltage, non-reversing, motor-rated controller.
 - b. Configured for control of single- or multispeed motors as indicated.
 - c. Enclosure: Hinged full-front access door with lock and key.
 - 1) Located in Service Corridor: NEMA 250, [Type 1][Type 4][or][Type 12]<Insert Type>.
 - 2) Located on Exterior of Air-Handling Unit Casing: NEMA 250, [Type 3R][Type 4][or][Type 4X]<Insert Type>.
 - d. Externally Operated Disconnect: [Door-Interlocked,][Fused disconnect switch][Nonfused disconnect switch][Circuit breaker] with lockable handle.
 - e. Short-Circuit Current Rating: As required by electrical power distribution system, but not less than [42,000][65,000][100,000]<Insert value> A.
 - f. Hand-Off-Auto Switch: Mounted on face of enclosure.
 - g. Push-to-Test Run Status Pilot Lights: NEMA ICS 2, heavy-duty type.
 - h. Control Relays: Time-delay relays.
 - i. Phase-Failure, Phase-Reversal, Undervoltage Relays: Solid-state sensing circuit with adjustable undervoltage setting and isolated output contacts for hardwired connection.
 - j. Elapsed-Time Meters: Numerical readout in hours on face of enclosure.
 - k. Number-of-Starts Counter: Numerical readout on face of enclosure.
12. Variable-Frequency Controllers:

- a. Description: NEMA ICS 2; arranged to achieve motor variable speed by adjusting output voltage and frequency.
- b. Enclosure: Unit mounted, with hinged full-front access door with lock and key.
 - 1) Located in Service Corridor: NEMA 250, [Type 1][Type 4][or][Type 12]<Insert Type>.
 - 2) Located on Exterior of Air-Handling Unit Casing: NEMA 250, [Type 3R][Type 4][or][Type 4X]<Insert Type>.
- c. Externally Operated Disconnect: [Door-Interlocked,][Fused disconnect switch][Nonfused disconnect switch][Circuit breaker] with lockable handle.
- d. Minimum Short-Circuit Current Rating: As required by electrical power distribution system, but not less than [42,000][65,000][100,000]<Insert value> A.
- e. Technology: Pulse-width-modulation (PWM) output with insulated gate bipolar transistors (IGBT); suitable for variable torque loads.
- f. Controller shall consist of a rectifier converter section, a digital/analog driver regulator section, and an inverter output section.
- g. Output Rating: Three phase; with voltage proportional to frequency throughout voltage range.
- h. Output signal shall be programmed to not cause mechanical vibration issues with fan drive assembly.
- i. Operating Requirements:
 - 1) Input AC Voltage Tolerance: [10]<Insert number> percent.
 - 2) Input frequency tolerance of 60 Hz, plus or minus 2 Hz.
 - 3) Capable of driving full motor load, without derating.
 - 4) Minimum Efficiency: 96 percent at 60 Hz, full load.
 - 5) Minimum Displacement Primary-Side Power Factor: 95 percent.
 - 6) Overload Capability: 1.05 times the full-load current for 7 seconds.
 - 7) Starting Torque: As required by fan and motor drive assembly.
 - 8) Speed Regulation: 1 percent.
 - 9) Speed Range: 10:1 speed range.
 - 10) To avoid equipment resonant vibrations, include critical speed lockout circuitry to allow bands of operating frequency at which controller shall not operate continuously.
 - 11) Capable of being restarted into a motor coasting in either the forward or reverse direction without tripping.
- j. Controller Adjustability Capabilities: Minimum and maximum output frequency, acceleration and deceleration, and current limit.
- k. Self-Protection and Reliability Features: Subjecting the controller to any of the following conditions shall not result in component failure or need for replacement:
 - 1) Surge suppression.
 - 2) Loss of input signal protection.
 - 3) Critical frequency rejection.
 - 4) Overtemperature.
 - 5) Short circuit at controller output.
 - 6) Ground fault at controller output. Variable-frequency controller shall be able to start a grounded motor.
 - 7) Open circuit at controller output.
 - 8) Input undervoltage.
 - 9) Input overvoltage.
 - 10) Loss of input phase.
 - 11) Reverse phase.

- 12) AC line switching transients.
 - 13) Instantaneous overload, line to line or line to ground.
 - 14) Sustained overload exceeding 100 percent of controller rated current.
 - 15) Starting a rotating motor.
 - 16) **<Insert features>**.
- l. Motor Protection: Controller shall protect motor against overvoltage and undervoltage, phase loss, reverse phase, overcurrent, overtemperature, and ground fault.
- m. Automatic Reset and Restart:
- 1) Capable of multiple restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction.
 - 2) Capable of automatic restart on phase-loss and overvoltage and undervoltage trips.
- n. Visual Indication: On face of controller; indicating the following conditions:
- 1) Power on.
 - 2) Run.
 - 3) Overcurrent and overvoltage.
 - 4) Motor speed (percentage).
 - 5) Various faults with alarm status.
 - 6) Input kilovolt amperes.
 - 7) Power factor.
 - 8) Input kilowatts and kilowatt-hours.
 - 9) Three-phase input and output voltage.
 - 10) Three-phase input and output current.
 - 11) Output frequency.
 - 12) Elapsed operating time (hours).
 - 13) Diagnostic and service parameters.
 - 14) **<Insert conditions>**.
- o. Operator Interface: Start-stop and auto-manual selector with manual-speed-control potentiometer.
- p. Hardwired Control Signal Interface: A minimum of **[two]<Insert number>** analog inputs (0 to 10 V or 0/4 to 20 mA) and **[four]<Insert number>** programmable digital inputs.
- q. Remote Communication Interface: **[ASHRAE 135 BACnet MS/TP][ASHRAE 135 BACnet IP]<Insert requirements>**.
- r. Line Conditioning:
- 1) Input line conditioning.
 - 2) Output filtering.
 - 3) EMI/RFI filtering.
- s. Bypass Controller:
- 1) Bypass Controller/Variable-Frequency Controller Selector Switch: Include manual selector switch on face of enclosure for local operator control of preferred controller.
 - 2) Bypass Mode: **[Manual operation only][Field-selectable automatic or manual]**.
 - a) In automatic mode, include fail-safe control logic to automatically transfer fan motor operation from failed variable-frequency controller to bypass controller.
 - 3) Type: Integrated NEMA ICS 2, Class A, full-voltage, non-reversing, motor-rated controller to operate fan motor if variable-frequency controller is not operational.
 - 4) Arrangement: Configure power supply to bypass controller and variable-frequency controller to completely isolate power to variable-frequency controller while

- operating fan motor through bypass controller for safe servicing of variable-frequency controller.
- 5) Enclosure: Install bypass controller in same enclosure as variable-frequency controller.
- 6) Remote Monitoring: Include control relay for remote indication of bypass controller operation.

RR. Factory-Assembled Controls:

1. General:

- a. Air-handling unit manufacturer shall furnish and factory install control instruments, control power circuit, control transformers, power supplies, wiring, tubing, raceways, and control panels.
- b. Provide for a single-point field connection to [120][277]-V electrical power for all factory-installed controls. Terminate power connection with a toggle switch mounted in control panel.
- c. Control panel shall serve as field tie-in point for all electric damper actuators, and control instruments located within air-handling unit. Controls for control dampers, control valves and instruments installed in ductwork and piping are not included as part of air-handling unit factory-installed controls.
- d. Control instruments shall be installed in accordance with manufacturer's written instructions.
- e. Control panel shall house flow, moisture, pressure and temperature transmitters, transformers, dc voltage power supplies, and wiring terminal strip.
- f. Carbon dioxide transmitters shall be mounted on air-handling unit casing exterior with sensor port exposed to the airstream.
- g. Factory install the following control instruments:
 - 1) Flow station and flow transmitter for each fan.
 - 2) Pressure sensors (inlet and discharge) and one combination pressure differential transmitter, switch, and controller for each filter bank installed in the air-handling unit.
 - 3) Pressure sensor and combination pressure differential transmitter, switch, and controller at the inlet of each fan.
 - 4) Pressure sensor and combination pressure differential transmitter, switch, and controller at the discharge of each fan.
 - 5) Carbon dioxide sensor/transmitters at locations indicated on Drawings.
 - 6) Moisture and temperature sensors and transmitters at locations indicated on Drawings.
 - 7) Temperature switches at locations indicated on Drawings.
 - 8) Control instruments indicated on Drawings.
 - 9) <Insert requirements>.

2. Wire and Cable:

- a. Single Conductor Control Wiring above 24 V:
 - 1) Wire size shall be at least No. 16 AWG.
 - 2) Conductor shall be 7/24 soft annealed copper stranding with a **2- to 2-1/2-inch (50- to 65-mm)** lay.
 - 3) Conductor insulation shall be 600 V, Type THWN or Type THHN, 90 deg C in accordance with UL 83.
 - 4) Conductor colors shall be black (hot), white (neutral), and green (ground).

- b. Single Twisted Shielded Instrumentation Cable above 24 V:
 - 1) Wire size shall be minimum No. 18 AWG.
 - 2) Conductors shall be a twisted, 7/24 soft annealed copper stranding with a **2- to 2-1/2-inch (50- to 65-mm)** lay.
 - 3) Conductor insulation shall have a Type THHN/THWN or Type TFN rating.
 - 4) Shielding shall be 100 percent 0.35/0.5-mil aluminum/mylar tape, helically applied with 25 percent overlap, and aluminum side in with a No. 18 AWG-7/26 tinned copper drain wire.
 - 5) Outer jacket insulation shall have a 600-V, 90 deg C rating and shall be Type TC cable.
 - 6) For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red, and white.
- c. Single Twisted Shielded Instrumentation Cable 24 V and Lower:
 - 1) Wire size shall be minimum No. 18 AWG.
 - 2) Conductors shall be a twisted, 7/24 soft annealed copper stranding with a **2- to 2-1/2-inch (50- to 65-mm)** lay.
 - 3) Conductor insulation shall have a nominal 15-mil thickness, constructed from flame-retardant PVC.
 - 4) Shielding shall be 100 percent 1.35-mil aluminum/polymer tape, helically applied with 25 percent overlap, and aluminum side in with a No. 20-22 AWG tinned copper drain wire.
 - 5) Outer jacket insulation shall have a 300-V, 105 deg C rating and shall be Type PLTC cable.
 - 6) For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red, and white.
- d. Wire and Cable Installation:
 - 1) Comply with manufacturer's written instructions and NFPA 70.
 - 2) Grounding shall be in accordance with IEEE C2. Ground wire shall be copper. Demonstrate ground resistance.
 - 3) Wiring and cables shall be installed in conduit. Exposed wire and cable are unacceptable.
 - 4) Wire and cables may be grouped in a common raceway, except do not group wires and cables from different voltages.
 - 5) Install control wiring in a separate conduit from power wiring.
 - 6) Wiring shall be continuous from terminal to terminal without splices.
 - 7) Do not install low-voltage wire and cable closer than **[12 inches (300 mm)]<Insert distance>** from line voltage electrical power wire and cables. Provide an installation free of EMI.
 - 8) Use insulated spade lugs for wiring connection to screw terminals.
 - 9) Use shielded cable to transmitters.
 - 10) Terminate wiring and cables within a control panel, within instrument housing, or in a junction box. Clamp the cable over the jacket, in the junction box. Individual conductors in the stripped section of cable shall be slack between clamping point and terminal block.
 - 11) Terminate wire and cable in control panel with terminal blocks.
 - 12) Identify each wire and cable on each end and at each terminal with a number coded identification tag. Each wire and cable conductor shall have a unique tag.
 - 13) Perform continuity and meager testing on wiring and cable.

3. Raceways:

- a. Conduit:
 - 1) Install wiring and cable in conduit.
 - 2) Minimum Conduit Size: [1/2 inch (13 mm)][3/4 inch (20 mm)]<Insert dimension>.
 - 3) Materials: Metal, corrosion resistant[**and constructed of stainless steel**].
 - 4) Supports: Support conduits, boxes, and enclosures using corrosion-resistant fastening hardware[**constructed of stainless steel**].
 - 5) Terminations to Actuators and Instruments: Flexible conduit, NRTL listed, not to exceed **24 inches (600 mm)** long.
 - b. Boxes, Conduit Outlet Boxes, and Enclosures:
 - 1) Located in Airstream: NEMA 250, [Type 4][Type 4X][or][Type 12]<Insert Type>.
 - 2) Located in Service Corridor: NEMA 250, [Type 1][Type 4][or][Type 12]<Insert Type>.
 - 3) Located on Exterior of Air-handling Unit Casing: NEMA 250, [Type 4][or][Type 4X]<Insert Type>.
 - c. Seals: Seal pathways to prevent air leakage between air-handling unit exterior and interior, and between internal component sections.
 - d. Conduit Installation:
 - 1) Conduit shall be continuous and secured in a manner that is electrically continuous throughout.
 - 2) Secure threaded conduit entering a cabinet, box or enclosure with a locknut on outside and on inside, such that conduit system is electrically continuous throughout.
 - a) Install a metal bushing with insulated throat on inside.
 - b) Locknuts designed to bite into metal, or on inside of enclosure and shall have a grounding wedge lug under locknut.
 - 3) Conduit box connectors for conduit entering enclosures shall be insulated throat type.
 - 4) Connect conduit with watertight sealing locknuts that are suitable for wet applications.
 - 5) Offset conduits where they enter surface-mounted equipment and panels.
 - 6) Neatly loop and lace wiring installed in panels and other enclosures.
 - 7) Seal conduit runs to prevent the circulation of air by installing seal fittings.
 - 8) Install conduit inside of air-handling unit casing. Wiring and conduit running on exterior of air-handling unit casing is unacceptable.
4. Tubing and Fittings:
- a. Products in this paragraph are intended for use with the following:
 - 1) Main air and signal air to pneumatically controlled instruments, actuators, and other control devices and accessories.
 - 2) Signal air between pressure instruments, such as sensors, switches, transmitters, controllers, and accessories.
 - b. Copper Tubing:
 - 1) Seamless phosphor deoxidized copper, soft annealed or drawn tempered, with chemical and physical properties in accordance with ASTM B75/B75M.
 - 2) Performance, dimensions, weight and tolerance in accordance with ASTM B280.

- 3) Diameter, as required by application, not less than nominal **0.25 inch (6 mm)**.
- 4) Wall thickness, as required by application, but not less than **0.030 inch (0.8 mm)**.
- c. Copper Tubing Fittings: Brass, compression type.
- d. Polyethylene Tubing:
 - 1) Fire-resistant black virgin polyethylene in accordance with ASTM D1248, Type 1, Class C and Grade 5.
 - 2) Tubing shall comply with stress crack test in accordance with ASTM D1693.
 - 3) Diameter, as required by application, of not less than nominal **0.25 inch (6 mm)**.
- e. Polyethylene Tubing Fittings: Brass, compression type.
- f. Stainless Steel Tubing:
 - 1) Seamless Type 316 stainless steel, Grade TP, cold drawn, annealed and pickled, free from scale.
 - 2) Chemical and physical properties in accordance with ASTM A269/A269M.
 - 3) Diameter, as required by application, of not less than nominal **0.25 inch (6 mm)**.
 - 4) Wall thickness, as required by application, but not less than **0.035 inch (0.9 mm)**.
 - 5) Furnish stainless steel tubing in **20-foot (6-mm)** straight random lengths.
- g. Stainless Steel Tubing Connectors and Fittings:
 - 1) Connectors and fittings shall be stainless steel, with stainless steel collets, flareless type.
 - 2) Connect instruments to tubing with connectors having compression connector on one end and IPS or NPT thread on other end.
- h. Tubing Installation:
 - 1) Use **[copper][or][stainless steel]** tubing except use fire-resistant polyethylene for tubing located in control panels.
 - 2) Run tubing parallel to, and at right angles to, casing.
 - 3) Route multiple runs of tubing in neat parallel lines.
 - 4) Support tubing as follows:
 - a) Support metal tubing with hangers, clips, and tube trays.
 - b) Do not use tapes for mounting tubing.
 - c) Place a support within **1 foot (0.3 m)** of each change in direction and each branch take off.
 - d) Spacing between supports shall not exceed **[60 inches (1500 mm)]<Insert distance>**.
 - 5) Tubing shall not interfere with access to dampers and equipment or obstruct passageways of any kind.
 - 6) Provide vibration loops in tubing when connecting to equipment that might vibrate.
 - 7) Where joining or mating dissimilar metals where galvanic action could occur, provide dielectric isolation.
 - 8) Make tubing bends with a bending tool. Hard bends, or wrinkled or flattened bends are unacceptable.
 - 9) Install tubing fitting make-up in accordance with manufacturer's written instructions.
 - 10) Do not make tubing connections to a fitting before completing make-up connection.
 - 11) Properly align tubing with fitting. Springing tube into position can result in excessive stress on both tubing and fitting with possible resulting leaks.
 - 12) Do not install fittings close to a bend. Length of straight tubing, not deformed by bending is required for a proper connection.

- 13) Check tubing for correct diameter and wall thickness. Tube ends shall be cut square and deburred. Exercise care during cutting to keep tubing round.
- 14) Wrap threads of fittings with a single wrap of PTFE tape.
- 15) Install tubing with extreme care to keep foreign matter out. Keep open ends of tubing plugged to keep out dust, dirt, and moisture.
- 16) Mark each tube on each end with a number-coded identification. Each tube shall have a unique number.
- 17) Test tubing as follows:
 - a) Test for leaks and obstructions. Disconnect each tubing run before test is run, and blow out trash, condensate, and other foreign material with compressed air.
 - b) After foreign matter is expelled and the line is free from obstructions, plug the far end of tubing run.
 - c) Connect a pressure source to the near end with a needle valve between air supply and tubing run. Only commercially pure dry compressed air or nitrogen as distributed in gas cylinders is acceptable for this test.

5. Control Panels:

- a. Design control panels for grouping and protecting various electric, and/or electronic components.
- b. NRTL listed in accordance with UL 50 or UL 50E.
- c. Enclosure:
 - 1) Located in Service Corridor: NEMA 250, **[Type 1][Type 4][or][Type 12]<Insert Type>**.
 - 2) Located on Exterior of Air-Handling Unit Casing: NEMA 250, **[Type 4][or][Type 4X]<Insert Type>**.
- d. Construct enclosure of steel, not less than the following:
- e. Enclosure Size Less Than 24 inches (600 mm): **[0.053 inch (1.35 mm)][or][0.067 inch (1.7 mm)]** thick.
- f. Enclosure size 24 inches (600 mm) and Larger: **[0.067 inch (1.7 mm)][or][0.093 inch (2.36 mm)]** thick.
- g. Support front panel using a non-removable piano hinge that runs entire height of cabinet.
- h. Each panel shall not exceed height of air-handling unit casing and **72 inches (1800 mm)** high.
- i. Secure front panel with a key locking mechanism. Common key the locks, and provide one pair of keys per panel.
- j. Front panel with a window of size so all instrument displays are visible with door closed.
- k. Mount panels on exterior wall of air-handling unit casing on primary access side of unit.
- l. Paint control panel exterior with enamel at least 5 mils thick. Color of panel exterior and interior shall be white.
- m. Include panel field power supply with a toggle-type switch located at entrance inside panel to disconnect power.
- n. Include panel with a line-voltage nominal 20-A GFCI duplex receptacle for service and testing tools. Wire receptacle on hot side of enclosure disconnect switch and include with a 5-A circuit breaker.
- o. Size control panel to provide at least 25 percent spare area on subpanel.
- p. Arrange control panel so similar type equipment is grouped together, and a barrier is installed between electrical and electronic equipment.
- q. Interior ambient temperature shall not rise above manufacturer's recommended maximum operating temperature for products installed within the panels. Provide filtered louvers and circulating fans, when necessary, to meet criteria.

- r. Panel shall serve as a central tie-in point for control devices such as remote sensors, transmitters, power supplies, and transformers.
 - 1) Factory install internal wiring in compliance with specified standards.
 - 2) Terminate wiring using an electric terminal strip with heavy-duty terminal blocks.
 - 3) Include spare terminals, equal to not less than **[10][20]<Insert number>** percent of used terminals.
 - 4) Include spade lugs for stranded wire.
 - 5) Install a maximum of two wires on each side of a terminal.
 - 6) Label each end of cable, wire, and tubing within panel following an approved identification system.
 - s. Polyethylene tubing may be used within panel enclosure in place of copper.
 - t. Supply each control panel with a complete set of as-built schematics, tubing, and wiring diagrams that are bound in a three-ring protective binder and located within panel.
 - u. Mount instruments and other products within control panel on an internal panel(s) and provide with nameplates. Provide engraved, laminated phenolic nameplates (black letters on a white background). Nameplates shall have at least **1/4-inch- (6-mm-)** high lettering.
 - v. Route tubing, cable and wiring located inside control panel within a raceway that has a continuous removable cover.
6. Pitot Tube Airflow Stations:
- a. Fan Inlet Airflow Sensor (Piezometer Ring):
 - 1) Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a) **[ebm-papst Inc.]**
 - b) **[Greenheck Fan Corporation]**
 - c) **[Twin City Fan & Blower]**
 - d) **<Insert manufacturer's name>**
 - 2) Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a) **[ebm-papst Inc.]**
 - b) **[Greenheck Fan Corporation]**
 - c) **[Twin City Fan & Blower]**
 - d) **<Insert manufacturer's name>**
 - 3) Source Limitations: Obtain sensors from single source from single manufacturer.
 - 4) Provide fans with airflow measurement integral to fan inlet cones for continuously measurement of air volume flow rate.
 - 5) Fan inlet airflow sensor shall contain multiple pressure sensor points strategically placed along the circumference of the inlet cone and internally connected to an averaging ring manifold located behind the inlet cone.
 - 6) Sensor points shall neither protrude beyond the surface of the inlet cone nor be adversely affected by particle contamination present in the airstream.
 - 7) Sensor shall produce steady, non-pulsating signals to achieve accuracy within 5 percent of actual airflow.
 - 8) Sensor shall be non-intrusive and not impact fan performance.
 - 9) Product shall be a standard offering of fan manufacturer and include published

literature with supporting test data to validate sensor performance.

7. Thermal Airflow Measurement Stations:

- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Air Monitor; an ONICON Brand]**
 - 2) **[Ebtron, Inc]**
 - 3) **<Insert manufacturer's name>**
- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Air Monitor; an ONICON Brand]**
 - 2) **[Ebtron, Inc]**
 - 3) **<Insert manufacturer's name>**
- c. Source Limitations: Obtain stations from single source from single manufacturer.
- d. Description: Airflow station shall consist of one or more sensor probes and a remotely mounted microprocessor-based transmitter.
- e. Performance:
 - 1) Capable of independently processing up to **[16]<Insert number>** independently wired sensor assemblies.
 - 2) Airflow rate of each sensor assembly shall be equally weighted and averaged by transmitter prior to output.
 - 3) Temperature of each sensor assembly shall be velocity weighted and averaged by transmitter prior to output unless temperature sensor has an accuracy of **0.1 deg F (0.06 deg C)**.
 - 4) Listed and labeled by an NRTL as successfully tested as an assembly in accordance with UL 873 or UL 60730.
 - 5) Components shall be interconnected by exposed NRTL-listed plenum-rated cable or non-plenum-rated cable placed in conduit.
 - 6) Each flow station shall be factory calibrated at a minimum of **[six][16]<Insert number>** airflow rates and **[two][three]<Insert number>** temperatures to standards that are traceable to NIST.
 - 7) Individual Sensor Airflow Accuracy: Within **[2][3]<Insert number>** percent of reading over the entire operating airflow range.
 - 8) Thermal Airflow Station Assembly Airflow Accuracy: Within **[2][3][5]<Insert number>** percent of reading over the entire operating airflow range.
 - a) Devices whose accuracy is combined accuracy of transmitter and sensor probes must demonstrate that total accuracy meets performance requirements throughout the measurement range.
 - 9) Temperature Accuracy: Within **0.2 deg F (0.11 deg C)** over entire operating range of **minus 20 to plus 140 deg F (minus 29 to plus 60 deg C)**.
 - 10) Sensor Ambient Operating Temperature Range: **Minus 20 to plus 160 deg F (Minus 29 to plus 71 deg C)**.
 - 11) Transmitter Ambient Operating Temperature Range: **Minus 20 to plus 120 deg F (Minus 29 to plus 49 deg C)**.

- 12) Sensor and Transmitter Ambient Operating Humidity Range: Zero to 99 percent, noncondensing.
- 13) Instrument shall compensate for changes in air temperature and density throughout calibrated velocity range for seasonal extremes at Project location.
- 14) Pressure Drop: **0.05 inch wg (12.5 Pa) at 2000 fpm (10.2 m/s)** across a **24-by-24-inch (600-by-600-mm)** area.
- 15) Instruments mounted in throat or face of fan inlet cone shall not negatively influence fan performance by reducing flow more than **[1][2]<Insert number>** percent of Project design flow or negatively impact fan-generated sound. Losses in performance shall be documented with submittal data, and adjustments to compensate for performance impact shall be made to fan to deliver Project design airflow indicated.

f. Sensor Assemblies:

- 1) Each sensor probe shall contain two individually wired, hermetically sealed **[bead-in-glass]**thermistors.
- 2) Mount thermistors in sensor using a marine-grade, waterproof material.
- 3) Thermistor leads shall be protected and not exposed to environment.
- 4) Each sensor assembly shall independently determine airflow rate and temperature at each measurement point.
- 5) Each sensor probe shall have an integral cable for connection to remotely mounted transmitter.
- 6) Sensor Probe Material: Gold anodized, extruded Alloy 6063 aluminum tube or Type 304 stainless steel.
- 7) Probe Assembly Mounting Brackets Material: Type 304 stainless steel.

g. Transmitter:

- 1) Integral digital display capable of simultaneously displaying total airflow and average temperature, individual airflow, and temperature readings of each independent sensor assembly.
- 2) Capable of field configuration and diagnostics using an onboard push-button interface and digital display.
 - a) Include an integral power switch to operate on 24-V ac (isolation not required) and include the following:
 - b) Integral protection from transients and power surges.
 - c) Circuitry to ensure reset after power disruption, transients, and brownouts.
 - d) Integral transformer to convert field power source to operating voltage required by instrument.

h. Remote Signal Interface:

- 1) Linear Analog Signals for Airflow and Temperature: Fuse protected and isolated, **[field selectable],[0 to 10 V dc][or][4 to 20 mA]**.
- 2) RS-485: BACnet-ARCNET, BACnet-MS/TP, and Modbus-RTU.
- 3) 10 Base-T Ethernet: BACnet Ethernet, BACnet-IP, Modbus-TCP, and TCP/IP.
- 4) LonWorks free topology.

8. Flow Transmitters for Pitot Tube Sensors:

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

- 1) **[Air Monitor; an ONICON Brand]**
 - 2) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Air Monitor; an ONICON Brand]**
 - 2) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain sensors from single source from single manufacturer.
 - d. Receives total and static pressure signals from a flow element, amplify, extract the square root, and scale the signal to produce a 4- to 20-mA dc output signal linear to airflow.
 - e. Housed in NEMA 250, Type 1 enclosure.
 - f. Assembly constructed so that shock, vibration, and pressures surges of up to **1 psig (6.9 kPa)** will neither harm transmitter nor affect its accuracy.
 - g. Provide transmitter with an automatic zeroing circuit capable of automatically readjusting transmitter zero at predetermined time intervals. Automatic zeroing circuit shall re-zero transmitter to within 0.1 percent of true zero.
 - h. Performance:
 - 1) Range: At least 20 percent below minimum airflow and 20 percent greater than design airflow.
 - 2) Calibrated Span: Field adjustable, minus 40 percent of the range.
 - 3) Accuracy: Within 0.10 percent of natural span.
 - 4) Repeatability: Within 0.15 percent of calibrated span.
 - 5) Linearity: Within 0.2 percent of calibrated span.
 - 6) Hysteresis and Deadband (Combined): Less than 0.2 percent of calibrated span.
 - i. Equip transmitter with an integral digital LED or LCD for continuous indication of airflow.
 - j. Install in control panel.
9. Humidity Sensors and Transmitters with Digital Display:
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Vaisala]**
 - 2) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Vaisala]**
 - 2) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain sensors and transmitters from single source from single manufacturer.
 - d. Performance:
 - 1) Accuracy including non-linearity, hysteresis, and repeatability: Within 2 percent from zero to 90 percent relative humidity and within 2.5 percent from 90 to 100 percent

- relative humidity when operating between **60 to 77 deg F (16 to 25 deg C)**.
- 2) Relative Humidity Range: Zero to 100 percent.
- 3) Factory calibrated and NIST traceable with certificate included.
- e. Construction:
 - 1) Provide housing with remote sensor probe for ducted applications.
 - a) Duct Sensor Body: 300 series stainless steel or chrome-plated aluminum, at least **2 inches (50 mm)** long for duct-mounted applications.
 - b) Provide sensor with cable for field installation in conduit.
 - c) For duct-mounted applications, thread the sensor assembly for connection to a threaded mounting flange.
 - 2) Provide general-purpose humidity sensor unless application requires special requirements. Provide sensor with sintered stainless steel filter.
 - 3) Housing shall be ABS/PC plastic or powder-coated aluminum.
 - 4) Housing Classification: NEMA 250, Type 4 or Type 4X.
 - 5) Provide housing with wall-mounting plate.
- f. Output Signal: Two-wire, 4- to 20-mA output signal with a drive capacity of at least 500 ohms at 24 V dc.
- g. Provide unit with a digital display of relative humidity in percent.
- 10. Air Pressure Sensors:
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) **[Dwyer Instruments, Inc]**
 - 2) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Dwyer Instruments, Inc]**
 - 2) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain sensors from single source from single manufacturer.
 - d. Insertion length shall be at **[4 inches (100 mm)][6 inches (150 mm)][8 inches (200 mm)][12 inches (300 mm)]**.
 - e. Sensor with four radial holes of **0.04-inch (1-mm)** diameter.
 - f. **[Brass][or][stainless steel]** construction.
 - g. Sensor with threaded end support, sealing washers, and nuts.
 - h. Connection: **NPS 1/4 (DN 6)** compression fitting.
- 11. Air-Pressure Differential Indicating Transmitter, Switch, and Controller:
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

- 1) [Dwyer Instruments, Inc]
 - 2) <Insert manufacturer's name>
- b. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- 1) [Dwyer Instruments, Inc]
 - 2) <Insert manufacturer's name>
- c. Source Limitations: Obtain from single source from single manufacturer.
- d. Description:
- 1) Three-in-one instrument, including digital display, control relay switches, and a transmitter with a current output.
 - 2) Field configurable for pressure, velocity, and volumetric flow applications through user interface.
 - 3) Select instrument range based on application. Range shall be approximately 2 times set point.
- e. Performance:
- 1) Accuracy Including Hysteresis and Repeatability:
 - a) Within 1 percent for ranges less than **5 inches wg (1250 Pa)**.
 - b) Within 0.5 percent at **77 deg F (25 deg C)** for other ranges.
 - 2) Stability: Within 1 percent per year.
 - 3) Response Time: 250 ms.
 - 4) Overpressure: **5 psig (34 kPa)** for instrument ranges less than **50 inch wg (12.5 kPa)** and **9 psig (62 kPa)** for **100-inch wg (25-kPa)** range.
 - 5) Temperature Limits: **32 to 140 deg F (0 to 60 deg C)**.
 - 6) Thermal Effects: 0.020 percent per deg F.
 - 7) Warm-up Period: One hour.
- f. Controller Programming through Menu Keys to Access Five Menus:
- 1) Security level.
 - 2) Pressure, velocity, or flow application.
 - 3) Engineering units.
 - 4) K-factor for use with flow application.
 - 5) Set-point control only; set-point and alarm operation; and alarm operation as high, low, or high/low with manual or automatic reset and delay.
 - 6) View high and low readings.
 - 7) Digital dampening for smoothing erratic applications.
 - 8) Scaling of analog output to fit range and field calibration.
- g. Display:
- 1) Digital, four-digit display with backlight, with **0.4-inch- (10-mm-)** high, alphanumeric characters.
 - 2) Four indicators; two for set point and two for alarm status.
- h. Operator Interface:

- 1) Set-point adjustment through keypad on face of instrument.
 - 2) Zero and span adjustments accessible through menu.
 - 3) Programming through keypad.
 - i. Analog Output Signal:
 - 1) Two-wire, 4- to 20-mA dc current source.
 - 2) Signal capable of operating into a 900-ohm load.
 - j. Digital Output Signal:
 - 1) Two SPDT relays.
 - 2) Each rated for 1 A at 30 V ac or dc.
 - k. Construction:
 - 1) Die cast-aluminum casing and bezel.
 - 2) Threaded, **NPS 1/8 (DN 6)** connections on side and back.
 - 3) Vertical plane mounting.
 - 4) NEMA 250, Type 1.
 - 5) Nominal **4-inch- (100-mm-)** diameter face.
 - 6) Mounting Bracket: Appropriate for installation.
12. Carbon Dioxide Sensors/Transmitters:
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) **[Vaisala]**
 - 2) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Vaisala]**
 - 2) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain sensors/transmitters from single source from single manufacturer.
 - d. Description:
 - 1) NDIR technology or equivalent technology providing long-term stability and reliability.
 - 2) Two-wire, 4- to 20-mA output signal; linearized to carbon dioxide concentration in ppm.
 - e. Construction:
 - 1) House electronics in an ABS plastic enclosure. Provide equivalent of NEMA 250, Type 4.
 - 2) Equip with digital display for continuous indication of carbon dioxide concentration.
 - f. Performance:

- 1) Measurement Range: 0 to 2000 ppm.
 - 2) Accuracy: Within 2 percent of reading, plus or minus 30 ppm.
 - 3) Repeatability: Within 1 percent of full scale.
 - 4) Temperature Dependence: Within 0.05 percent of full scale over an operating range of **25 to 110 deg F (minus 4 to plus 43 deg C)**.
 - 5) Long-Term Stability: Within 5 percent of full scale after more than five years.
 - 6) Response Time: Within 60 seconds.
 - 7) Warm-up Time: Within five minutes.
- g. Provide calibration kit. Turn over to Owner at start of warranty period.
13. Air Temperature Sensors:
- a. Platinum Resistance Temperature Detector (RTD): Common Requirements:
- 1) 100 or 1000 ohms at 0 deg C and a temperature coefficient of 0.00385 ohms/ohm/deg C.
 - 2) Two-wire Teflon insulated **22-gauge (0.65-mm)** stranded copper leads.
 - 3) Performance Characteristics:
 - a) Range: **Minus 50 to plus 275 deg F (Minus 46 to plus 135 deg C)**.
 - b) Interchangeable Accuracy: At **32 deg F (0 deg C)** within **0.5 deg F (0.3 deg C)**.
 - c) Repeatability: Within **0.5 deg F (0.3 deg C)**.
 - d) Self-Heating: Negligible.
 - 4) Transmitter Requirements:
 - a) Transmitter required for each 100-ohm RTD.
 - b) Transmitter optional for 1000-ohm RTD, contingent on compliance with end-to-end control accuracy.
- b. Platinum RTD, Averaging Sensor:
- 1) Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a) **[Minco]**
 - b) **<Insert manufacturer's name>**
 - 2) Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a) **[Minco]**
 - b) **<Insert manufacturer's name>**
 - 3) Source Limitations: Obtain sensors from single source from single manufacturer.
 - 4) **[100][or][1000]** ohms.
 - 5) Temperature Range: **Minus 50 to plus 275 deg F (Minus 45 to plus 135 deg C)**.
 - 6) Multiple sensors to provide average temperature across entire length of sensor.
 - 7) Rigid probe of aluminum, brass, copper or stainless steel sheath.
 - 8) Flexible probe of aluminum, brass, copper or stainless steel sheath and formable to

- a **4-inch (100-mm)** radius.
 - 9) Length: As required by application to cover entire cross section of air tunnel.
 - 10) Enclosure: Junction box with removable cover; NEMA 250, Type 4.
 - 11) Gasket for attachment to duct or equipment to seal penetration airtight.
 - 12) Conduit Connection: **1/2-inch (13-mm)** trade size.
14. Air Temperature Switches:
- a. Thermostat and Switch for Low Temperature Control:
 - 1) Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a) **[Honeywell Building Solutions; Honeywell International, Inc.]**
 - b) **[Siemens Industry, Inc., Building Technologies Division]**
 - c) **<Insert manufacturer's name>**
 - 2) Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a) **[Honeywell Building Solutions; Honeywell International, Inc.]**
 - b) **[Siemens Industry, Inc., Building Technologies Division]**
 - c) **<Insert manufacturer's name>**
 - 3) Source Limitations: Obtain switches from single source from single manufacturer.
 - 4) General:
 - a) Two-position control.
 - b) Field-adjustable set point.
 - c) Manual reset.
 - d) NRTL listed.
 - 5) Performance:
 - a) Operating Temperature Range: **15 to 55 deg F (Minus 9 to plus 13 deg C).**
 - b) Temperature Differential: **5 deg F (2.8 deg C)**, non-adjustable and additive.
 - c) Enclosure Ambient Temperature: **Minus 20 to plus 140 deg F (Minus 11 to plus 60 deg C).**
 - d) Sensing Element Maximum Temperature: **250 deg F (121 deg C).**
 - e) Voltage: 120 V ac.
 - f) Current: 16 full-load A.
 - g) Switch Type: Two SPDT snap switches operate on coldest **12-inch (300-mm)** section along element length.
 - 6) Construction:
 - a) Vapor-Filled Sensing Element: Nominal **20 feet (6 m)** long.
 - b) Dual Temperature Scale: Fahrenheit and Celsius visible on face.
 - c) Set-Point Adjustment: Screw.
 - d) Enclosure: Painted metal, NEMA 250, Type 1.
 - e) Electrical Connections: Screw terminals.
 - f) Conduit Connection: **1/2-inch (13-mm)** trade size.

15. Air Temperature RTD Transmitters:

- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Minco]**
 - 2) **<Insert manufacturer's name>**
- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Minco]**
 - 2) **<Insert manufacturer's name>**
- c. Source Limitations: Obtain transmitters from single source from single manufacturer.
- d. House electronics in NEMA 250, Type 1 enclosure. Mount transmitter in control panel.
- e. Conduit Connection: **1/2-inch (36-mm)** trade size.
- f. Functional Characteristics:
 - 1) Input:
 - a) 100-ohm platinum RTD temperature coefficient of 0.00385 ohms/ohms/deg C; two-wire sensors.
 - b) 1000-ohm platinum RTD temperature coefficient of 0.00385 ohms/ohms/deg C; two-wire sensors.
 - 2) Span (Adjustable):
 - a) Exhaust Air: **50 to 100 deg F (10 to 38 deg C)**.
 - b) Mixed Air: **Minus 40 to plus 140 deg F (Minus 40 to plus 60 deg C)**.
 - c) Outdoor: **Minus 40 to plus 140 deg F (Minus 40 to plus 60 deg C)**.
 - d) Supply Air, Cooling, and Heating: **40 to 120 deg F (4 to 49 deg C)**.
 - e) Return Air: **50 to 100 deg F (10 to 38 deg C)**.
 - 3) Output: 4- to 20-mA dc linear with temperature; RFI insensitive; minimum drive load of 600 ohms at 24 V dc.
 - 4) Zero and span field adjustments plus or minus 5 percent of span. Minimum span **50 deg F (28 deg C)**.
 - 5) Match sensor with temperature transmitter and factory calibrate together.
- g. Performance Characteristics:
 - 1) Calibration Accuracy: Within 0.1 percent of span.
 - 2) Stability: Within 0.2 percent of span for at least six months.
 - 3) Combined Accuracy: Within 0.5 percent.
- h. Provide each transmitter with a digital display.

16. Liquid Flow Meters:

- a. General: Extended range of **[10][20]<Insert number>** percent above Project design flow and **[10][20]<Insert number>** percent below Project minimum flow to signal abnormal flow

conditions.

b. In-line Body Electromagnetic Liquid Flow Meters:

- 1) Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a) **[Armstrong International, Inc]**
 - b) **[Badger Meter, Inc.]**
 - c) **[ONICON Incorporated]**
 - d) **[Spirax Sarco Limited]**
 - e) **<Insert manufacturer's name>**
- 2) Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a) **[Armstrong International, Inc]**
 - b) **[Badger Meter, Inc.]**
 - c) **[ONICON Incorporated]**
 - d) **[Spirax Sarco Limited]**
 - e) **<Insert manufacturer's name>**
- 3) Source Limitations: Obtain flow meters from single source from single manufacturer.
- 4) Description:
 - a) No moving parts.
 - b) Suitable for flow measurement of fluids with electrical conductivity more than 5 micro-Seimens per cm.
 - c) Inherent bi-directional flow measurement.
 - d) Flow measurement with three pipe diameters upstream and two pipe diameters downstream.
 - e) Wet calibrate and tag meters to standards traceable to NIST, and provide each meter with a certificate of calibration.
 - f) Transmitter **[integral to][remote from]** meter.
- 5) Performance:
 - a) Accuracy for Velocities between 3.3 and 33 fps (1 and 10 m/s): Within 0.2 percent of reading.
 - b) Accuracy for Velocities between 1.0 and 3.3 fps (0.3 and 1 m/s): Within 0.75 percent of reading.
 - c) Accuracy for Velocities Less than 1.0 fps (0.3 m/s): Within **0.0075 fps (0.0023 m/s)**.
 - d) Ambient Temperature: **Minus 4 to plus 140 deg F (Minus 20 to plus 60 deg C)**.
 - e) Process Temperature: **Minus 4 to plus 212 deg F (Minus 20 to plus 100 deg C)**.
 - f) Pressure: **[225 psig (1551 kPa)][580 psig (3999 kPa)]**.
- 6) Analog Output Current Signal:
 - a) Two-wire, 4- to 20-mA dc current source.
 - b) Signal capable of operating into 1000-ohm load.
 - c) Isolated.

-
- 7) Digital Output Signal: Two, programmable, digital/pulse outputs configurable for frequency, pulse, or directional flow.
 - 8) Operator Interface:
 - a) Keypad.
 - b) Digital Display: Multiple-line digital display of alphanumerical characters.
 - c) LED for normal and alarm operation.
 - 9) Construction:
 - a) Body: **[Epoxy-coated carbon steel][Type 316 stainless steel]**.
 - b) Body Liner Material: **[PTFE][Ebonite][Polypropylene]**.
 - c) Flow Tube: Type 304 stainless steel.
 - d) Connection: **[150 Class flange][300 Class flange][Threaded][Wafer]**.
 - e) Electrodes: Type 316 stainless steel. Quantity determined by manufacturer based on application.
 - 10) Electronics Enclosure:
 - a) Painted aluminum.
 - b) Removable cover.
 - c) NEMA 250, Type 4 or Type 6.
- c. Vortex-Shedding Liquid Flow Meters with Integral Pressure and Temperature Measurement:
- 1) Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a) **[Armstrong International, Inc]**
 - b) **[Badger Meter, Inc.]**
 - c) **[ONICON Incorporated]**
 - d) **<Insert manufacturer's name>**
 - 2) Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a) **[Armstrong International, Inc]**
 - b) **[Badger Meter, Inc.]**
 - c) **[ONICON Incorporated]**
 - d) **<Insert manufacturer's name>**
 - 3) Source Limitations: Obtain flow meters from single source from single manufacturer.
 - 4) Description:
 - a) Mass flow measurement corrected for density using vortex shedding body with integral piezoelectric pressure sensors and 1000-ohm platinum RTD.
 - b) Meter **NPS 1/2 through NPS 12 (DN 15 through DN 300)**.
 - c) Each meter shall be factory calibrated at five points from **0 to 250 fps (0 to 76 m/s)** and tagged accordingly against manufacturer's flow standards. Manufacturer shall provide a certificate of calibration for meter.
 - d) Each meter shall be programmed using Project-specific application data.

- e) Meter shall include integral diagnostics to verify installation conditions and proper operation.
- 5) Performance:
 - a) Volumetric Flow Accuracy for Liquid: Within 0.75 percent of reading for Reynolds numbers 20000 and larger.
 - b) Volumetric Flow Accuracy for Steam and Gas: Within 1 percent of reading for Reynolds numbers 20000 and larger.
 - c) Mass Flow Accuracy for Steam and Gas: Within 1.5 percent of reading for Reynolds numbers 20000 and larger.
 - d) Repeatability: Within 0.1 percent.
 - e) Long-Term Stability: Within 0.1 percent per year.
 - f) Ambient Temperature: **Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).**
 - g) Process Temperature: **Minus 40 to plus 464 deg F (Minus 40 to plus 240 deg C).**
 - h) Pressure: Equal to flange rating.
- 6) Output Signals:
 - a) Analog Current Signal of Flow Rate:
 - b) Two-wire, 4- to 20-mA dc current source.
 - c) Signal capable of operating into 1000-ohm load.
 - d) Analog Current Signals for Pressure and Temperature: Separate 4- to 20-mA signals for gauge pressure and temperature.
 - e) Digital Signal:
 - f) Pulse output for flow totalization. Two wire, scaled pulse, 0.5 Hz, 100 mA at 30 V dc.
 - g) HART, FSK protocol.
- 7) Operator Interface:
 - a) Keypad.
 - b) Digital Display: Two-line digital display of alphanumerical characters. Meter shall display flow rate, flow totalization, pressure, temperature, and support field programming of all parameters.
- 8) Construction:
 - a) Material: Type 316L stainless steel.
 - b) Connection: **[Class 150][Class 300][Class 600]** flange.
 - c) Enclosure:
 - d) Epoxy-painted cast aluminum.
 - e) Removable screw-on cover.
 - f) NEMA 250, Type 4 or Type 6.
 - g) Electrical Connection: Screw terminals.
 - h) Conduit Connection: Two, **1/2-inch (13-mm)** trade size.
- 9) Upstream Flow Straightener:
 - a) Meter manufacturer shall provide flow straightener where required by installation to comply with manufacturer's written installation instructions.
 - b) Straightener shall be wafer type, constructed of Type 304 stainless steel, designed to be installed between field-installed flanges.
 - c) Straightener size shall match meter size.

17. Liquid Pressure Differential Switches:

- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Ashcroft Inc]**
 - 2) **<Insert manufacturer's name>**
- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Ashcroft Inc]**
 - 2) **<Insert manufacturer's name>**
- c. Source Limitations: Obtain switches from single source from single manufacturer.
- d. Description:
 - 1) Type 316 stainless steel double opposing bellows operate to actuate an SPDT snap switch.
 - 2) Wetted Materials: Type 316 stainless steel.
 - 3) Seal: **[Buna-N][or][FKM]**.
 - 4) Electrical Connections: Screw terminal.
 - 5) Enclosure Conduit Connection: Knock-out or threaded connection.
 - 6) User Interface: Thumbscrew set-point adjustment with enclosed set-point indicator and scale.
 - 7) High and Low Process Connections: Threaded, **NPS 1/4 (DN 10)**.
 - 8) Enclosure: NEMA 250, Type 4 or Type 4X.
 - 9) Operating Data:
 - a) Electrical Rating: 10 A at 120- to 240 V ac.
 - b) Pressure Limits: **0 to 500 psig (0 to 3447 kPa)**.
 - c) Ambient Temperature Limits: **Minus 20 to plus 150 deg F (Minus 29 to plus 66 deg C)**.
 - d) Process Temperature Limits: **20 to 300 deg F (Minus 7 to plus 149 deg C)**.
 - e) Operating Range: 2 times set point unless otherwise required by application.
 - f) Deadband: **[Adjustable][Fixed][Adjustable or fixed as required by application]**.
 - 10) Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

18. Liquid Pressure Transmitters:

- a. Liquid Gauge Pressure Transmitter with Adjustable Span:
 - 1) Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a) **[Rosemount; Emerson Electric Co., Automation Solutions]**
 - b) **<Insert manufacturer's name>**

- 2) Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a) **[Rosemount; Emerson Electric Co., Automation Solutions]**
 - b) **<Insert manufacturer's name>**
- 3) Source Limitations: Obtain transmitters from single source from single manufacturer.
- 4) Performance:
 - a) Range: **Minus 300 to 300 psig (Minus 2068 to 2068 kPa).**
 - b) Span: Field adjustable.
 - c) Minimum Span: **3 psig (21 kPa).**
 - d) Reference Accuracy: Within 0.07 percent of span or better.
 - e) Stability: Within 0.125 percent of upper range limit for five years.
 - f) Overpressure Limits: **3626 psig (25 000 kPa).**
 - g) Process Temperature Limits: **Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).**
 - h) Ambient Temperature Limits: **Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).**
 - i) Temperature Effect: Within 0.025 percent of upper range limit plus 0.125 percent of span.
 - j) Shock and vibration shall not harm the transmitter.
- 5) Analog Output Current Signal:
 - a) Two-wire, 4- to 20-mA dc current source.
 - b) Signal capable of operating into 1000-ohm load.
 - c) Digital signal based on HART protocol carried with current signal.
 - d) Dampening: Field selectable from zero to 30 seconds.
- 6) Operator Interface: Zero and span adjustments located behind cover.
- 7) Display: Digital, five-digit, two-line display with **0.4-inch- (10-mm-)** high, alphanumeric characters.
- 8) Construction:
 - a) Non-wetted parts of transmitter constructed of aluminum or stainless steel.
 - b) Enclosure with removable cover on each side.
 - c) Wetted parts of transmitter constructed of Type 316 stainless steel.
 - d) Threaded, **NPS 1/2 (DN 15)** process connection on bottom of instrument.
 - e) Drain/vent valve on process connection.
 - f) Two **1/2-inch (16-mm)** trade size conduit connections on side of instrument enclosure.
 - g) Screw terminal block for wire connections.
 - h) NEMA 250, Type 4X.
 - i) Mounting Bracket: Appropriate for installation.
- 9) Three-Valve Manifold:
 - a) Include with each transmitter an integrally mounted manifold.
 - b) Construct manifold body of Type 316 stainless steel.
 - c) Manifold with threaded, **NPS 1/2 (DN 15)** female process connections.

b. Liquid, Pressure-Differential Transmitter with Adjustable Span:

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

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

- a) [Rosemount; Emerson Electric Co., Automation Solutions]
 - b) <Insert manufacturer's name>
- 2) Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a) [Rosemount; Emerson Electric Co., Automation Solutions]
 - b) <Insert manufacturer's name>
- 3) Source Limitations: Obtain transmitters from single source from single manufacturer.
- 4) Performance:
- a) Range: **Minus 300 to 300 psig (Minus 2068 to 2068 kPa).**
 - b) Span: Field adjustable.
 - c) Minimum Span: **3 psig (21 kPa).**
 - d) Reference Accuracy: Within 0.07 percent of span or better.
 - e) Stability: Within 0.125 percent of upper range limit for five years.
 - f) Overpressure Limits: **3626 psig (25 000 kPa).**
 - g) Process Temperature Limits: **Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).**
 - h) Ambient Temperature Limits: **Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).**
 - i) Temperature Effect: Within 0.025 percent of upper range limit plus 0.125 percent of span.
 - j) Shock and vibration shall not harm the transmitter.
- 5) Analog Output Current Signal:
- a) Two-wire, 4- to 20-mA dc current source.
 - b) Signal capable of operating into 1000-ohm load.
 - c) Digital signal based on HART protocol carried with current signal.
 - d) Dampening: Field selectable from zero to 30 seconds.
- 6) Operator Interface: Zero and span adjustments located behind cover.
- a) Display: Digital, five-digit, two-line display with **0.4-inch- (10-mm-)** high, alphanumeric characters.
 - b) Construction:
 - c) Non-wetted parts of transmitter constructed of aluminum or stainless steel.
 - d) Enclosure with removable cover on each side.
 - e) Wetted parts of transmitter constructed of Type 316 stainless steel.
 - f) Threaded, **NPS 1/2 (DN 15)** process connection on bottom of instrument.
 - g) Drain/vent valve on process connection.
 - h) Two **1/2-inch (13-mm)** trade size conduit connections on side of instrument enclosure.
 - i) Screw terminal block for wire connections.
 - j) NEMA 250, Type 4X.
 - k) Mounting Bracket: Appropriate for installation.
- 7) Five-Valve Manifold:

- a) Include with each transmitter an integrally mounted manifold.
- b) Construct manifold body of Type 316 stainless steel.
- c) Manifold with threaded, **NPS 1/2 (DN 15)** female process connections.

19. Liquid Temperature Sensors:

- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) **[Minco]**
 - 2) **<Insert manufacturer's name>**
- b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Minco]**
 - 2) **<Insert manufacturer's name>**
- c. Source Limitations: Obtain sensors from single source from single manufacturer.
- d. Resistance temperature (RTD) sensors shall comply with IEC 60751, Class B requirements.
- e. Platinum with a value of 100 ohms at 0 deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
- f. Encase RTD in a Type 316 stainless steel sheath with a **0.25-inch (8-mm)** OD.
- g. Provide three-wire, PTFE-insulated, nickel-coated, 22-gauge, stranded copper leads.
- h. Provide spring-loaded RTDs for thermowell installations.
- i. Performance Characteristics:
 - 1) Range: **Minus 328 to plus 932 deg F (Minus 200 to plus 500 deg C).**
 - 2) Interchangeable Accuracy: Within **0.54 deg F (0.3 deg C)** at **32 deg F (0 deg C).**
 - 3) Stability: Within 0.05 percent maximum ice-point resistance shift after 1000 hours at **752 deg F (400 deg C).**
 - 4) Hysteresis: Within 0.04 percent of range.
 - 5) Response Time: 62.8 percent of change in four seconds with water flowing across sensor at **3 fps (0.9 m/s).**
- j. Thermowells:
 - 1) Stem: **[Straight][or][stepped][or][tapered]** shank formed from solid bar stock.
 - 2) Material: **[Type 304][or][Type 316]** stainless steel.
 - 3) Process Connection: Threaded, **NPS 3/4 (DN 20).**
 - 4) Sensor Connection: Threaded, **NPS 1/2 (DN 15).**
 - 5) Bore: Sized to accommodate sensor with tight tolerance between sensor and well.
 - 6) Furnish thermowells installed in insulated pipes and equipment with an extended neck that extends beyond the face of the insulation covering.
 - 7) Length: As required by application and pipe size.
 - 8) Thermowells furnished with heat-transfer compound to eliminate air gap between wall of sensor and thermowell and to reduce time constant.
- k. Connection Heads:
 - 1) Housing: Low-copper cast-aluminum alloy, complying with NEMA 250, Type 4.
 - 2) Terminals: Six or eight as required by sensor.

- 3) Conduit Connection: **1/2-inch (13-mm)** trade size.
 - 4) Sensor Connection: **NPS 1/2 (DN 15)**.
 - I. Assembly: Sensor manufacturer shall furnish sensor, thermowell, and sensor connection head to provide a matched assembly.
20. Liquid Temperature Transmitters:
- a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) **[Minco]**
 - 2) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Minco]**
 - 2) **<Insert manufacturer's name>**
 - c. Source Limitations: Obtain transmitters from single source from single manufacturer.
 - d. Enclosure: House electronics in NEMA 250, **[Type 4][or][Type 4X]** enclosure.
 - e. Enclosure Connection: **1/2-inch (13-mm)** trade size.
 - f. Functional Characteristics:
 - 1) Input: 100-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, three-wire sensors.
 - 2) Default Span (Adjustable):
 - a) Chilled Water: **0 to 100 deg F (Minus 18 to plus 38 deg C)**.
 - b) Heating Hot Water: **32 to 212 deg F (0 to 100 deg C)**.
 - c) **<Insert system and span>**.
 - 3) Output: 4- to 20-mA dc, linear with temperature; RFI insensitive; minimum drive load of 600 ohms at 24-V dc.
 - 4) Zero and span field adjustments, plus or minus 5 percent of span. Minimum span of **50 deg F (28 deg C)**.
 - 5) Match sensor with temperature transmitter and factory calibrate together. Each matched sensor and transmitter set shall include factory calibration data traceable to NIST.
 - g. Performance Characteristics:
 - 1) Calibration Accuracy: Within 0.1 percent of the span.
 - 2) Stability: Within 0.2 percent of the span for at least six months.
 - 3) Combined Accuracy: Within 0.5 percent.
21. Control Transformers:
- a. Size each transformer for the total connected load, plus an additional 25 percent of the connected load.
 - b. Each transformer shall be at least 100 VA.

- c. Provide transformer with both primary and secondary fuses.
22. 25-V dc Power Supply:
- a. Plug-in style suitable for mating with a standard eight-pin octal socket.
 - b. Enclose circuitry within a housing.
 - c. Include line and load regulation to ensure a stable output. To protect both power supply and load, include power supply with an automatic current limiting circuit.
 - d. Performance:
 - 1) Output voltage nominally 25 V dc within 5 percent.
 - 2) Output current up to 100 mA.
 - 3) Input voltage nominally 120 V ac, 60 Hz.
 - 4) Load regulation within 0.5 percent from 0- to 100-mA load.
 - 5) Line regulation within 0.5 percent at a 100-mA load for a 10 percent line change.
 - 6) Stability within 0.1 percent of rated volts for 24 hours after a 20-minute warmup.
23. Instrument Identification:
- a. Engraved tag bearing instrument identification.
 - 1) Each tag identifying an instrument shall have a unique identification that does not match identification of a similar device.
 - 2) Tag field instruments identified by equipment being controlled or monitored, followed by point identification used on I/O schematics.
 - 3) Example: DDC-AHU-01.01; PDIT1.
 - b. Letter size shall be minimum **1/4 inch (6 mm)** high.
 - c. Letter type shall be sans serif gothic bold style.
 - d. Lettering and background color scheme shall be white letters on black background.
 - e. Tag shall be engraved phenolic constructed of three layers of pressure rigid laminate. Top and bottom layers are color-coded, contrasting white center is exposed by engraving through outer layer. Engrave both sides. Material shall be stain proof, heat resistant, non-conductive, or non-corrosive.
 - f. Tag shall be fastened to equipment/instrument with drive pins or attached with a stainless steel chain.
 - g. Instruments furnished with identification tags provided by original manufacturer do not require an additional tag.
24. Checkout Procedures:
- a. Check instruments for proper location and accessibility.
 - b. Check instruments for proper installation for direction of flow, elevation, orientation, and other applicable considerations.
 - c. Damper Check-out: Verify that proper blade alignment, either parallel or opposed, has been provided.
25. Calibration and Adjustment:
- a. Calibrate every instrument.
 - b. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
 - c. Equipment and procedures used for calibration shall meet requirements of instrument manufacturer's written instructions. Test equipment used in calibration of instruments shall have an accuracy at least double that of instrument being calibrated.
 - d. Calibrate each instrument in accordance with the accuracy outlined in instruction manual

- supplied for instrument by manufacturer.
- e. Control System Inputs and Outputs:
- 1) Check analog inputs using a precision voltage or current source at zero, 50, and 100 percent of span.
 - 2) Check analog outputs using a milliampere meter at zero, 50, and 100 percent output.
 - 3) Check digital inputs using a jumper wire.
 - 4) Check digital outputs using an ohmmeter to test for contact making or breaking.
 - 5) Check resistance temperature inputs at zero, 50, and 100 percent of span using a precision-resistant source.
 - a) Flow: Set differential pressure flow transmitters for zero and 100 percent values with three-point calibration accomplished at 100, 50, and 90 percent of span.
 - b) Gas: Calibrate gas transmitters at zero, 50, and 100 percent of span.
 - c) Humidity: Calibrate relative humidity transmitters at zero, 50, and 100 percent of span.
 - d) Pressure: Calibrate pressure transmitters at zero, 50, and 100 percent of span.
 - e) Temperature: Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistant source.
 - f) Dampers: Stroke and adjust control dampers following the recommended procedure from manufacturer, such that damper is 100 percent open and closed.
 - g) Replace out of tolerance instruments failing the test.
 - h) Provide diagnostic and test instruments for calibration and adjustment.

SS. Smoke Detectors:

1. System, Duct Smoke Detectors: For connection to conventional fire-alarm system. Coordinate requirements with **[Section 284600 "Fire Detection and Alarm."][Section 284614 "Single- and Multiple-Station Alarms."][Section 284600 "Fire Detection and Alarm" and Section 284614 "Single- and Multiple-Station Alarms."]**
 - a. Operating at 24-V dc, nominal.
 - b. Detectors shall be **[four][two]**-wire type.
 - c. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
 - d. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
 - e. Integral Visual-Indicating Light: LED type, indicating detector has operated **[and power-on status]**.
 - f. Provide multiple levels of detection sensitivity for each sensor **[, with alarm-verification feature]**.
 - g. Duct Smoke Detectors: Photoelectric type complying with UL 268A.
 - 1) Remote indication **[and test]** station. **[Operating key switch initiates an alarm test.]**
 - 2) Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector for smoke detection in HVAC systems.
 - 3) Sampling Tubes: Design and dimensions as recommended by manufacturer for specific size, air velocity, and installation conditions where applied.
 - 4) Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.

2. Nonsystem, Single-Station Duct Smoke Detectors:
 - a. Nonsystem smoke detectors shall be listed as compatible with fire-alarm equipment installed or shall have a contact closure interface listed for the connected load.
 - b. Nonsystem smoke detectors shall meet the monitoring for integrity requirements in NFPA 72.
 - c. Comply with UL 268A; operating at 120 V ac.
 - d. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. The fixed base shall be designed for mounting directly to mounting brackets air-handling unit. Provide terminals in the fixed base for connection to building wiring.
 - 1) Enclosure: NEMA 250, Type 4X; listed for use with the supplied detector.
 - e. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific size, air velocity, and installation conditions where applied.
 - f. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.
3. Air-Handling Unit Factory Assembly:
 - a. Furnish and install smoke detectors inside air-handling units to comply with governing building codes.
 - b. Install smoke detectors in accordance with smoke detector manufacturer's written installation instructions.
 - 1) Sampling tubes shall extend the full width of airstream.
 - 2) Sampling tubes greater than **36 inches (900 mm)** long shall be supported on both ends.
 - c. Install smoke detectors within air-handling units in a location that is easily accessible for inspection, repair, and replacement of smoke detector, and in a location that does not hinder access to other internal components.
4. Air-Handling Unit Factory Testing: Functionally test smoke detectors to ensure proper operation in accordance with smoke detector manufacturer's written instructions.
5. Air-Handling Unit Factory Installation of Addressable Smoke Detectors Furnished by Building Fire-Alarm System Supplier:
 - a. Where addressable duct smoke detectors are indicated to be installed within air-handling unit casing, air-handling unit manufacturer shall install duct smoke detector components supplied by building fire-alarm system supplier.
 - b. Mount duct smoke detector sampling housing on exterior of air-handling unit casing. Locate on accessible side and coordinate with installers before installation.
 - c. Seal air-handling unit casing penetrations.
 - d. Install duct smoke detector components in accordance with written instructions furnished by supplier.
 - 1) Sampling tubes shall extend the full width of airstream.
 - 2) Sampling tubes greater than **36 inches (900 mm)** long shall be supported on both ends.
 - e. Photograph installation and transmit photos to fire-alarm system Installer before air-handling unit shipment to ensure proper installation. Fire-alarm system Installer shall review photos and provide written acceptance of installation to air-handling unit manufacturer before air-handling unit shipment.

- 1) Document date of photos and approval for record purposes.
 - 2) Make corrective measures required by fire-alarm system Installer as required for acceptance.
- f. Coordinate work schedule of air-handling unit manufacturer and fire-alarm system supplier to meet requirements of Project schedule.
- g. See [Section 284600 "Fire Detection and Alarm"]**[and]**[Section 284614 "Single- and Multiple-Station Alarms"]**<Insert Section>** for additional requirements.

TT. Catwalks, Handrails, And Ladders:

1. General:

- a. Provide elevated air-handling units and top levels of multilevel stacked units with catwalks, handrails, and ladders to provide service access.
- b. Factory-fabricate catwalks, handrails, and ladders to ensure proper alignment and attachment.
- c. Catwalks, handrails, and ladders may be disassembled and shipped separate from the air-handling unit for field installation.
- d. Design and fabricate catwalk to be completely self-supported from air-handling unit frame without need for any type of field-installed supports.
- e. Comply with OSHA requirements where requirements are more stringent than requirements indicated.
- f. Install catwalk, handrails, and ladders level and plumb.

2. Catwalks:

- a. Extend catwalks to service elevated portions of air-handling units that are accessible through access doors and panels.
- b. Catwalk width shall be of sufficient size to properly access and service equipment and maintain code-required clearances to electrical devices. Width shall be at least **[60 inches (1500 mm)]<Insert dimension>** clear between the exterior casing and handrail.
- c. Cantilever catwalk base frame from the air-handling unit base frame. Removable catwalks shall be bolted to the air-handling unit base frame at multiple points to ensure a rigid and firm attachment.
- d. Catwalk base frame material and finish shall match air-handling unit frame.
- e. Catwalk floor material shall match air-handling unit floor material.
- f. Catwalk walking surface elevation shall match floor surface inside air-handling unit.

3. Handrails:

- a. Provide catwalk with handrail, kneerail, toeboard, and vertical supports along entire length of catwalk. Comply with 29 CFR 1910.23.
- b. Handrail shall be a minimum of **[42 inches (1050 mm)]<Insert dimension>** high and comply with OSHA requirements. Vertical supports shall be spaced not more than **[96 inches (2400 mm)]<Insert value>** o.c.
- c. Construct handrail, kneerail, and vertical supports from not less than nominal **[1-1/2-inch-(38-mm-)]<Insert dimension>** diameter tube.
- d. Handrail shall be capable of withstanding a live load force of not less than **[100 lb/ft. (450 N/300 mm)]** and a **[200-lb (900-N)]<Insert value>** concentrated force in any direction.
- e. Provide lift-out sections of handrail to facilitate removal of air-handling unit internal components from the top-level to grade.
- f. Provide self-closing gate at ends of catwalk accessible by ladders to provide fall protection.
- g. Construct handrails, kneerails, toeboards, and vertical supports of

[aluminum][fiberglass][galvanized-steel][or][stainless steel] materials.

1) Finish: Hot-dip galvanize assemblies constructed of steel after fabrication.

4. Ladders with Safety Cages:

- a. Provide a permanently attached ladder at **[one][each]** end of catwalk.
- b. Ladder shall rise from building structural floor to the top of handrail.
- c. Provide for construction tolerance and adjustable means to fasten the ladder at its base to the building structural floor.
- d. Fabricate ladders with dimensions, spacing, details, and anchorages as required.
- e. Comply with requirements of ALI A14.3 and 29 CFR 1910.27.
- f. Support each ladder at top and bottom. Use welded or bolted brackets, designed for adequate support and anchorage, and to hold ladder **[7 inches (175 mm)]<Insert dimension>** clear from catwalk walking surface.
- g. Extend rails at least **[42 inches (1050 mm)]<Insert dimension>** above top rung, and return rails with secure handholds fastened to handrail.
- h. Construct ladders of **[aluminum][fiberglass][galvanized-steel][or][stainless steel]** materials.

1) Finish: Hot-dip galvanize ladders, brackets, and fasteners constructed of steel after fabrication.

- i. Provide non-slip surface on top of each rung, either by coating rung with aluminum-oxide granules set in epoxy-resin adhesive or by using a type of manufactured rung that has a non-slip top surface.

UU. Hardware:

1. Screws:

- a. For Galvanized-Steel Materials: Self-tapping, hex-head, **[zinc-plate steel][or][300 series stainless steel]** screws with a neoprene gasket encapsulated by a **[zinc-plate steel][or][300 series stainless steel]** washer.
- b. For Aluminum and Stainless Steel Materials: Self-tapping, hex-head, 300 series stainless steel screws with a neoprene gasket encapsulated by a 300 series stainless steel washer.
- c. Provide protective covers on exposed screws to prevent personnel injury.

2. Bolts, Nuts, and Washers:

- a. For Joining Galvanized and Painted Carbon Steel Materials: Hex-head, high-strength, **[galvanized steel][or][300 series stainless steel]**.
- b. For Joining Aluminum and Stainless Steel Materials: Hex-head, high-strength, 300 series stainless steel.
- c. Use washers and lock washers at each bolted connection.
- d. Select bolt size and spacing sufficient for load and application.

VV. Welding:

1. Welding Filler Metals: Comply with AWS welding codes for welding materials appropriate for thickness and chemical analysis of material being welded.
 - a. Use welding materials with corrosion properties equal to material being welded.
2. Use welders that are certified to weld at least **[twice]** the thickness of the material to be welded. Certification shall be within **[three][six]<Insert number>** months of work being performed.

3. Welds shall be continuous, full-penetration welds unless otherwise indicated. Intermittent welds, stitch welds and tack welds are permitted only in specific applications indicated.
4. Use welders and welding procedures complying with the following:
 - a. Piping Systems: Section IX of the ASME Boiler and Pressure Vessel Code and Section V of ASME B31.1.
 - b. Structural Aluminum: AWS D1.2/D1.2M.
 - c. Structural Carbon Steel: AWS D1.1/D1.1M.
 - d. Structural Stainless Steel: AWS D1.6/D1.6M.
 - e. Sheetmetal: AWS D9.1/D9.1M.

WW. Painting:

1. General:
 - a. Painted OEM components do not require additional coating other than touch-up to damaged areas. Match the touchup coating to surrounding undamaged surfaces.
 - b. Finish miscellaneous surfaces to match continuous surfaces.
 - c. Protect mill galvanized surfaces that are exposed to view, such as raw steel cuts and damage by welding, with multiple coats of matching galvanized paint.
 - d. Protect mill galvanized surfaces that are concealed, such as raw steel cuts and damage by welding, with multiple coats of zinc-rich paint or matching galvanized paint.
 - e. Touch up or entirely repaint surface finishes, damaged during shipment and installation, to the original condition, using original materials and methods.
2. Preparation:
 - a. Submit proposed manufacturer's written preparation and application instructions for information.
 - b. If paint manufacturer's recommended preparation requirements differ from those indicated, use the more stringent requirements.
 - c. Structural carbon steel to be painted shall be deburred, ground smooth, cleaned, and blasted in accordance with **[SSPC-SP 6/NACE No. 3]****[or]****[SSPC-SP 10/NACE No. 5]**.
 - d. Before applying a primer and a finish coat, remove oil and grease from surfaces to be coated using clean rags soaked in thinner in accordance with SSPC-SP 1.
 - e. Treat surfaces to be painted to ensure that paint adheres.
3. Primer:
 - a. Rust-inhibiting type, with a minimum dry film thickness of **[1][2]<Insert value>** mil(s) per coat.
 - b. Apply at least **[two]<Insert number>** coats of primer to unfinished carbon steel surfaces and at least one coat of primer to other surfaces.
 - c. Use primer that is compatible with substrate and finish coat.
4. Finish Coat:
 - a. Finish coat painting system shall be **[alkyd-enamel][epoxy][polyurethane]<Insert coating>**.
 - b. Use dry film thickness recommended by paint manufacturer for each coat. Total dry film thickness of all finish coats not less than **[3][5]<Insert value>** mils.
 - c. Painted Surfaces Minimum Properties:
 - 1) Salt Spray ASTM B117: 5 percent salt solution fog at **95 deg F (35 deg C)** for **[1000][2000][4000]<Insert value>** hours with no deterioration.

- 2) Adhesion, ASTM D3359: When the coating is cut into **0.0625-inch (1.6-mm)** squares and 3M No. 600 tape is suddenly removed, there is no loss of adhesion.
 - 3) Acid Resistance ASTM D3260: 15-minute exposure to 10 percent hydrochloric acid at room temperature with no effect.
 - 4) Alkali Resistance ASTM D1647: 15-minute exposure to 10 percent sodium hydroxide at room temperature with no effect.
 - 5) Humidity Resistance ASTM D2247: 850-hour exposure to **100 deg F (38 deg C)** and at least 95 percent relative humidity with no effect.
 - 6) Pencil Hardness ASTM D3363: A hardness of 1H.
- d. Finish coat color shall be selected by Architect and not be limited to manufacturer's standard offering.
- 1) Submit a written request for color selection and indicate in the request the date color selection must be returned without impacting schedule.
5. Application: Paint the following surfaces with primer and finish coat indicated:
- a. Unfinished carbon steel surfaces.
 - b. Exposed mill galvanized-steel surfaces of air-handling unit casing exterior.
 - c. Exposed aluminum surfaces of air-handling unit casing exterior.
 - d. Exposed stainless steel surfaces of air-handling unit casing exterior.

XX. Cleanliness Requirements:

1. General:
 - a. Provide equipment that has been manufactured, shipped, stored, and installed maintaining highest degree of cleanliness possible.
 - b. Owner Cleanliness Inspection: Air-handling unit(s) cleanliness is subject to Owner cleanliness inspection [**and must pass a white glove test**]before packaging for shipment.
 - c. **<Insert requirements>**.
2. During Manufacturing:
 - a. Clean materials to be free of mill grease, oxidation, dirt, dust, and other impurities before manufacturing and assembly.
 - b. Protect casing materials from contamination during manufacturing and assembly.
 - c. Use sealing materials that do not outgas.
 - d. Provide OEM components and equipment from their respective manufacturers free of grease, oxidation, and dirt. Store OEM components and equipment indoors. Cover and protect OEM components and equipment to maintain cleanliness. Follow OEM instructions for equipment storage.
3. After Manufacturing:
 - a. Before shipment, after unit is completely assembled, clean unit inside and out.
 - 1) Vacuum entire inside to remove dirt, dust, and debris using HEPA-filtered vacuum equipment.
 - 2) Purge hard to reach surfaces with dry, oil-free, compressed or bottled nitrogen.
 - 3) Wipe down all surfaces, inside and out, with a residue-free cleaning agent.
 - b. Protect unit to maintain cleanliness.
4. Shipping:

- a. Protect interior and exterior of air-handling unit from exposure to weather dirt, dust, and debris during shipment and rigging.
- b. Cover openings with puncture-resistant durable coverings to ensure that cleanliness is maintained inside unit while providing an air- and watertight seal.

5. On-Site Storage:

- a. If air-handling unit is to be stored before installation, Installer shall work closely with air-handling unit manufacturer for air-handling unit manufacturer to provide adequate protection at the factory to ensure that cleanliness for both unit interior and unit exterior is maintained. This protection shall remain in place until unit startup is performed.
- b. For extended periods of storage, provide a means to rotate fan and motor assemblies on a periodic basis (as recommended in writing by manufacturer) without compromising unit cleanliness.

YY. Accessories:

1. Tool Kit:

- a. Manufacturer shall assemble a tool kit specially designed for use in servicing air-handling units furnished.
- b. Include only special tools required to service air-handling unit components not readily available for purchase by Owner service personnel in performing routine maintenance.
- c. Place tools in a lockable case with hinged cover.
- d. Mark case cover with large and permanent text to indicate special purpose of tool kit, such as "Air-Handling Unit Tool Kit." Text size shall be at least [1 inch (25 mm)]<Insert dimension> high.
- e. Provide a list of each tool furnished and permanently attach the list to underside of case cover. Text size shall be at least [1 inch (25 mm)]<Insert dimension>high.

2.5 SOURCE QUALITY CONTROL

A. AHRI Compliance:

1. AHRI 260 (I-P): Air-handling unit sound ratings shall be in accordance with AHRI 260 (I-P), "Sound Rating of Ducted Air Moving and Conditioning Equipment."
2. AHRI 261 (SI): Air-handling unit sound ratings shall be in accordance with AHRI 261 (SI), "Sound Rating of Ducted Air Moving and Conditioning Equipment."
3. AHRI 410: Air-handling unit coils shall be rated in accordance with AHRI 410 and shall be listed by AHRI[and labeled in accordance with AHRI].
4. AHRI 1060 (I-P) Certification: Air-handling units that include [energy wheels][fixed plate heat exchangers][and][heat pipe heat exchangers] shall be rated in accordance with AHRI 1060 (I-P) and shall be listed by AHRI[and labeled in accordance with AHRI].
5. AHRI 1061 (SI) Certification: Air-handling units that include [energy wheels][fixed plate heat exchangers][and][heat pipe heat exchangers] shall be rated in accordance with AHRI 1061 (SI) and shall be listed by AHRI[and labeled in accordance with AHRI].

B. AMCA Compliance:

1. AMCA 201: Air-handling unit manufacturer shall evaluate fan's performance within the air-handling unit in accordance with AMCA 201, "Fans and Systems" and account for conditions within the air-handling unit that could be detrimental to fan's performance by adjusting the fan performance indicated on Drawings.
2. AMCA 205 Certification: Air-handling unit fan's fan efficiency grade (FEG) shall be rated in

accordance with AMCA 205, "Energy Efficiency Classifications for Fans"[**and shall bear the AMCA-certified fan efficiency grade seal**].

3. AMCA 210 Certification: Air-handling unit fan's air performance shall be rated in accordance with AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating"[**and shall bear the AMCA-certified air ratings seal**].
4. AMCA 300: Air-handling unit fan's sound performance shall be rated in accordance with AMCA 300, "Reverberant Room Method for Sound Testing of Fans."
5. AMCA 301 Certification: Air-handling unit fans sound performance shall be rated in accordance with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data"[**and shall bear the AMCA-certified sound ratings seal**].
6. AMCA 500-D: Air-handling unit damper's performance shall be rated in accordance with AMCA 500-D, "Laboratory Methods of Testing Dampers for Rating"[**and shall bear the AMCA-certified air ratings seal**].

C. NFPA Compliance:

1. NFPA 70: Electrical components, devices, and accessories shall be listed and labeled by a qualified testing agency, and marked for intended location and application.
2. NFPA 90A: Design, fabrication, and installation of air-handling units and components shall comply with NFPA 90A.

D. UL Compliance:

1. UL 1598 Certification: Air-handling unit UVGI shall be NRTL listed and labeled in accordance with UL 1598, "Luminaires."
2. UL 1995 Certification: Where indicated, air-handling unit components shall be NRTL listed and labeled in accordance with UL 1995, "Standard for Safety Heating and Cooling Equipment."

2.6 SOURCE QUALITY CONTROL - INDEPENDENT LABORATORY TESTING

A. General:

1. Project-specific testing by an independent laboratory is not required if air-handling unit manufacturer has written independent laboratory test results of past tests performed on same casing construction proposed for use on this Project.
2. If Project-specific testing is required, testing shall be performed in ample time to include test reports with submittals and before manufacturing of air-handling units. Include sufficient lead time for unit delivery, installation, and testing required by construction schedule.

B. Casing Structural Deflection Test:

1. Include service of an independent testing laboratory to verify casing structural deflection requirements indicated.
 - a. In lieu of independent laboratory testing, manufacturer may perform factory deflection testing of proposed construction to prove compliance if witnessed by **[Architect][and][Owner]**. Manufacturer shall bear cost of labor and travel expenses to witness testing.
2. Test casing construction to performance criteria indicated.
3. Test casing construction proposed for use on Project. Include, at a minimum, particulars such as metal materials and thickness, internal support and reinforcing, and insulation material and thickness.
4. Test largest full-size casing panel proposed for use on Project.
5. Test proposed construction of walls, floor, and roof. Include a separate test for each unique

- casing construction proposed.
- 6. Submit test reports for each test to show compliance with performance indicated.

C. Casing Airborne Sound Transmission Test:

- 1. Include services of an independent testing laboratory to test proposed casing construction for sound transmission. Include a separate test for each unique casing construction proposed.
- 2. Conduct tests in accordance with ASTM E90.
- 3. Determine sound transmission class by using ASTM E413.
- 4. Test proposed construction of walls and roof.
- 5. Test proposed construction of floor assembly only if air-handling unit is not installed on a concrete housekeeping pad or building structural floor.
- 6. Submit test reports for each test to show compliance with performance indicated.

D. Casing Sound Absorption Test:

- 1. Include services of an independent testing laboratory to verify casing sound absorption coefficients for perforated casing panels. Provide a separate test for each unique casing construction proposed.
- 2. Conduct tests in accordance with ASTM C423 and ASTM E795.
- 3. Test proposed construction of walls and roof.
- 4. Submit test reports to show compliance with performance indicated.

2.7 SOURCE QUALITY CONTROL - AIR-HANDLING UNIT FACTORY TESTS

A. Witness of Testing: Allow **[Architect][Commissioning Agent][Construction Manager][and][Owner]<Insert entity>** access to place where air-handling units are being tested for witness testing.

- 1. Submit written notification at least **[30][20]<Insert number>** days in advance of testing.
- 2. Schedule testing at mutually agreeable dates and times.

B. Witness Testing Travel Expenses:

- 1. Include in bid the cost of travel expenses to witness factory testing. Total cost for travel expenses shall be clearly indicated separately in bid.
- 2. Expenses shall include roundtrip **[coach][or][first]** class airfare, out-of-town hotel accommodations, out-of-town meals (breakfast, lunch, and dinner), out-of-town ground transportation and parking, and all associated taxes and fees.
- 3. Exclude other incidental expenses not indicated.
- 4. Include travel expenses for **[one][two]<Insert value>** representative(s) with origin of **<Insert city and state>**.

C. Casing Leakage Test:

- 1. Perform a leak test for **[each assembled air-handling unit][each assembled air-handling unit of unique size and arrangement]<Insert requirement>**.
- 2. Follow testing procedures in accordance with ASHRAE 111.
- 3. Perform leak test before shipping first air-handling unit **[of unique size and arrangement]**.
- 4. Test results shall indicate that units comply with leakage requirements indicated. Make changes to noncompliant air-handling units and retest until units comply with requirements.
- 5. Prepare test reports in accordance with ASHRAE 111.
- 6. Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and

witnesses. If multiple tests are required to achieve compliance for a single air-handling unit, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

D. Casing Structural Deflection Test:

1. Perform a structural deflection test for **[each assembled air-handling unit][each assembled air-handling unit of unique size and arrangement][only one air-handling unit with the worst-case condition]<Insert requirement>**.
2. Pressurize and load air-handling units to the performance criteria indicated for structural deflection. Test air-handling unit **[floors][walls and roofs]**.
3. Test results shall indicate that units comply with deflection requirements indicated. Make changes to noncompliant air-handling units and retest until units comply with requirements.
4. Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single air-handling unit, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

E. Functional Run Test:

1. Run test each unit before shipment.
2. Test and balance fans to comply with vibration requirements indicated.
3. Energize each electrical device to ensure it is operational.
 - a. Take meter readings for volts, amperes, and kVA_r on each phase leg of each motor.
 - b. Take meter readings for volts, amperes, and kVA_r on each single-phase power connection to field power.
4. Exercise each damper to ensure proper operation.
5. Exercise each access door to ensure proper fit.
6. Exercise each valve to ensure proper operation.
7. Submit a written report for each unit tested. Written report shall include, at a minimum, full name of each person witnessing test, detailed list of each unit component tested, condition observed, and corrective action required. Each line item shall have full name of the person doing the checkout and date and time the checkout was performed.

F. Fan Vibration Test:

1. Perform a fan vibration test for **[each assembled air-handling unit][each assembled air-handling unit of unique size and performance]<Insert requirement>**.
2. Energize each fan within the air-handling unit after air-handling unit final assembly and perform a vibration analysis with fan operating at design speed **[and at all speeds throughout the range from design to minimum speed]**.
3. Three vibration measurements shall be taken for each bearing in horizontal, vertical, and axial directions. Vibration measurements shall be recorded and consist of vibration amplitude verses frequency **[with filter-in]**.
4. Fan bearing measurement points shall be marked or scribed on bearings for permanent record.
5. Test results shall indicate that units comply with vibration requirements indicated. Make changes to noncompliant air-handling units and retest until units comply with requirements.
6. Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single air-handling unit, report shall include test date and time, test results, and full names of personnel performing tests and

witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

G. Acoustical Performance Test:

1. Perform an acoustical performance test for **[each assembled air-handling unit][each assembled air-handling unit of unique size and performance]<Insert requirement>**.
2. Air-handling unit acoustic performance shall be verified by factory test in accordance with AHRI 260 (I-P) or AHRI 261 (SI).
3. Air-handling unit supply-air discharge, return-air inlet, and casing radiated sound components shall be measured with air-handling unit operating at design conditions.
4. Testing Location: Perform testing in a location complying with AHRI 220, "Reverberation Room Qualification and Testing Procedures for Determining Sound Power of HVAC Equipment."
 - a. Test location shall be broadband qualified in accordance with AHRI 220 Section 5.1 and discrete frequency qualified in accordance with Section 5.2.
5. Operating conditions used in acoustic testing shall be verified by test in accordance with AMCA 210[**in an AMCA-accredited facility**].
6. Test results shall indicate that units comply with acoustical requirements indicated. Make changes to noncompliant air-handling units and retest until units comply with requirements.
7. Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single air-handling unit, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

H. Airflow Capacity Performance Test:

1. Perform an airflow capacity performance test for **[each assembled air-handling unit][each assembled air-handling unit of unique size and performance]<Insert requirement>**.
2. Operating conditions shall be verified by test in accordance with AMCA 210[**in an AMCA-accredited facility**].
3. Test results shall indicate that units comply with design airflow requirements indicated. Make changes to noncompliant air-handling units and retest until units comply with requirements.
4. Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single air-handling unit, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

I. Hydronic Piping Systems Testing: Pressure test factory-assembled piping systems with compressed air or water at a pressure to comply with governing codes and ASME B31.9, but not less than design pressure indicated.

1. Test results shall indicate that piping systems are without leaks. Make changes to noncompliant piping systems and retest until units comply with requirements.
2. Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single air-handling unit, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

- J. Steam and Condensate Piping Systems Testing: Pressure test factory-assembled piping systems with compressed air or water at a pressure to comply with governing codes and ASME B31.1 or ASME B31.9 as applicable for service, but not less than design pressure indicated.
1. Test results shall indicate that piping systems are without leaks. Make changes to noncompliant piping systems and retest until units comply with requirements.
 2. Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single air-handling unit, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

2.8 SOURCE QUALITY CONTROL - OEM COMPONENT FACTORY TESTS

A. Air Blender Testing:

1. Owner-witnessed performance test to demonstrate compliance with performance requirements indicated.

B. Coil Testing:

1. Hydronic Coils: Factory tested with air while coil is completely submerged underwater to design pressure indicated, but not less than **[300-psig (2070-kPa)]<Insert pressure>** internal pressure.
2. Refrigerant Coils: Factory tested with air while coil is completely submerged underwater to design pressure indicated, but not less than **[300-psig (2070-kPa)]<Insert pressure>** internal pressure.
3. Steam Coils: Factory tested with air while coil is completely submerged underwater to design pressure indicated, but not less than to **[300-psig (2070-kPa)]<Insert pressure>** internal pressure.
4. Coils to display a tag with inspector's identification as proof of testing.

C. Fan Vibration Testing:

1. Perform a fan vibration test for **[each fan]<Insert requirement>**.
2. Energize each fan after final assembly and perform a vibration analysis with fan operating at design speed **[and at all speeds throughout the range from design to minimum speed]**.
3. Three vibration measurements shall be taken for each bearing in the vertical, and axial directions. Vibration measurements shall be recorded and consist of vibration amplitude verses frequency **[with filter-in]**.
4. Fan bearing measurement points shall be marked or scribed on bearings for permanent record.
5. Test results shall indicate units comply with vibration requirements indicated. Make changes to noncompliant fans and retest until fans comply with requirements.
6. Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single fan, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine air-handling units before installation. Reject units with physical damage, and air-handling unit components that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for the following before installation of air-handling units:
 - 1. Structural substrate mounting and anchorage to verify actual sizes, types, and locations.
 - 2. Piping systems to verify actual sizes, types, and locations of connections.
 - 3. Ductwork and plenums to verify actual sizes, types, and locations of connections.
 - 4. Electrical services and controls to verify actual sizes, types, and locations of connections.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF OUTDOOR, CUSTOM AIR-HANDLING UNITS

- A. Equipment Mounting: Install air-handling units at locations indicated on Drawings. Unless, otherwise indicated on Drawings, install air-handling units on concrete equipment bases.
 - 1. Units Mounted on Concrete Bases:
 - a. Install air-handling units on cast-in-place concrete equipment bases. Coordinate sizes and locations of concrete bases with actual equipment provided. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - b. Level air-handling unit bases using aluminum or stainless steel shims compatible with air-handling unit base material.
 - c. Fill voids between air-handling unit bases and concrete bases using high-strength non-shrink grout.
 - d. Continuously seal between concrete bases and perimeter of air-handling unit bases with nonhardening sealant.
 - 2. Units Mounted to Structural-Steel Supports: Level unit air-handling bases using aluminum or stainless steel shims compatible with air-handling unit base material. Continuously seal between structural supports and air-handling unit bases with nonhardening sealant.
 - 3. Units Mounted Directly to Finished Floors: Level air-handling unit bases using aluminum or stainless steel shims compatible with air-handling unit base material. Continuously seal between floor and perimeter of air-handling unit bases with nonhardening sealant.
 - 4. Suspended Units: Suspend and laterally brace air-handling units from building structure by attaching to only air-handling unit bases at manufacturer-designated locations.
 - 5. Install air-handling units on curbs following air-handling unit manufacturer's written procedures.
 - a. Install gaskets before setting air-handling units on curbs.
 - b. Secure air-handling units to curbs using stainless steel fasteners.
 - c. Install curb and fasten to structure.
 - d. Coordinate curb requirements, attachment, and location before installation.
- B. Roof Openings:

1. Provide exact size and location of roof openings to trade installing structural framing and roof structure.
2. Supervise framing of openings to ensure coordinated installation with air-handling units.
- C. Seismic Control: Comply with requirements for seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
- D. Equipment Clearances and Access:
 1. Arrange installation of air-handling units to provide access space around air-handling units for service and maintenance and for removal and replacement of internal components.
 2. Provide clearance and access required by governing codes and NFPA 70.
 3. At a minimum, comply with requirements indicated on Drawings and air-handling unit manufacturer's written instructions.

3.3 PROTECTION DURING CONSTRUCTION

- A. Exterior Covers: Cover air-handling units during construction with sealed covers to protect air-handling unit casing and externally mounted components from physical damage, dirt, dust and debris, paint splatter, and any other construction materials.
 1. Minor physical damage, as determined by Owner, shall be repaired by air-handling unit factory service personnel to factory-finished condition.
 2. Replace air-handling units with damage that in any way compromises the performance indicated.
- B. Internal Access: Keep access doors locked to maximum extent possible and restrict access to only authorized personnel.
 1. Open access doors only during periods authorized work inside air-handling units is required.
 2. Coordinate and monitor work inside air-handling units on a shift basis. Lock access doors once work is complete or at the end of each shift.
 3. Immediately report unauthorized access and any observed damage to Owner.

3.4 DUCT CONNECTIONS

- A. Connect ducts and plenums to air-handling unit connections. Comply with requirements in Section 233113 "Metal Ducts."
- B. Connect ducts and plenums to air-handling unit connections with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."
- C. Provide duct transitions required to make field connections to air-handling units.
- D. Arrange ducts and plenums to provide unobstructed access to inside of air-handling units.

3.5 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to air-handling unit, provide unobstructed access to inside of air-handling units for service and maintenance.

- C. Connect piping to air-handling units with flexible connectors.
- D. Drain Pan Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping."
 - 1. Make connections to air-handling unit connections with **[flanges or]**unions.
 - 2. Extend **[dedicated]**drain piping from each air-handling unit connection to nearest equipment or floor drain and arrange piping to maintain clear service aisle paths free of potential tripping hazards.
 - 3. Construct traps near air-handling unit connections to seal airflow from escaping within air-handling unit. Locate traps in a serviceable location that is away from access doors.
 - 4. Install threaded cleanouts at changes in direction.
 - 5. Secure drain piping to structure.
- E. Air-Handling Unit Floor Drains: Do not require installation of permanent drain piping.
- F. Air-Handling Unit Floor Drain Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping."
 - 1. Make connections to air-handling unit connections with **[flanges or]**unions.
 - 2. Extend **[dedicated]**drain piping from each air-handling unit connection to nearest equipment or floor drain and arrange piping to maintain clear service aisle paths free of potential tripping hazards.
 - 3. Construct traps near air-handling unit connections to seal airflow from escaping within air-handling unit. Locate traps in a serviceable location that is away from access doors.
 - 4. Install threaded cleanouts at changes in direction.
 - 5. Secure drain piping to structure.
- G. Chilled-Water Coil Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
 - 1. Comply with requirements indicated on Drawings.
 - 2. Make connections to coils with a **[flange][or][union]**.
 - 3. Connect to each coil inlet with shutoff valve, test plug, **[pressure gauge][and][thermometer]**.
 - 4. Connect to each coil outlet with balancing valve, test plug, **[pressure gauge][thermometer][flow meter][and][shutoff valve]**.
 - 5. Connect each coil drain connection with a drain valve, which is full size of drain connection.**[Connect drain pipe to drain valve with union, and extend drain pipe to terminate over floor drain.]**
 - 6. Connect each coil vent connection with **[automatic][or][manual]** vent, which is full size of vent connection.
- H. Hot-Water Coil Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
 - 1. Comply with requirements indicated on Drawings.
 - 2. Make connections to coils with a **[flange][or][union]**.
 - 3. Connect to each coil inlet with shutoff valve, test plug, **[pressure gauge][and][thermometer]**.
 - 4. Connect to each coil outlet with balancing valve, test plug, **[pressure gauge][thermometer][flow meter][and][shutoff valve]**.
 - 5. Connect each coil drain connection with a drain valve, which is full size of drain connection.**[Connect drain pipe to drain valve with union, and extend drain pipe to terminate over floor drain.]**
 - 6. Connect each coil vent connection with **[automatic][or][manual]** vent, which is full size of vent connection.

- I. Steam and Condensate Coil Piping: Comply with applicable requirements in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties." Install shutoff valve at steam supply connections, float and thermostatic trap assembly, and union or flange at each coil return connection.
- J. Refrigerant Coil Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Install shutoff valve at each supply and return connection.
- K. Steam Humidifier Piping: Comply with applicable requirements in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties." Install gate valve and inlet strainer at supply connection of steam humidifiers and steam trap assemblies to condensate return connection.

3.6 ELECTRICAL CONNECTIONS

- A. Install field power to each air-handling unit electrical power connection. Coordinate with air-handling unit manufacturer and installers.
- B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- E. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least [1/2 inch (13 mm)]<Insert dimension> high.

3.7 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."
- C. Install nameplate for each control connection, indicating field control panel designation and I/O control designation feeding connection.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least [1/2 inch (13 mm)]<Insert dimension> high.

3.8 STARTUP SERVICE

- A. Engage an air-handling unit factory[-authorized] service representative to perform startup service.

1. Complete installation and startup checks in accordance with manufacturer's written instructions.
2. Verify that shipping, blocking, and bracing are removed.
3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, controls, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
4. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
5. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
6. Verify that face-and-bypass dampers provide full face flow.
7. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
8. Comb coil fins for parallel orientation.
9. Verify that proper thermal-overload protection is installed for electric heaters.
10. Install new, clean filters.
11. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.
12. **<Insert requirement>**.

B. Starting procedures for air-handling units include the following:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. **[Replace fan and motor pulleys as required to achieve design conditions.]**
2. Measure and record motor electrical values for voltage and amperage.
3. Manually operate dampers from fully closed to fully open position and record fan performance.
4. **<Insert requirement>**.

C. Heat Wheel Startup Service:

1. After field installation is complete, a final checkout and startup shall be completed to ensure proper purge adjustment, seal adjustment, control settings, and other key operational functions.
2. Service shall be completed by trained factory service personnel employed by heat wheel manufacturer.
3. Submit a report summarizing findings, adjustments made, and final settings.

3.9 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.
- C. Before turning equipment over to Owner for use, adjust air-handling unit components that require further adjustment for proper operation. Consult air-handling unit manufacturer for instruction.
- D. Occupancy Adjustments: When requested within **[12]<Insert number>** months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to **[two]<Insert number>** visits to Project during other-than-normal occupancy hours for this purpose.
- E. Seasonal Adjustments: Make seasonal visits during warranty period to inspect and review operation of equipment. Make necessary adjustments for components observed to require adjustments for proper operation. Prepare and submit a report to Owner documenting each visit, observations, and any adjustments made.

3.10 CLEANING

- A. Cleaning Schedule: After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems, and after completing startup service, and immediately before Owner use, clean air-handling units to remove foreign material and construction dirt and dust.
- B. Unit Interior: Clean air-handling units internally to factory clean condition. Remove foreign material and construction debris, dirt, and dust.
 - 1. Vacuum clean with HEPA-filtered vacuum and then wipe down with cleaning solution.
 - 2. Clean casing floors, roofs, wall surfaces, access doors, and panels.
 - 3. Clean all internal components, such as coils, dampers, filter frames, fans, and motors.
 - 4. Clean light fixtures and control devices.
- C. Unit Exterior: Clean external surfaces of air-handling units to factory clean condition. Remove foreign material and construction debris, dirt and dust. Vacuum clean with HEPA-filtered vacuum and then wipe down all surfaces with cleaning solution.
- D. Cleaning Materials: Use cleaning materials and products recommended in writing by air-handling unit manufacturer.
- E. Acceptance: Following unit cleaning submit a written request for review and [Owner] acceptance. Acceptance for cleaning of air-handling units **[with absolute filters]** must pass a white glove test.

3.11 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Tests and Inspections: Perform the following tests and inspections **[with the assistance of a factory-authorized service representative]**.
 - 1. After field piping connections are complete, test **[hydronic][and][steam]** coils and connections for leaks.
 - 2. Charge refrigerant coils with refrigerant and test for leaks.
 - 3. Field-Assembly Supervision: Instruct Installer and supervise field installation of **[first]<Insert quantity>** air-handling unit(s) shipped in multiple pieces for field assembly.
 - 4. Roof-Mounted Field-Installation Supervision: Instruct Installer and supervise field installation of **[first]<Insert quantity>** roof-mounted air-handling unit(s).
 - 5. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 6. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Field Casing Leakage Test:
 - 1. Perform leak testing of air-handling units that include field assembly of multiple sections. Air-handling units that are shipped and installed as a single piece do not require field testing.
 - 2. Leak test **[one]<Insert value>** air-handling unit(s) of each unique size and arrangement randomly selected by **[Architect][Commissioning Agent][Owner]**.
 - 3. Follow procedures complying with ASHRAE 111.
 - 4. Assembled air-handling units shall satisfy leakage criteria indicated. Modify air-handling units that

fail to satisfy criteria and retest. For every air-handling unit that fails test, another air-handling unit shall be tested until all air-handling units tested pass leakage criteria on first attempt.

5. Submit a test report for each test indicating test equipment, procedures, results, date and time, and full name of personnel performing tests and witnesses.
6. Test report shall be in accordance with ASHRAE 111.
7. Witness Testing:
 - a. Provide written notification at least [30][20]<Insert number> business days in advance of testing.
 - b. Testing shall be conducted in presence of testing and balancing agent.
 - c. Other parties such as Architect, Commissioning Agent, and Owner shall be invited to witness testing with attendance being optional.

E. Field Fan Vibration Test:

1. Perform fan vibration testing for every one out of [10]<Insert number> air-handling unit fans randomly selected by [Architect][Commissioning Agent][Owner].
2. Test after air-handling unit installation is complete.
3. Three vibration readings shall be taken for each bearing in horizontal, vertical, and axial directions. Record each reading including vibration amplitude verses frequency.
4. Modify fans that fail to satisfy performance criteria and retest. For every fan that fails test, another fan shall be tested until all fans tested pass criteria on first attempt.
5. Submit a report for each fan tested indicating air-handling unit designation, fan designation, test equipment, procedures, results, date and time, and full name of personnel performing tests and witnesses.
6. Witness Testing:
 - a. Provide written notification at least [30][20]<Insert number> business days in advance of testing.
 - b. Testing shall be conducted in presence of testing and balancing agent.
 - c. Other parties such as Commissioning Agent, Architect, and Owner shall be invited to witness testing with attendance being optional.

F. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.

G. Prepare test and inspection reports.

3.12 OPERATION DURING CONSTRUCTION

A. Operation of air-handling units for temporary cooling, heating, and ventilation is not allowed without Owner authorization.

1. Submit written request for Owner approval by signature with detailed description of operating procedures to be followed including, but not limited to, the following:
 - a. Description of construction activities while units are operating.
 - b. Operation:
 - 1) Beginning and ending calendar dates.
 - 2) List each day during week.
 - 3) List start and stop time and hours for each day.
 - c. Startup procedures and shut-down procedures.

- d. Provisions for routine monitoring of unit operation.
 - e. Provisions to prevent and protect against damage to equipment due to adverse operation such as, low temperature, high temperature, over pressure, fire, smoke, electrical over- and undervoltage and current and electrical fault.
 - f. Provisions and safeguards for filtration to keep inside of units from getting dirty.
 - g. Record keeping.
2. If approved by Owner, units used for temporary cooling, heating, and ventilation during and before interior finish work is complete shall include an unconditional complete unit labor and parts warranty to extend at least **[two]<Insert number>** years after the warranty indicated expires.
 3. Interior and exterior of air-handling units shall be cleaned to a factory-cleaned condition and clean condition must be accepted by Owner.

B. Filtration During Temporary Use:

1. Protect air-handling system ducts (exhaust air, outdoor air, and return air) with temporary filters installed and supported to prevent filter media from collapse and bypass of unfiltered air. Temporary media shall be installed at each inlet and shall have a published filtration efficiency of MERV **[8][11][13]<Insert MERV>** in accordance with ASHRAE 52.2.
2. Protect air-handling units with open inlets that are not ducted with temporary filters installed and supported to prevent filter media from collapse and by-pass of unfiltered air. Temporary media shall be installed at each inlet and shall have a published filtration efficiency of MERV **[8][11][13]<Insert MERV>** in accordance with ASHRAE 52.2.
3. Do not operate air-handling units until both temporary and scheduled permanent air-handling unit particulate filters are in place. Temporary filters must be installed upstream of permanent filters while units are operating.
4. Replace temporary and permanent filters used during construction when dirty. After end of temporary use, replace permanent filters with new, clean filters before beginning testing, adjusting and balancing.

- C. Comply with SMACNA 008, "IAQ Guidelines for Occupied Buildings under Construction," for procedures to protect HVAC system.

3.13 DEMONSTRATION

- A. Engage air-handling unit manufacturer **[employed training instructor][or][factory-authorized service representative]** to train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.
- B. Training shall include, but not be limited to, procedures and schedules related to performance, safety, startup and shut down, troubleshooting, servicing, preventive maintenance, and how to obtain replacement parts.
1. Access Doors: Adjustment, gasket removal and replacement, handle removal and replacement, and spare parts.
 2. Access Panels: Removal and replacement, adjustment, gasket removal and replacement, and spare parts.
 3. Air Blenders: Cleaning, operation, removal, and replacement.
 4. Coils: Cleaning, combing fins, draining, venting, removal, and replacement.
 5. Controls: Calibration, cleaning, operation, service, removal and replacement, and spare parts.
 6. Damper Assemblies: Cleaning, operation, service, removal and replacement, and spare parts.
 7. Drain Pans: Cleaning, removal, and replacement.
 8. Duct Silencers: Cleaning, removal, and replacement.
 9. Electric Heaters: Cleaning, operation, service, removal and replacement, and spare parts.
 10. Heat Wheels: Cleaning, operation, service, removal and replacement, and spare parts.



11. Fan and Motor Assemblies: Cleaning, operation, removal and replacement, service, and spare parts.
12. Filters: Operation, removal and replacement, frame gasket removal and replacement, clip removal and replacement, and spare parts.
13. Fixed Plate heat Exchangers: Cleaning, removal, and replacement.
14. Heat Pipe Heat Exchangers: Cleaning, combing fins, removal, and replacement.
15. Humidifiers: Cleaning, operation, service, removal and replacement, and spare parts.
16. UV-C Lamp Systems: Cleaning, operation, service, removal and replacement, and spare parts.
17. Lights, Receptacles and Switches: Cleaning, operation, service, removal and replacement, and spare parts.
18. **<Insert requirement>**.

C. Instructor:

1. Instructor shall be factory trained and certified by air-handling unit manufacturer with current training on equipment installed.
2. Instructor's credentials shall be submitted for review by **[Architect][Commissioning Agent][Owner]** before scheduling training.
3. Instructor(s) **[primary][sole]** job responsibility shall be Owner training.
4. Instructor(s) shall have not less than **[three]<Insert number>** years of training experience with air-handling unit manufacturer and past training experience on at least **[three]<Insert number>** projects of comparable size and complexity.

D. Schedule and Duration:

1. Schedule training with Owner at least **[20]<Insert number>** business days before first training session.
2. Training shall occur before Owner occupancy.
3. Training shall be held at mutually agreed date and time during normal business hours.
4. Each training day shall not exceed **[eight]<Insert number>** hours of training. Daily training schedule shall allow time for a **[one]<Insert number>**-hour lunch period and **[15]<Insert number>**-minute break after every **[two]<Insert number>** hours of training.
5. Perform not less than **[eight][16][24]<Insert number>** hours of training.

E. Location: Owner to provide a suitable on-site location to host classroom training.

F. Training Attendees: Assume **[three]<Insert number>** people.

G. Training Attendance Records: For record purposes, document training attendees at start of each new training session. Record date, time, brief description of training covered during the session, attendee's name, signature, phone number, and e-mail address. Submit scanned copy of sign-in sheet to Owner for each training session.

H. Training Format: Individual training modules to include classroom training followed by hands-on field demonstration and training.

I. Training Materials: Provide training materials in electronic format to each attendee.

1. Include instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.

J. Training Video Recording: Video record each classroom training session and submit an electronic copy to Owner before requesting Owner acceptance of training.

K. Written Acceptance: Obtain **[Architect][Commissioning Agent][or][Owner]** written acceptance that



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training is complete and requirements indicated have been satisfied.

END OF SECTION 23 74 00 00A



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SECTION 23 74 00 00B - DEDICATED OUTDOOR-AIR UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Dedicated outdoor-air units.

B. Related Requirements:

1. [Section 284600 "Fire Detection and Alarm."][Section 284614 "Single- and Multiple-Station Alarms."][Section 284600 "Fire Detection and Alarm" and "Section 284614 "Single- and Multiple-Station Alarms."]

1.2 DEFINITIONS:

- A. ECM: Electronically commutated motor.
- B. IS COP: Integrated Seasonal Coefficient of Performance.
- C. ISMRE: Integrated Seasonal Moisture Removal Efficiency.
- D. MRC: Moisture Removal Capacity.

1.3 ACTION SUBMITTALS

A. Product Data:

1. For each type of product.
 - a. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 - b. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - c. Include unit dimensions and weight.
 - d. Include cabinet material, metal thickness, finishes, insulation, and accessories.
 - e. Fans:
 - 1) Certified fan-performance curves with system operating conditions indicated.
 - 2) Certified fan-sound power ratings.
 - 3) Fan construction and accessories.
 - 4) Motor ratings, electrical characteristics, and motor accessories.
 - f. Include certified coil-performance ratings with system operating conditions indicated.
 - g. Include filters with performance characteristics.
 - h. Include heat exchangers with performance characteristics.
 - i. Include dampers, including housings, linkages, and operators.

B. Sustainable Design Submittals:

1. Product Data: Showing compliance with ASHRAE 62.1.
2. Product Data: For air filtration performance.
3. Product Data: For adhesives, mastics, and sealants, indicating VOC content.
4. Laboratory Test Reports: For adhesives, mastics, and sealants, indicating compliance with requirements for low-emitting materials.
5. Refrigerant: Product Data for refrigerants, indicating compliance with refrigerant management practices.
6. Product Data: Provide the following:
 - a. Manufacturer cut sheet indicating water consumption.
 - b. WaterSense certification for residential fixtures, commercial water closets, commercial urinals, and commercial showers.

C. Shop Drawings: For each dedicated outdoor-air unit.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

D. Delegated Design Submittal: For dedicated outdoor-air-unit supports indicated to comply with performance and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Include design calculations for selecting vibration isolators [**seismic restraints**][and][**wind restraints**], and for designing vibration isolation bases.
2. [**Wind**][and][**Seismic**]-Restraint Details: Detail fabrication and attachment of wind and seismic restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.
3. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor/roof plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

B. Sample Warranty: For manufacturer's warranty.

C. Seismic Qualification Data: Certificates, for dedicated outdoor-air units, accessories, and components, from manufacturer.

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

D. Product Certificates: Submit certification that specified equipment will withstand wind forces identified in

"Performance Requirements" Article and in Section 230548 "Vibration and Seismic Controls for HVAC."

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

E. Source quality-control reports.

F. Startup service reports.

G. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For dedicated outdoor-air units to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fan Belts: **[One]<Insert number>** set(s) for each belt-driven fan.
2. Filters: **[One]<Insert number>** set(s) for each unit.
3. Gaskets: **[One]<Insert number>** set(s) for each access door.

1.7 WARRANTY

- A. Warranty: Manufacturer agrees to replace components of dedicated outdoor-air units that fail in materials or workmanship within specified warranty period.
1. Warranty Period for Dedicated Outdoor-Air-Handling Units: **[Two][Three]<Insert number>** years from date of Substantial Completion.
 2. Warranty Period for Compressors: **[Five]<Insert number>** years from date of Substantial Completion.
 3. Warranty Period for Heat Exchangers: **[Five][10]<Insert number>** years from date of Substantial Completion.
 4. Warranty Period for Rotary Heat Exchangers: **[Five]<Insert number>** years from date of Substantial Completion.
 5. **<Insert components requiring extended warranty>**.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an "NRTL" (nationally recognized testing laboratory), and marked for intended location and application.

- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of units and components.
- C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- D. ASHRAE 15 and ASHRAE 34 Compliance: For refrigeration system safety.
- E. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- F. ASHRAE 84 Compliance: Comply with capacity ratings for **[heat-wheel][fixed plate]** energy-recovery equipment.
- G. UL Compliance:
 - 1. Electric Coils: Comply with requirements in UL 1995.
- H. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design **[vibration isolation][seismic restraints][and][wind restraints]**.
- I. Seismic Performance: Units are to withstand the effects of earthquake motions determined in accordance with **[ASCE/SEI 7]<Insert requirement>**. See Section 230548 "Vibration and Seismic Controls for HVAC."
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified **[and the unit will be fully operational after the seismic event]**."
 - 2. Component Importance Factor: **[1.5][1.0]**.
 - 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.
- J. Wind-Restraint Performance:
 - 1. See **[Section 230548 "Vibration and Seismic Controls for HVAC][Section 230548.13 "Vibration Controls for HVAC"]** for requirements.

2.2 CAPACITIES AND CHARACTERISTICS

- A. Supply-Air Fan:
 - 1. Type: **[DWDI, backward-inclined centrifugal fan][DWDI, forward-curved centrifugal fan][DWDI, airfoil centrifugal fan][SWSI, airfoil unhooded centrifugal fan]<Insert fan type>**.
 - 2. Class: AMCA 99, Section 14, **[Class I][Class II]**.
 - 3. Airflow: **<Insert cfm (L/s)>**.
 - 4. External Static Pressure: **<Insert inches wg (kPa)>**.
 - 5. Size: **<Insert wheel size>**.
 - 6. Design Fan Speed: **<Insert number>** rpm.
 - 7. Motor Characteristics:
 - a. Horsepower: **<Insert number>** hp.
 - b. Motor Speed: **[Multispeed][ECM][Constant]<Insert number>** rpm.
 - c. Volts: **[120][208][230][460]<Insert number>** V.

- d. Phase: **[Single][Three]**.
 - e. Hertz: 60.
8. Fan Discharge Sound Power, dB:
- a. 1st Octave: **<Insert value>**.
 - b. 2nd Octave: **<Insert value>**.
 - c. 3rd Octave: **<Insert value>**.
 - d. 4th Octave: **<Insert value>**.
 - e. 5th Octave: **<Insert value>**.
 - f. 6th Octave: **<Insert value>**.
 - g. 7th Octave: **<Insert value>**.
 - h. 8th Octave: **<Insert value>**.
- B. Relief (Exhaust)-Air Fan:
- 1. Type: **[DWDI, backward-inclined centrifugal fan][DWDI, forward-curved centrifugal fan][DWDI, airfoil centrifugal fan][SWSI, airfoil unhooded centrifugal fan]<Insert fan type>**.
 - 2. Class: AMCA 99, Section 14, **[Class I][Class II]**.
 - 3. Airflow: **<Insert cfm (L/s)>**.
 - 4. External Static Pressure: **<Insert inches wg (kPa)>**.
 - 5. Design Fan Speed: **<Insert number>** rpm.
 - 6. Motor Characteristics:
 - a. Horsepower: **<Insert number>** hp.
 - b. Motor Speed: **[Multispeed][ECM][Constant]<Insert number>** rpm.
 - c. Volts: **[120][208][230][460]<Insert number>** V.
 - d. Phase: **[Single][Poly]**.
 - e. Hertz: 60.
 - 7. Fan Inlet Sound Power, dB:
 - a. 1st Octave: **<Insert value>**.
 - b. 2nd Octave: **<Insert value>**.
 - c. 3rd Octave: **<Insert value>**.
 - d. 4th Octave: **<Insert value>**.
 - e. 5th Octave: **<Insert value>**.
 - f. 6th Octave: **<Insert value>**.
 - g. 7th Octave: **<Insert value>**.
 - h. 8th Octave: **<Insert value>**.
- C. Condenser-Air Fan:
- 1. Motor Characteristics:
 - a. Horsepower: **<Insert number>** hp.
 - b. Motor Speed: **[Multispeed][ECM][Constant]<Insert number>** rpm.
 - c. Volts: **[120][208][230][460]<Insert value>** V.
 - d. Phase: **[Single][Poly]**.
 - e. Hertz: 60.
- D. Refrigerant Cooling Coil:
- 1. Capacity: **<Insert tons (kW)>**.
 - 2. ISMRE: **<Insert number>**.
 - 3. Condenser Ambient-Air Temperature: **<Insert deg F (deg C)>**.

4. Evaporator Coil:

- a. Sensible Heat-Transfer Rate: **<Insert Btu/h (kW)>**.
- b. Total Heat-Transfer Rate: **<Insert Btu/h (kW)>**.
- c. Entering-Air, Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
- d. Entering-Air, Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
- e. Leaving-Air, Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
- f. Leaving-Air, Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
- g. Face Area: **<Insert sq. ft. (sq. m)>**.
- h. Maximum Face Velocity: **<Insert fpm (m/s)>**.
- i. Maximum Air-Side, Static-Pressure Drop: **<Insert inches wg (Pa)>**.
- j. Fin Spacing: **<Insert fins per inch (cm)>**.
- k. Fin Thickness: **<Insert inches (mm)>**.
- l. Number of Rows: **<Insert number>**.

E. Hot-Gas Reheat Coil:

1. Heating Capacity: **<Insert Btu/h (kW)>**.
2. Entering-Air Temperature: **<Insert deg F (deg C)>**.
3. Air-Temperature Rise: **<Insert deg F (deg C)>**.
4. Refrigerant Type: **<Insert refrigerant type>**.

F. Electric-Resistance Heating Coils:

1. Heat-Transfer Rate: **<Insert Btu/h (kW)>**.
2. Entering-Air Temperature: **<Insert deg F (deg C)>**.
3. Leaving-Air Temperature: **<Insert deg F (deg C)>**.
4. Power Input: **<Insert number> kW**.
5. Volts: **[120][208][230][480]<Insert number> V**.
6. Phase: **[Single][Three]**.
7. Hertz: 60.
8. Full-Load Amperes: **<Insert number> A**.
9. Maximum Overcurrent Protection: **<Insert number> A**.
10. Capacity Control: Number of Steps or SCR: **<Insert number or SCR>**.

G. Gas-Fired Furnace Heating:

1. Heat-Transfer Rate: **<Insert Btu/h (kW)>**.
2. Entering-Air Temperature: **<Insert deg F (deg C)>**.
3. Leaving-Air Temperature: **<Insert deg F (deg C)>**.
4. Efficiency: **[80]<Insert number> percent**.
5. Fuel: **[Natural][Propane] gas**.
6. Burner: **[Modulating][Staged]**.
7. Turndown Ratio: Minimum **[5:1][6:1][8:1]<Insert ratio>**.
8. Gas Heating Value: **<Insert Btu/cu. ft. (kJ/L)>**.
9. Gas Input: **<Insert cfh (mL/s)>**.
10. Gas Burner Electrical Characteristics:
 - a. Power Input: **<Insert number> kW**.
 - b. Volts: **[120][208][230][460]<Insert number> V**.
 - c. Phase: **[Single][Three]**.
 - d. Hertz: 60.
 - e. Full-Load Amperes: **<Insert number> A**.
 - f. Minimum Circuit Ampacity: **<Insert number> A**.
 - g. Maximum Overcurrent Protection: **<Insert number> A**.

H. Heating Coils: **[Hot Water][Steam]**.

1. Heat-Transfer Rate: **<Insert Btu/h (kW)>**.
2. Entering-Air Temperature: **<Insert deg F (deg C)>**.
3. Leaving-Air Temperature: **<Insert deg F (deg C)>**.
4. Face Area: **<Insert sq. ft. (sq. m)>**.
5. Maximum Face Velocity: **<Insert fpm (m/s)>**.
6. Maximum Air-Side, Static-Pressure Drop: **<Insert inches wg (Pa)>**.
7. Coil Type: **[Continuous circuit][Self-draining][Cleanable][Distributing][Single tube]**.
8. Piping Connections: **[Threaded][Flanged]; [same end][opposite ends]** of coil.
9. Tube Thickness: **<Insert inches (mm)>**.
10. Fin Spacing: **<Insert fins per inch (cm)>**.
11. Fin Thickness: **<Insert inches (mm)>**.
12. Number of Rows: **<Insert number>**.
13. Coil Working-Pressure Ratings: **[200 psig (1380 kPa), 325 deg F (163 deg C)]<Insert value>**.
14. Fluid Flow: **<Insert gpm (L/s)>**.
15. Maximum Fluid-Pressure Drop: **<Insert feet of head (kPa)>**.
16. Entering-Fluid Temperature: **<Insert deg F (deg C)>**.
17. Leaving-Fluid Temperature: **<Insert deg F (deg C)>**.
18. Fluid Velocity: **<Insert fpm (L/s)>**.
19. Steam Flow: **<Insert lb/h (g/s)>**.
20. Inlet Steam Pressure: **<Insert psig (kPa)>**.

I. Rotary Heat Exchanger:

1. Effectiveness: **<Insert number>** percent.
2. Intake Airflow: **<Insert cfm (L/s)>**.
3. Pressure Differential: **<Insert inches wg (kPa)>**.
4. Entering Supply-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
5. Entering Supply-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
6. Leaving-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
7. Leaving-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
8. Relief/Exhaust Airflow: **<Insert cfm (L/s)>**.
9. Entering Relief/Exhaust-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
10. Entering Relief/Exhaust-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
11. Leaving Relief/Exhaust-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
12. Leaving Relief/Exhaust-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.

J. Filters:

1. Type: **[Panel]<Insert type>**.
2. Face Dimensions, Each: **<Insert inches by inches (mm by mm)>**.
3. Depth: **<Insert inches (mm)>**.
4. Number of Filters in Filter Bank: **<Insert number>** wide by **<Insert number>** high.
5. Access Location: **[Side]<Insert location>**.
6. Maximum or Rated Face Velocity: **<Insert fpm (m/s)>**.
7. Initial Resistance: **<Insert inches wg (Pa)>**.
8. Recommended Final Resistance: **<Insert inches wg (Pa)>**.
9. Minimum Efficiency Reporting Value and Average Arrestance:
 - a. MERV Rating and Corresponding Average Arrestance: **[MERV 1][MERV 2][MERV 3][MERV 4]**, and corresponding average arrestance, in accordance with ASHRAE 52.2.
10. Minimum Efficiency Reporting Value:
 - a. MERV Rating: **[MERV 6][MERV 8][MERV 11][MERV 13][MERV 14]<Insert value>**, in

accordance with ASHRAE 52.2.

K. Electrical Characteristics for Single-Point Connection:

1. Volts: [120][208][230][460]<Insert number> V.
2. Phase: [Single][Three].
3. Hertz: 60.
4. Full-Load Amperes: <Insert number> A.
5. Minimum Circuit Ampacity: <Insert number> A.
6. Maximum Overcurrent Protection: <Insert number> A.

2.3 DEDICATED OUTDOOR-AIR UNITS

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

1. [AAON]
2. [Addison]
3. [Desert Aire]
4. [Munters Corporation]
5. [REZNOR, a brand of Nortek Global HVAC]
6. <Insert manufacturer's name>

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

1. [AAON]
2. [Addison]
3. [Desert Aire]
4. [Munters Corporation]
5. [REZNOR, a brand of Nortek Global HVAC]
6. <Insert manufacturer's name>

C. Source Limitations: Obtain dedicated outdoor-air units from single manufacturer.

D. Unit Casing:

1. General Fabrication Requirements for Casings: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.
2. Configuration: Horizontal unit with [top][horizontal][bottom] discharge for [roof-mounting][concrete-base] installation.
3. Double-Wall Configuration:
 - a. Outside Casing Wall: [Galvanized steel][Stainless steel], stainless steel in cooling coil section<Insert material>, minimum [18 gauge (1.3 mm)]<Insert value> thick with [manufacturer's standard finish][corrosion-resistant coating]<Insert special coating>, with pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs.
 - b. Inside Casing Wall:
 - 1) Inside Casing, Burner Section: [Galvanized steel]<Insert material>, solid, minimum [14-gauge- (0.759-mm-)]<Insert value> thick steel.

- 2) Inside Casing, All Other Sections: **[Galvanized steel]<Insert material>, [solid][perforated].**
- 3) Antimicrobial Coating: Applied during the manufacturing process. Coating is to be **[EPA approved][NSF approved][FDA listed].**
- c. Floor Plate: Reinforced metal surface; reinforced to limit deflection when walked on by service personnel. Insulation is provided below metal walking surface.
- d. Roof: Standing seam or membrane; sloped to drain water.
- e. Casing Insulation:
 - 1) Materials: Polyurethane foam insulation.
 - 2) Casing Panel R-Value: Minimum **[R-6.5][R-11][R-13]<Insert value>.**
 - 3) Insulation Thickness: **[1 inches (25 mm)][2 inches (50 mm)]<Insert dimension>.**
 - 4) Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roofs of air-handling unit.
4. Airstream Surfaces: Surfaces in contact with airstream are to comply with requirements in ASHRAE 62.1.
5. Static-Pressure Classifications:
 - a. For Unit Sections Upstream of Fans: Minus **[2 inches wg (500 Pa)][3 inches wg (750 Pa)]<Insert value>.**
 - b. For Unit Sections Downstream and Including Fans: **[2 inches wg (500 Pa)][3 inches wg (750 Pa)][4 inches wg (1000 Pa)]<Insert value>.**
6. Panels and Doors:
 - a. Panels:
 - 1) Fabrication: Formed and reinforced double-wall and insulated panels of same materials and thicknesses as casing.
 - 2) Fasteners: Two or more camlock-type fasteners for panel lift-out operation. Arrangement is to allow panels to be opened against airflow.
 - 3) Gasket: Neoprene, applied around entire perimeters of panel frames.
 - 4) Size: Large enough to allow unobstructed access for inspection and maintenance of unit's internal components.
 - b. Doors:
 - 1) Fabrication: Formed and reinforced double-wall and insulated panels of same materials and thicknesses as casing.
 - 2) Hinges: A minimum of two ball-bearing hinges or stainless steel piano hinge and two wedge-lever latches, operable from inside and outside. Arrange doors to be opened against airflow. Provide safety latch retainers on doors so that doors do not open uncontrollably.
 - 3) Gasket: Neoprene, applied around entire perimeters of panel frames.
 - 4) Size: Large enough to allow for unobstructed access for inspection and maintenance of air-handling unit's internal components.
 - c. Locations and Applications:
 - 1) Fan Section: **[Panels][Doors].**
 - 2) Access Section: Doors.
 - 3) Gas-Fired Burner Section: **[Panels][Doors].**
 - 4) Damper Section: **[Panels][Doors].**
 - 5) Filter Section: **[Panels][Doors]** large enough to allow periodic removal and

- 6) installation of filters.
- 6) Relief Section: Doors.

7. Condensate Drain Pans:

- a. Location: Each refrigerant coil[**and rotary heat exchanger**].
- b. Construction:
 - 1) Single-wall, [**galvanized-steel or noncorrosive polymer**][**stainless steel**] sheet.
- c. Size: Large enough to collect condensate from cooling coils, including coil piping connections, coil headers, and return bends.
- d. Drain Connection:
 - 1) Located on [**one end**][**both ends**] of pan, at lowest point of pan.
 - 2) Terminated with threaded nipple.
 - 3) Minimum Connection Size: [**NPS 1 (DN 25)**][**NPS 2 (DN 50)**]**<Insert pipe size>**.
- e. Slope: Minimum [**0.125-inch/ft. (10-mm/m)**]**<Insert value>** slope[, **to comply with ASHRAE 62.1,**] in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers and to direct water toward drain connection.
- f. Length: Extend drain pan downstream from leaving face [**for distance to comply with ASHRAE 62.1**]**<Insert distance>**.
- g. Width: Entire width of water-producing device.
- h. Depth: A minimum of [**2 inches (50 mm)**]**<Insert dimension>** deep.
- i. Pan-Top Surface Coating for Galvanized-Steel Drain Pans: Asphaltic waterproofing compound.
- j. Provide units having stacked coils with intermediate drain pan to collect condensate from top coil.

E. Fans, Drives, And Motors:

- 1. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.
- 2. Supply-Air Fans and Relief-Air Fans: Centrifugal; galvanized or painted steel; mounted on solid-steel shaft.
 - a. Shafts: With field-adjustable alignment.
 - 1) Turned, ground, and polished hot-rolled steel with keyway.
 - b. Shaft Bearings:
 - 1) Heavy-duty, self-aligning, pillow-block type with an [**L-50**]**<Insert bearing life rating>** rated life of minimum [**100,000**]**<Insert number>** hours in accordance with ABMA 9.
 - c. Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.
 - 1) Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.
 - d. Housings, Plenum Fans: Steel frame and panel; fabricated without fan scroll and volute

- e. housing. Provide inlet screens for Type SWSI fans.
- e. Backward-Inclined, Centrifugal Fan Wheels: Construction with curved inlet flange, backplate, backward-inclined blades welded or riveted to flange and backplate; **[steel][aluminum]** hub riveted to backplate and fastened to shaft with setscrews.
- f. Forward-Curved, Centrifugal Fan Wheels: Inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically fastened to flange and backplate; **[steel][aluminum]** hub swaged to backplate and fastened to shaft with setscrews.
- g. Airfoil, Centrifugal Fan Wheels (Plenum Fan Wheels): Smooth-curved inlet flange, backplate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange and backplate; steel hub riveted to backplate and fastened to shaft with setscrews.
- h. Mounting: For internal vibration isolation **[and seismic control]**. Factory mount fans with manufacturer's standard **[restrained]** vibration isolation mounting devices having a minimum static deflection of **[1 inch (25 mm)][2 inches (50 mm)]<Insert dimension>**.
- i. Shaft Lubrication Lines: Extended to a location outside the casing.
- j. Flexible Connector: Factory fabricated with a fabric strip minimum **3-1/2 inches (89 mm) <Insert dimension>** wide, attached to two strips of minimum **2-3/4-inch- (70-mm-) wide <Insert width>** by **0.028-inch- (0.7-mm-) thick, galvanized-steel sheet**.
- 1) Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives are to comply with UL 181, Class 1.
- 3. Drive, Direct: Factory-mounted direct drive.
- 4. Drive, Belt: Factory-mounted V-belt drive, with adjustable alignment and belt tensioning, and with **[1.5][1.25]** service factor based on fan motor.
 - a. Pulleys: Cast iron or cast steel with split, tapered bushing, dynamically balanced at the factory.
 - b. Belts: Oil resistant, nonsparking and nonstatic; in matched sets for multiple-belt drives.
 - c. Belt Guards: Comply with requirements specified by OSHA and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards"; **[0.146 inch (2.7 mm)]<Insert dimension>** thick, **[3/4-inch (20-mm)]<Insert dimension>** diamond-mesh wire screen, welded to steel angle frame; prime coated.
- 5. Condenser-Coil Fan: **[Variable-speed]**propeller, mounted on shaft of permanently lubricated **[multispeed][electronically commutated]** motors.
- 6. Motors:
 - a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - b. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - c. Enclosure Type: **[Open, dripproof][Totally enclosed, fan cooled]<Insert type>**.
 - d. Enclosure Materials: **[Cast iron]<Insert material>**.
 - e. Motor Bearings: **<Insert requirements>**.
 - f. Unusual Service Conditions:
 - 1) Ambient Temperature: **<Insert deg C (deg C)>**.
 - 2) Altitude: **<Insert feet (m)>** above sea level.
 - 3) High humidity.
 - 4) **<Insert conditions>**.
 - g. Efficiency: Premium efficient as defined in NEMA MG 1.
 - h. NEMA Design: **<Insert designation>**.
 - i. Motor Pulleys: Adjustable pitch for use with **[5]<Insert number>** hp motors and smaller;

- fixed pitch for use with motors larger than [5]<Insert number> hp. Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions.
- j. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
 - k. <Insert unique motor characteristics>.
 - l. Mount unit-mounted disconnect switches on [exterior][interior] of unit.
7. Comply with Section 262923 "Variable-Frequency Motor Controllers."
 8. Variable-Frequency Motor Controller: Serving [each fan individually][all fans combined] in fan array.
 - a. Manufactured Units: Pulse-width modulated; [constant torque][and][variable torque]<Insert application> for [Design A and Design B][inverter-duty] motors.
 - b. Output Rating: Three phase; 10 to [60 Hz, with voltage proportional to frequency throughout voltage range][66 Hz, with torque constant as speed changes]; maximum voltage equals input voltage.
 - c. Unit Operating Requirements:
 - 1) Internal Adjustability:
 - a) Minimum Speed: 5 to 25 percent of maximum rpm.
 - b) Maximum Speed: 80 to 100 percent of maximum rpm.
 - c) Acceleration: [0.1 to 999.9]<Insert range> seconds.
 - d) Deceleration: [0.1 to 999.9]<Insert range> seconds.
 - e) Current Limit: 30 to minimum of 150 percent of maximum rating.
 - 2) Self-Protection and Reliability Features:
 - a) Surge suppression.
 - b) Loss of input signal protection.
 - c) Under- and overvoltage trips.
 - d) Variable-frequency motor controller and motor-overload/overtemperature protection.
 - e) Critical frequency rejection.
 - f) Loss-of-phase protection.
 - g) Reverse-phase protection.
 - h) Motor-temperature fault.
 - 3) Bidirectional autospeed search.
 - 4) Torque boost.
 - 5) Motor temperature compensation at slow speeds.
 - a) Panel-mounted operator station.
 - b) Historical logging information and displays.
 - c) Digital indicating devices.
 - 6) Control Signal Interface: Electric.
 - 7) Proportional Integral Directive (PID) control interface.
 - 8) DDC system for HVAC Protocols for Network Communications: [ASHRAE 135]<Insert protocol type>.
 - d. Line Conditioning:
 - 1) Input line conditioning.
 - 2) Output filtering.

- 3) EMI/RFI filtering.
- e. Bypass Systems:
 - 1) Bypass Mode: **[Manual operation only][Field-selectable automatic or manual]**.
 - 2) Bypass Controller, Two-Contactor Style: With bypass and output isolating contactors **[and isolating switch]**.
 - 3) Bypass Controller, Three-Contactor Style: With bypass and input and output isolating contactors **[and isolating switch]**.
 - 4) Bypass Contactor Configuration: **[Full-voltage (across the line)][Reduced-voltage (autotransformer)]<Insert type>** type.
- F. Coils:
 - 1. General Requirements for Coils:
 - a. Comply with AHRI 410.
 - b. Fabricate coils section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
 - c. Coils are not to act as structural component of unit.
 - 2. Supply-Air Refrigerant Coils:
 - a. Tubes: **[Copper]<Insert material>**.
 - b. Fins:
 - 1) Material: **[Aluminum][Copper]<Insert material>**.
 - 2) Fin Spacing: Maximum **[12][10][8]<Insert spacing>** fins per inch (mm).
 - c. Fin and Tube Joints: Mechanical bond.
 - d. Headers: **[Seamless-copper headers with brazed connections]<Insert material and connections>**.
 - e. Frames: **[Galvanized steel]<Insert material frame>**.
 - f. Coatings: **[None][Corrosion-resistant coating]**.
 - g. Ratings: Designed, tested, and rated in accordance with ASHRAE 33 and AHRI 410.
 - 1) Working Pressure: Minimum **300 psig (2070 kPa)**.
 - 3. Hot-Gas Reheat Refrigerant Coils:
 - a. Tubes: **[Copper]<Insert material>**.
 - b. Fins:
 - 1) Material: **[Aluminum][Copper]<Insert material>**.
 - 2) Fin Spacing: Maximum **[12][10][8]<Insert spacing>** fins per inch (mm).
 - c. Fin and Tube Joints: Mechanical bond.
 - d. Headers: **[Seamless-copper headers with brazed connections]<Insert material and connections>**.
 - e. Frames: **[Galvanized steel][Stainless steel]<Insert material frame>**.
 - f. Coatings: **[None][Corrosion-resistant coating]**.
 - g. Ratings: Designed, tested, and rated in accordance with ASHRAE 33 and AHRI 410.
 - 1) Working Pressure: Minimum **300 psig (2070 kPa)**.
 - h. Coating: **[None][Corrosion-resistant coating]**.

- i. Suction-discharge bypass valve.
4. Electric-Resistance Heating Coils: Comply with UL 1995.
 - a. Casing Assembly: **[Slip-in][Flanged]** type with galvanized-steel frame.
 - b. Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
 - c. Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout, safety device; serviceable through terminal box without removing heater from coil section.
 - d. Secondary Protection: Load-carrying, manually resetting or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
 - e. Control Panel: **[Unit][Remote]** mounted with disconnecting means and overcurrent protection.
 - 1) Magnetic contactor.
 - 2) Solid-state, stepless pulse controller.
 - 3) Toggle switches, one per step.
 - 4) **[Step][SCR]** controller.
 - 5) Time-delay relay.
 - 6) Pilot lights, one per step.
 - 7) Airflow proving switch.
5. Heating-Water Coils: **[Continuous circuit][Self-draining][Cleaning]**.
 - a. Piping Connections: **[Threaded][Flanged]**, **[same end][opposite ends]** of coil.
 - b. Tube Material: **[Copper]<Insert material>**.
 - c. Fin Type: Plate.
 - d. Fin Material: **[Aluminum][Copper]<Insert material>**.
 - e. Fin Thickness: **<Insert inches (mm)>**.
 - f. Fin and Tube Joint: **[Mechanical bond][Silver brazed]**.
 - g. Headers:
 - 1) Cast iron with **[cleaning plugs and]** drain and air vent tappings **[extended to exterior of unit]**.
 - 2) Seamless copper tube with brazed joints, prime coated.
 - 3) Fabricated steel, with brazed joints, prime coated.
 - 4) Provide insulated cover to conceal exposed outside casings of headers.
 - 5) Frames: Channel frame, minimum **0.052-inch (1.3-mm)** thick galvanized steel.
 - 6) Coil Working-Pressure Ratings: **[200 psig (1380 kPa), 325 deg F (163 deg C)]<Insert value and temperature>**.
 - h. Coating: **[None][Corrosion-resistant coating]**.
6. Steam Heating Coils:
 - a. Steam Coils: **[Distributed][Single tube]**.
 - 1) Steam Outer-Tube Diameter: **<Insert inches (mm)>**.
 - 2) Piping Connections: **[Threaded][Flanged]**, **[same end][opposite ends]** of coil.
 - 3) Tube Material: **[Copper]<Insert material>**.
 - 4) Fin Type: Plate.
 - 5) Fin Material: **[Aluminum][Copper]<Insert material>**.
 - 6) Fin Thickness: **<Insert inches (mm)>**.
 - 7) Fin and Tube Joint: **[Mechanical bond][Silver brazed]**.

- 8) Headers:
 - a) Cast iron with[**cleaning plugs and**] drain and air vent tappings[**extended to exterior of unit**].
 - b) Seamless copper tube with brazed joints, prime coated.
 - c) Fabricated steel, with brazed joints, prime coated.
 - d) Provide insulated cover to conceal exposed outside casings of headers.
- 9) Frames: Channel frame, minimum **0.052-inch (1.3-mm)** thick galvanized steel.
- 10) Coil Working-Pressure Ratings: **[200 psig (1380 kPa), 325 deg F (163 deg C)]<Insert value and temperature>**.
- 11) Coating: **[None][Corrosion-resistant coating]**.

7. Condenser Refrigerant Coils:

- a. Tube Material: **[Copper]<Insert material>**.
- b. Fin Material: **[Aluminum][Copper]**.
- c. Fin and Tube Joint: Mechanical bond.
- d. Coating: **[None][Corrosion-resistant]**.

G. Refrigeration Circuit Components:

1. Compressors: Hermetic, **[variable-speed]** scroll compressors, mounted on integral vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief[, **and crankcase heater**].
2. Refrigerant: **[R-410A]<Insert other available type>**.
3. Refrigeration Specialties:
 - a. Expansion valve with replaceable thermostatic element.
 - b. Refrigerant filter/dryer.
 - c. Manual-reset high-pressure safety switch.
 - d. Automatic-reset low-pressure safety switch.
 - e. Minimum off-time relay.
 - f. Automatic-reset compressor motor thermal overload.
 - g. Thermostat for coil freeze-up protection during low-ambient-temperature operation or loss of air.
 - h. Brass service valves installed in discharge and liquid lines.
 - i. Low-ambient kit high-pressure sensor.
 - j. Single compressor with evaporator and condenser coil within the refrigerant section to provide initial pre-cooling and to reheat for humidity control.
 - k. **[Single stage][Modulating]** hot-gas reheat solenoid valve with a replaceable magnetic coil.
 - l. Heat-pipe heat exchanger, wrapped around the evaporator coil to pre-cool the air entering the evaporator coil and reheat the air leaving the evaporator coil to control humidity.
 - m. Hot-gas bypass refrigerant control for capacity control with continuous dehumidification for single-speed compressor.

H. Air Filtration:

1. Particulate air filtration is specified in Section 234100 "Particulate Air Filtration."
2. Panel Filters:
 - a. Description: **[Flat, nonpleated][Pleated]** factory-fabricated, self-supported disposable air filters with holding frames.
 - b. Filter Unit Class: UL 900.
 - c. Media: Interlaced glass, synthetic, or cotton fibers coated with nonflammable adhesive and

- antimicrobial coating.
 - d. Filter-Media Frame: [**High wet-strength beverage board**]<Insert material> with perforated metal retainer, or metal grid, on outlet side.
- I. Adhesive: As recommended by air-filter manufacturer and with a VOC content of [80]<Insert number> g/L or less.
1. Mounting Frames:
- a. Panel filters arranged for flat or angular orientation, with access doors on both sides of unit. Filters are to be removable from one side or from access plenum.
 - b. Cartridge filters arranged for flat orientation, removable from access plenum.
 - c. Galvanized or stainless steel with gaskets and fasteners, suitable for bolting together into built-up filter banks[**with space for prefilter**].
- J. Rotary Heat Exchanger:
1. Casing:
- a. Galvanized steel, stainless steel, or aluminum with manufacturer's standard factory-painted finish.
 - b. Integral purge section limiting carryover of exhaust air to between [0.05 percent at 1.6-inch wg and 0.20 percent at 4-inch wg (0.05 percent at 400-Pa and 0.20 percent at 1000-Pa)]<Insert values> differential pressure.
 - c. Casing seals on periphery of rotor and on duct divider and purge section.
 - d. Support vertical rotor on grease-lubricated ball bearings having extended grease fittings[**or permanently lubricated bearings**]. Support horizontal rotors on tapered roller bearings.
2. Rotor - Aluminum, Metallic, or Polymer: Aluminum, metallic, or polymer segmented wheel, strengthened with radial spokes impregnated with nonmigrating, water-selective, molecular-sieve desiccant coating.
3. Drive: Fractional horsepower motor and gear reducer[, **with speed changed by variable-frequency controller**]. Provide permanently lubricated wheel bearings.
4. Controls:
- a. Starting relay, factory mounted and wired, and manual motor starter for field wiring.
 - b. Variable-frequency controller, factory mounted and wired, permitting input of 4-20 mA or 1-10 V control signal.
 - c. Control energy recovery to permit air economizer operation.
- 1) Bypass dampers to assist energy recovery control.
- d. Pilot-Light Indicator: Display rotor rotation and speed.
 - e. Speed Settings: Adjustable settings for maximum and minimum rotor speed limits.
 - f. Integral purge section limiting carryover of exhaust air to between [0.05 percent at 1.6-inch wg and 0.20 percent at 4-inch wg (0.05 percent at 400-Pa and 0.20 percent at 1000-Pa)]<Insert value> differential pressure.
 - g. Defrost cycle.
 - h. <Insert additional control features>.
- K. Indirect-Fired Gas Furnace Heating:
1. Description: Factory assembled, piped, and wired; and complying with ANSI Z21.47 and with NFPA 54.
2. CSA Approval: Designed and certified by and bearing label of CSA.

3. Burners:
 - a. Heat-Exchanger Material: **[Aluminized steel with stainless steel inserts][Stainless steel]**.
 - b. Fuel: **[Natural][Propane]** gas.
 - c. Ignition: Electronically controlled electric spark with flame sensor.
 - d. Gas Control Valve: **[Single stage][Two stage][Electronic modulating]**.
 - e. Gas Train: Single-body, regulated, redundant, 24 V ac gas valve assembly containing pilot solenoid valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff.
 - f. High-Altitude Model Kit: For Project elevations of more than **2000 feet (610 m)** above sea level.
4. Venting, Gravity: Gravity vented.
5. Venting, Power: Power vented, with integral, motorized centrifugal fan interlocked with gas valve.
6. Heat-Exchanger Drain Pan: Stainless steel.
7. Safety Controls:
 - a. Gas Manifold: Safety switches and controls complying with ANSI standards **[and][FM Global]<Insert insurer>**.
 - b. Vent Flow Verification: **[Differential pressure switch to verify open vent][Flame rollout switch]**.
 - c. High Limit: Thermal switch or fuse to stop burner.
 - d. Purge-period timer is to automatically delay burner ignition and bypass low-limit control.
 - e. Airflow Proving Switch: Differential pressure switch senses correct airflow before energizing pilot.
 - f. Automatic-Reset, High-Limit Control Device: Stops burner and closes main gas valve if high-limit temperature is exceeded.
 - g. Safety Lockout Switch: Locks out ignition sequence if burner fails to light after three tries. Controls are reset manually by turning the unit off and on.
- L. Dampers:
 1. Comply with requirements in Section 230923.12 "Control Dampers."
 2. Outdoor- and Relief-Air Dampers: Low-leakage, double-skin, airfoil-blade, **[galvanized-steel]<Insert material>** dampers with compressible jamb seals and extruded-vinyl blade edge seals in **[opposed][parallel]**-blade arrangement with **[zinc-plated]** steel operating rods rotating in **[sintered bronze or nylon]<Insert material>** bearings mounted in a single **[galvanized-steel]<Insert material>** frame, and with operating rods connected with a common linkage. Leakage rate is not to exceed **4 cfm/sq. ft. (20 L/s per sq. m)** at **1 inch wg (250 Pa)** and **8 cfm/sq. ft. (40 L/s per sq. m)** at **4 inches wg (1.0 MPa)**.
 3. Damper Operators: Comply with requirements in Section 230923.12 "Control Dampers."
 4. Electronic Damper Operators:
 - a. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
 - b. Electronic damper position indicator is to have visual scale indicating percentage of travel and 2 to 10 V dc feedback signal.
 - c. Operator Motors:
 - 1) Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - 2) Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
 - 3) Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit

switches, auxiliary switches, or feedback potentiometer.

- d. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running torque of **150 in. x lbf (16.9 N x m)** and breakaway torque of **300 in. x lbf (33.9 N x m)**.
- e. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running and breakaway torque of **150 in. x lbf (16.9 N x m)**.
- f. Size dampers for running torque calculated as follows:
 - 1) Parallel-Blade Damper with Edge Seals: **7 inch-lb/sq. ft. (86.8 kg-cm/sq. m)** of damper.
 - 2) Opposed-Blade Damper with Edge Seals: **5 inch-lb/sq. ft. (62 kg-cm/sq. m)** of damper.
 - 3) Parallel-Blade Damper without Edge Seals: **4 inch-lb/sq. ft. (49.6 kg-cm/sq. m)** of damper.
 - 4) Opposed-Blade Damper without Edge Seals: **3 inch-lb/sq. ft. (37.2 kg-cm/sq. m)** of damper.
 - 5) Dampers with 2 to 3 Inches wg (500 to 750 Pa) of Pressure Drop or Face Velocities of 1000 to 2500 fpm (5 to 13 m/s): Increase running torque by 1.5.
 - 6) Dampers with 3 to 4 Inches wg (750 to 1000 Pa) of Pressure Drop or Face Velocities of 2500 to 3000 fpm (13 to 15 m/s): Increase running torque by 2.0.
- g. Coupling: V-bolt and V-shaped, toothed cradle.
- h. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
- i. Fail-Safe Operation: Mechanical, spring-return mechanism with external, manual gear release on nonspring-return actuators.
- j. Power Requirements (Two-Position Spring Return): **[24 V dc][120 V ac][230 V ac]**.
- k. Power Requirements (Modulating): Maximum 10 VA at 24 V ac or 8 W at 24 V dc.
- l. Proportional Signal: 2 to 10 V dc or 4 to 20 mA, and 2 to 10 V dc position feedback signal.
- m. Temperature Rating: **[Minus 22 to plus 122 deg F (Minus 30 to plus 50 deg C)][40 to 104 deg F (5 to 40 deg C)]**.
- n. Run Time: **[12 seconds open, 5 seconds closed][30 seconds][60 seconds][120 seconds]**.

M. Electrical Power Connections:

1. Single-Point Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other necessary electrical devices are to provide a **[single-point]field power connection to unit [except for service lights and convenience outlets, which are to be powered separately]**.
2. Enclosure: NEMA 250, **[Type 3R][Type 4][Type 4X]<Insert type>**, mounted in unit with hinged access door in unit cabinet having a lock and key or padlock and key.
3. Wiring: Numbered and color-coded to match wiring diagram.
4. Wiring Location: Install factory wiring outside an enclosure in a raceway.
5. Power Interface: Field power interface to be **[wire lugs][NEMA KS 1, heavy-duty, nonfused disconnect switch]**.
6. Factory Wiring: Branch power circuit to each motor and to controls with one of the following disconnecting means:
 - a. NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection in accordance with IEC 60947-4-1.
 - b. NEMA KS 1, heavy-duty, nonfusible switch.
 - c. UL 489, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
7. Factory-Mounted, Overcurrent-Protection Service: For each motor.

8. Transformer: Factory mounted with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.
9. Controls: Factory wire unit-mounted controls where indicated.
 - a. Service Lights: **<Insert number of watts>[LED]<Insert lamp type>** vaporproof luminaire with individual switched junction box located **[outside][inside]**, adjacent to each access door and panel.
 - 1) Locations: **[Each section accessed with door or panel][Fan section]<Insert location>**.
 - b. Convenience Outlets: One 20 A duplex GFCI receptacle per location with junction box located on outside casing wall.
 - 1) Locations: **[Each section accessed with a door or panel][Fan section]<Insert location>**.
10. Control Relays: Auxiliary and adjustable time-delay relays.

N. Controls:

1. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC" for control equipment and sequence of operation.
2. Control Valves: Comply with requirements in Section 230923.11 "Control Valves."
3. Control Wiring: Factory wire connection for controls' power supply.
4. Control Devices: Sensors, transmitters, relays, switches, detectors, operators, actuators, and valves are to be manufacturer's standard items to accomplish indicated control functions.
5. Status Panel: **[Remote][Unit]** mounted.
 - a. Cooling/Off/Heating Controls: Control operational mode.
 - b. Damper Position: Indicate position of outdoor-air dampers in terms of percentage of outdoor air.
 - c. Status Lights:
 - 1) Filter dirty.
 - 2) Fan operating.
 - 3) Cooling operating.
 - 4) Heating operating.
 - 5) Smoke alarm.
 - 6) General alarm.
 - 7) **<Insert points>**.
 - d. Digital Numeric Display:
 - 1) Outdoor airflow.
 - 2) Supply airflow.
 - 3) Outdoor dry-bulb temperature.
 - 4) Outdoor dew point temperature.
 - 5) Space temperature.
 - 6) Supply temperature.
 - 7) Space relative humidity.
 - 8) Space carbon dioxide level.
 - 9) **<Insert points>**.
6. Refrigeration System Controls:

- a. Unit-mounted enthalpy controller is to lock out refrigerant system when outdoor-air enthalpy is less than **[28 Btu/lb (65 kJ/kg)]<Insert value>** of dry air or outdoor-air temperature is less than **60 deg F (15 deg C) <Insert value>**.
 - b. Outdoor-air sensor de-energizes dehumidifier operation when outdoor-air temperature is less than **60 deg F (15 deg C) <Insert value>**.
 - c. Relative-humidity sensor energizes dehumidifier operation when relative humidity is more than **[50]<Insert value>** percent.
7. Furnace Controls:
 - a. **[Factory-mounted sensor in supply outlet][Remote sensor for field installation in supply-air duct]** with sensor adjustment located in control panel to modulate gas furnace burner to maintain space temperature.
 - b. Wall-mounted, space-temperature sensor with **[temperature adjustment][unit-mounted temperature adjustment][adjustment on remote-control panel]** to modulate gas furnace burner to maintain space temperature.
 - c. Remote Setback: Adjustable room thermostat selected by timer, set at **[50 deg F (10 deg C)]<Insert temperature>**; cycles supply fan and gas furnace burner to maintain space temperature.
 - d. Burner Control: **[Two][Four][steps of control][Modulating]**.
8. Rotary Heat-Exchanger Control:
 - a. Sequence with refrigeration system controls and heating controls.
 - b. For operation of rotary heat exchanger itself, see "Rotary Heat Exchanger" Paragraph above.
9. Electric-Resistance Heat Controls:
 - a. **[Factory-mounted sensor in unit discharge][Remote sensor for field installation in supply-air duct]** with sensor adjustment located in control panel to control electric coil to maintain temperature.
 - b. Wall-mounted, space-temperature sensor with **[temperature adjustment][unit-mounted temperature adjustment][adjustment on remote-control panel]** to control electric coil to maintain temperature.
 - c. Capacity Controls: **[On/off][Multiple steps][Modulating SCR]<Insert type>**.
10. Hot-Water and Steam Coil Controls, Discharge Temperature Sensor: **[Factory-mounted sensor in unit discharge][Remote sensor for field installation in supply-air duct]** with sensor adjustment located in control panel to modulate factory-**[mounted][furnished]** coil control valve to maintain temperature.
11. Hot-Water and Steam Coil Controls, Space Temperature Sensor: With **[temperature adjustment][unit-mounted temperature adjustment][adjustment on remote-control panel]** to modulate factory-**[mounted][furnished]** coil control valve to maintain temperature.
12. Damper Controls: Space-pressure sensor modulates outdoor- and relief-air dampers to maintain a positive pressure in space at a minimum of **[0.05 inch wg (12.4 Pa)]<Insert value>** with respect to outdoor reference.
13. DDC Temperature Control: Standalone control module for link between unit controls and DDC temperature-control system. Control module is to be compatible with control system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC." Links are to include the following:
 - a. Start/stop interface relay and relay to notify DDC temperature-control system alarm condition.
 - b. Hardware interface or additional sensors for the following:

- 1) Room temperature.
 - 2) Discharge-air temperature.
 - 3) Refrigeration system operation.
 - 4) Furnace operation.
14. Interface with DDC System for HVAC: Factory-installed hardware and software to enable the DDC system for HVAC to monitor, control, and display unit status and alarms.
- a. Hardwired Points:
 - 1) Monitoring: On-off status, **[common trouble alarm]<Insert monitoring point>**.
 - 2) Control: On-off operation, **[space temperature set-point adjustment][supply temperature set-point adjustment][space humidity set-point adjustment][space pressure set-point adjustment]<Insert control point>**.
 - b. **[ASHRAE 135 (BACnet)][LonTalk][Modbus][Industry-accepted, open-protocol]<Insert type of interface>** communication interface with the DDC system for HVAC is to enable the DDC system for HVAC operator to remotely control and monitor the unit from an operator workstation. Control features and monitoring points displayed locally at unit control panel are to be available through the DDC system for HVAC.
15. **<Insert additional control sequences and requirements>**.
- O. Roof Curbs:
1. Roof curbs with vibration isolators and wind or seismic restraints are specified in Section 230548 "Vibration and Seismic Controls for HVAC." Roof curbs with vibration isolators and wind restraints are specified in Section 230548.13 "Vibration Controls for HVAC."
 2. Materials: Galvanized steel with corrosion-resistant coating, watertight gaskets, and factory-installed wood nailer; complying with National Roofing Contractors Association manuals for the specific type of roofing applicable to the Project.
 - a. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
 - 1) Materials: ASTM C1071, Type I or II.
 - 2) Thickness: **[1 inch (25 mm)][1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension>**.
 - b. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.
 - 1) Liner Adhesive: Comply with ASTM C916, Type I.
 - 2) Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
 - 3) Liner materials applied in this location are to have airstream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric, depending on service air velocity.
 3. Curb Dimensions: Height of **[14 inches (355 mm)][24 inches (610 mm)][36 inches (910 mm)]<Insert dimension>**. **[Provide adaptable horizontal dimensions as required for existing roof openings.]**
 4. Wind and Seismic Restraints: Metal brackets compatible with the curb and casing, painted to match unit, used to anchor unit to the curb, and designed for loads at Project site. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for wind-load requirements.

P. Intake And Relief Openings:

1. Type: Manufacturer's standard hood or louver, including moisture eliminator, at all unit intake and relief openings.
2. Materials: Match material and finish of casing exterior.
3. Bird Screen: Comply with requirements in ASHRAE 62.1.
4. Configuration: Designed to inhibit wind-driven rain and snow from entering unit.

2.4 MATERIALS

A. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for steel sheet.

B. Stainless Steel:

1. Manufacturer's standard grade for casing.
2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653/A653M.

D. Aluminum: **ASTM B209 (ASTM B209M)**.

E. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating.

F. Corrosion-Resistant Coating: Coat **[casing][coils][and][fan guards]** with a corrosion-resistant coating capable of withstanding a **[3,000]<Insert time>**-hour salt-spray test in accordance with ASTM B117.

1. Standards:

- a. ASTM B117 for salt spray.
- b. ASTM D2794 for minimum impact resistance of **100 in-lb (11.3 N-m)**.
- c. ASTM D3359 for cross-hatch adhesion of 5B.

2. Application: **[Immersion][Spray]**.

3. Thickness: **[1 mil]<Insert measurement>**.

4. Gloss: Minimum gloss of 50 gloss units on a single angle 60-degree meter.

2.5 SOURCE QUALITY CONTROL

- A. AHRI 920: Manufacturer to certify that performance ratings are in accordance with AHRI 920 if AHRI 920 certification program is not in place. Provide AHRI 920 certification if AHRI 920 certification program is in place.
- B. AHRI 260 or AMCA 311 Sound Performance Rating Certification: Test, rate, and label unit fan sound ratings in accordance with AHRI 260 or AMCA 311.
- C. Fan Aerodynamic Performance Rating: Test and rate fan performance for airflow, pressure, power, air density, rotation speed, and efficiency.

1. **[Test and rate fan performance in accordance with AMCA 210.]**
2. **[AMCA Fan Aerodynamic Certification Rating: Test, rate, and label, in accordance with AMCA 211.]**
- D. Fan Energy Index (FEI): Test in accordance with AMCA 210 and rate in accordance with AMCA 99, AMCA 207, and AMCA 208.
- E. Fan Operating Limits: Classify fans in accordance with AMCA 99, Section 14.
- F. Damper Leakage and Air Performance:
 1. **[Damper Rating: Test and rate dampers for leakage and air performance in accordance with AMCA 510.]**
 2. **[AMCA Damper Certification: Test, rate, and label in accordance with AMCA 511.]**
- G. Water Coils: Factory tested to **300 psig (2070 kPa)** in accordance with AHRI 410 and ASHRAE 33.
- H. Refrigerant Coils: Factory tested to minimum **[300 psig (2070 kPa)][450 psig (3105 kPa)]** internal pressure and to minimum **300 psig (2070 kPa)** internal pressure while under water, in accordance with AHRI 410 and ASHRAE 33.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping, ducts, and electrical systems to verify actual locations of connections before equipment installation.
- C. Examine roof curbs and equipment supports for suitable conditions where units will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF DEDICATED OUTDOOR-AIR UNITS

- A. Roof Curb: Install on roof structure or concrete base, level and secure, in accordance with **[NRCA's "The NRCA Roofing Manual: Membrane Roof Systems"]****[AHRI Guideline B]****<Insert reference document>**. Install units on curbs and coordinate roof penetrations and flashing with roof construction specified in Section 077200 "Roof Accessories." Secure units to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts. Coordinate sizes and locations of roof curbs with actual equipment provided.
- B. Unit Support: Install unit level on structural **[curbs]****[steel supports]**. Coordinate roof penetrations and flashing with roof construction. Secure units to structural support with anchor bolts. Coordinate sizes and locations of **[curbs]****[steel supports]** with actual equipment provided.
 1. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 2. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."



- C. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.
- D. Install filter-gauge, static-pressure taps upstream and downstream of filters. Mount filter gauges on outside of filter housing or filter plenum in accessible position. Provide filter gauges on filter banks, installed with separate static-pressure taps upstream and downstream of filters.
- E. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."
- F. Install wall- and duct-mounted sensors furnished by manufacturer for field installation. Install control wiring and make final connections to control devices and unit control panel.
- G. Comply with requirements for gas-fired furnace installation in NFPA 54.
- H. Install separate devices furnished by manufacturer and not factory installed.
- I. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.

3.3 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to units, allow space for service and maintenance.
- C. Connect piping to units mounted on vibration isolators with flexible connectors.
- D. Hot-Water Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.
- E. Steam and Steam Condensate Piping: Comply with applicable requirements in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties." Install shutoff valve at steam supply connections, float and thermostatic trap, and union or flange at each coil return connection. Install gate valve and inlet strainer at supply connection of dry steam humidifiers, and provide inverted bucket steam trap at condensate return connection.
- F. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Install shutoff valve and union or flange at each supply and return connection.
- G. Gas Piping: Comply with requirements in **[Section 231123 "Facility Natural-Gas Piping."][Section 231126 "Facility Liquefied-Petroleum Gas Piping."]** Provide AGA-approved flexible connectors.
 - 1. Connect gas piping to furnace, full size of gas train inlet, and connect with union[, **pressure regulator,**] and shutoff valve with sufficient clearance for burner removal and service.
 - 2. Install AGA-approved flexible connectors.
- H. Hydronic Piping Connections:
 - 1. Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
 - 2. Install shutoff valve and union or flange on each supply connection, and install balancing valve

and union or flange on each return connection.

I. Steam Piping Connections:

1. Comply with requirements in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties."
2. Install shutoff valve and union or flange on each supply connection.
3. Install, starting from the coil connection, union or flange, strainer, union, float and thermostatic trap, union, and shutoff valve.

J. Duct Connections:

1. Comply with requirements in Section 233113 "Metal Ducts."
2. Drawings indicate the general arrangement of ducts.
3. Connect ducts to units with flexible duct connectors. Comply with requirements for flexible duct connectors in Section 233300 "Air Duct Accessories."

3.4 ELECTRICAL CONNECTIONS

- A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 1. Nameplate is to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 2. Nameplate is to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch (13 mm)** high.

3.5 CONTROL CONNECTIONS

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

3.6 STARTUP SERVICE

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.
 1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 2. Inspect units for visible damage to furnace combustion chamber.
 3. Perform the following operations for both minimum and maximum firing, and adjust burner for peak efficiency:
 - a. Measure gas pressure at manifold.
 - b. Measure combustion-air temperature at inlet to combustion chamber.

- c. Measure flue-gas temperature at furnace discharge.
 - d. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
 - e. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
4. Verify operation of remote panel, including pilot-light operation and failure modes. Inspect the following:
 - a. High-limit heat exchanger.
 - b. Alarms.
5. Inspect units for visible damage to refrigerant compressor, condenser and evaporator coils, and fans.
6. Start refrigeration system when outdoor-air temperature is within normal operating limits. and measure and record the following:
 - a. Cooling coil leaving-air, dry- and wet-bulb temperatures.
 - b. Cooling coil entering-air, dry- and wet-bulb temperatures.
 - c. Condenser coil entering-air dry-bulb temperature.
 - d. Condenser coil leaving-air dry-bulb temperature.
7. Simulate maximum cooling demand and inspect the following:
 - a. Compressor refrigerant suction and hot-gas pressures.
 - b. Short-circuiting of air through outside coil or from outside coil to outdoor-air intake.
8. Inspect casing insulation for integrity, moisture content, and adhesion.
9. Verify that clearances have been provided for servicing.
10. Verify that controls are connected and operable.
11. Verify that filters are installed.
12. Clean coils and inspect for construction debris.
13. Clean furnace flue and inspect for construction debris.
14. Inspect operation of power vents.
15. Purge gas line.
16. Inspect and adjust vibration isolators and seismic restraints.
17. Verify bearing lubrication.
18. Clean fans and inspect fan-wheel rotation for movement in correct direction without vibration and binding.
19. Adjust fan belts to proper alignment and tension.
20. Start unit.
21. Inspect and record performance of interlocks and protective devices, including response to smoke detectors by fan controls and fire alarm.
22. Operate unit for run-in period.
23. Calibrate controls.
24. Adjust and inspect high-temperature limits.
25. Inspect outdoor-air dampers for proper stroke[**and interlock with return-air dampers**].
26. Verify operational sequence of controls.
27. Measure and record the following airflows. Plot fan volumes on fan curve.
 - a. Supply-air volume.
 - b. Relief-air flow.
 - c. Outdoor-air flow.

- B. After startup, change filters, verify bearing lubrication, and adjust belt tension.

- C. Remove and replace components that do not properly operate, and repeat startup procedures as specified above.
- D. Prepare written report of the results of startup services.

3.7 ADJUSTING

- A. Adjust initial temperature and humidity set points.
- B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- C. Occupancy Adjustments: When requested within [12]<Insert number> months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to [two]<Insert number> visits to Project during other-than-normal occupancy hours for this purpose.

3.8 CLEANING

- A. After completing system installation; testing, adjusting, and balancing dedicated outdoor-air unit and air-distribution systems; and completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, casings, dampers, coils, and filter housings, and install new, clean filters.

3.9 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
 - 1. Leak Test: After installation, fill water and steam coils with water, and test coils and connections for leaks.
 - 2. Charge refrigerant coils with refrigerant and test for leaks.
 - 3. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

3.10 DEMONSTRATION

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

END OF SECTION 23 74 00 00B



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23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 74 16 00	23 74 00 00	Outdoor, Semi-Custom Air-Handling Units
23 74 16 00	23 74 00 00a	Outdoor, Custom Air-Handling Units
23 74 16 00	23 74 00 00b	Dedicated Outdoor-Air Units



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SECTION 23 74 16 13 - PACKAGED, LARGE-CAPACITY, ROOFTOP AIR-CONDITIONING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Packaged, large-capacity, rooftop air-conditioning units.

B. Related Requirements:

1. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components.

1.2 DEFINITIONS

- A.** RTU: Rooftop unit. As used in this Section, this abbreviation means packaged, large-capacity, rooftop air-conditioning units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.

1.3 ACTION SUBMITTALS

A. Product Data: For each RTU.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Include rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories.
3. Include unit dimensions and weight.
4. Include cabinet material, metal thickness, finishes, insulation, and accessories.
5. Fans:
 - a. Include certified fan-performance curves with system operating conditions indicated.
 - b. Include certified fan-sound power ratings.
 - c. Include fan construction and accessories.
 - d. Include motor ratings, electrical characteristics, and motor accessories.
6. Include certified coil-performance ratings with system operating conditions indicated.
7. Include filters with performance characteristics.
8. Include gas furnaces with performance characteristics.
9. Include factory selection calculations for each antimicrobial UV lamp installation.
10. Include dampers, including housings, linkages, and operators.

B. Shop Drawings: For each packaged, large-capacity, rooftop air-conditioning unit.

1. Include plans, elevations, sections, and **[mounting][attachment]** details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

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

C. Delegated Design Submittals: For RTU supports, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Include design calculations for selecting vibration isolators[**and seismic restraints**] and for designing vibration isolation bases.
2. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
3. Restraint Details: [**Wind-**][**and**][**seismic-**]detail fabrication and attachment of[**wind and**] seismic restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.

D. Sustainable Design Submittals:

1. Product Data: Showing compliance with ASHRAE 62.1.
2. Product Data: For air filtration performance. Comply with efficiency requirements in IgCC/ASHRAE 189.1, which supersede requirements in ASHRAE/IES 90.1.
3. Product Data: For adhesives, mastics, and sealants, indicating VOC content.
4. Laboratory Test Reports: For adhesives, mastics, and sealants, indicating compliance with requirements for low-emitting materials.
5. Product Data: For adhesives, mastics, and sealants, indicating VOC content.
6. Laboratory Test Reports: For adhesives and sealants, indicating compliance with requirements for low-emitting materials.
7. Refrigerant: Product Data for refrigerants, indicating compliance with refrigerant management practices.
8. Product Data: For refrigerants, indicating compliance with refrigerant management practices.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

B. Seismic Qualification Data: Certificates, for RTUs, accessories, and components, from manufacturer.

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

C. Product Certificates: Submit certification that specified equipment will withstand wind forces identified in Section 230548 "Vibration and Seismic Controls for HVAC" and Section 018123 "Facility Seismic and Wind Criteria."

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

- D. Source quality control reports.
- E. System startup reports.
- F. Field quality control reports.
- G. Sample warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For RTUs.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Extra Stock Material: Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Filters: **[One]<Insert number>** set(s) of filters for each unit.
 - 2. Gaskets: **[One]<Insert number>** set(s) for each access door.
 - 3. Fan Belts: **[One]<Insert number>** set(s) for each belt-driven fan.

1.7 WARRANTY

- A. Warranty: Manufacturer agrees to repair or replace components of packaged, large-capacity, rooftop air-conditioning unit that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: **<Insert number>** year(s) from date of Substantial Completion.
 - 2. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than **[five][10]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of RTUs and components.
- C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and Startup."
- D. ASHRAE 15 Compliance: For refrigeration system safety.
- E. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- F. UL Compliance: Comply with UL 1995.



- G. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design mounting and restraints for RTUs, including comprehensive engineering analysis.
 - 1. Design RTU supports to comply with **[wind][and][seismic]** performance requirements.
- H. Wind-Restraint Performance:
 - 1. RTUs, accessories, and components are to withstand the effects of wind. See Section 230548 "Vibration and Seismic Controls for HVAC" and Section 018123 "Facility Seismic and Wind Criteria" for building classification criteria.
- I. Seismic Performance: RTUs, accessories, and components are to withstand the effects of earthquake motions. See Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment" and Section 018123 "Facility Seismic and Wind Criteria" for building seismic performance criteria.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified"**[and the unit will be fully operational after the seismic event]**.
 - 2. Component Importance Factor: **[1.5][1.0]**.
 - 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.

2.2 CAPACITIES AND CHARACTERISTICS

- A. Supply-Air Fan:
 - 1. Fan Type: **[Belt drive][Direct drive]**, **[double width][single width]**, **[forward curved][backward inclined]**, centrifugal[, plenum].
 - 2. Airflow: **<Insert cfm (L/s)>**.
 - 3. External Static Pressure: **<Insert inches wg (kPa)>**.
 - 4. Fan Speed: **[Variable]<Insert rpm>**.
 - 5. Motor Characteristics:
 - a. Enclosure Type: **[Open, dripproof][Totally enclosed, fan cooled][Totally enclosed, air over][Open, externally ventilated][Totally enclosed, nonventilated][Severe duty][Explosion proof][Dust-ignition-proof machine]**.
 - b. Enclosure Materials: **[Cast iron][Cast aluminum][Rolled steel]**.
 - c. Horsepower: **<Insert horsepower>**.
 - d. Motor Speed: **[Multispeed][ECM][Constant]<Insert rpm>**.
 - e. Volts: **[115][208][230][460]<Insert value> V**.
 - f. Phase: **[Single][Three]**.
 - g. Hertz: 60.
 - h. Full-Load Amperes: **<Insert value> A**.
 - i. Minimum Circuit Ampacity: **<Insert value> A**.
 - j. Maximum Overcurrent Protection: **<Insert value> A**.
- B. Return/Relief-Air Fan:
 - 1. Fan Type: **[Belt drive][Direct drive]**, **[double width][single width]**, **[forward curved][backward inclined]**, centrifugal[, plenum].
 - 2. Airflow: **<Insert cfm (L/s)>**.
 - 3. External Static Pressure: **<Insert inches wg (kPa)>**.

4. Fan Speed: **<Insert rpm>**.
5. Motor Characteristics:
 - a. Enclosure Type: **[Open, dripproof][Totally enclosed, fan cooled][Totally enclosed, air over][Open, externally ventilated][Totally enclosed, nonventilated][Severe duty][Explosion proof][Dust-ignition-proof machine]**.
 - b. Enclosure Materials: **[Cast iron][Cast aluminum][Rolled steel]**.
 - c. Horsepower: **<Insert horsepower>**.
 - d. Motor Speed: **<Insert rpm>**.
 - e. Volts: **[115][208][230][460]<Insert value> V**.
 - f. Phase: **[Single][Three]**.
 - g. Hertz: 60.
 - h. Full-Load Amperes: **<Insert value> A**.
 - i. Minimum Circuit Ampacity: **<Insert value> A**.
 - j. Maximum Overcurrent Protection: **<Insert value> A**.

C. Outdoor-Air-Refrigerant Coil Fan:

1. Fan Type: **[Direct-drive propeller][Belt drive][Direct drive], [double width][single width], [forward curved][backward inclined], centrifugal, [scroll][plenum] fan**.
2. Airflow: **<Insert cfm (L/s)>**.
3. Static Pressure: **<Insert inches wg (kPa)>**.
4. Fan Speed: **<Insert rpm>**.
5. Motor Characteristics:
 - a. Enclosure Type: **[Open, dripproof][Totally enclosed, fan cooled][Totally enclosed, air over][Open, externally ventilated][Totally enclosed, nonventilated][Severe duty][Explosion proof][Dust-ignition-proof machine]**.
 - b. Enclosure Materials: **[Cast iron][Cast aluminum][Rolled steel]**.
 - c. Horsepower: **<Insert horsepower>**.
 - d. Motor Speed: **[Multispeed][ECM][Constant]<Insert rpm>**.
 - e. Volts: **[115][208][230][460]<Insert value> V**.
 - f. Phase: **[Single][Three]**.
 - g. Hertz: 60.
 - h. Full-Load Amperes: **<Insert value> A**.
 - i. Minimum Circuit Ampacity: **<Insert value> A**.
 - j. Maximum Overcurrent Protection: **<Insert value> A**.

D. Rotary Heat Exchanger:

1. Effectiveness: **<Insert percentage>**.
2. Intake:
 - a. Intake Airflow: **<Insert cfm (L/s)>**.
 - b. Pressure Differential: **<Insert inches wg (kPa)>**.
 - c. Entering Supply-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
 - d. Entering Supply-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
 - e. Leaving-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
 - f. Leaving-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
3. Exhaust:
 - a. Exhaust Airflow: **<Insert cfm (L/s)>**.
 - b. Entering Exhaust-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
 - c. Entering Exhaust-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
 - d. Leaving Exhaust-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.

e. Leaving Exhaust-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.

E. Supply-Air Refrigerant Coil:

1. Total Cooling Capacity: **<Insert Btu/h (kW)>**.
2. Sensible Cooling Capacity: **<Insert Btu/h (kW)>**.
3. Entering-Air Cooling Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
4. Entering-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
5. Refrigerant Type: **<Insert refrigerant type>**.
6. Total Heating Capacity: **<Insert Btu/h (kW)>**.
7. Entering-Air Heating Dry-Bulb Temperature: **<Insert deg F (deg C)>**.

F. Hot-Water Coil:

1. Coil Face Dimensions:
 - a. Finned Length: **<Insert inches (mm)>**.
 - b. Finned Width: **<Insert inches (mm)>**.
2. Minimum Fin Spacing: **[0.125 inch (3.18 mm)][0.091 inch (2.31 mm)][0.071 inch (1.81 mm)][0.067 inch (1.70 mm)][0.056 inch (1.41 mm)][0.0075 inch (0.19 mm)]<Insert dimension>**.
3. Tube Diameter: **[0.375 inch (9.5 mm)][0.50 inch (12.7 mm)][0.625 inch (15.9 mm)][0.75 inch (19.0 mm)][1.0 inch (25.4 mm)]<Insert dimension>**.
4. Number of Rows: **<Insert number>**.
5. Serpentine: **[Single][Half][Full]**.
6. Mounting: **[Slip in][Flanged]**.
7. Air Side:
 - a. Flow Rate: **<Insert cfm (L/s)>**.
 - b. Finned Area Face Velocity: **<Insert fpm (m/s)>**.
 - c. Static Pressure Drop: **<Insert inches wg (Pa)>**.
 - d. Total Capacity: **<Insert Btu/h (kW)>**.
 - e. Entering Temperature: **<Insert deg F (deg C)>**.
 - f. Leaving Temperature: **<Insert deg F (deg C)>**.
8. Water Side:
 - a. Flow Rate: **<Insert gpm (L/s)>**.
 - b. Tube Velocity: **<Insert fpm (m/s)>**.
 - c. Glycol Type: **[Ethylene][Propylene]**.
 - d. Aqueous Glycol Solution Concentration: **<Insert percentage>**.
 - e. Pressure Drop: **<Insert feet (kPa)>**.
 - f. Entering Temperature: **<Insert deg F (deg C)>**.
 - g. Leaving Temperature: **<Insert deg F (deg C)>**.

G. Steam Heating Coil:

1. Minimum Fin Spacing: **[0.125 inch (3.18 mm)][0.091 inch (2.31 mm)][0.071 inch (1.81 mm)][0.067 inch (1.70 mm)][0.056 inch (1.41 mm)][0.0075 inch (0.19 mm)]<Insert dimension>**.
2. Tube Diameter: **[0.50 inch (12.7 mm)][0.625 inch (15.9 mm)][0.75 inch (19.0 mm)]<Insert dimension>**.
3. Number of Rows: **[One][Two]<Insert number>**.

- 4. Air Side:
 - a. Finned Area Face Velocity: **<Insert fpm (m/s)>**.
 - b. Total Capacity: **<Insert Btu/h (kW)>**.
 - c. Entering Temperature: **<Insert deg F (deg C)>**.
 - d. Leaving Temperature: **<Insert deg F (deg C)>**.
- 5. Steam Side:
 - a. Inlet Pressure: **<Insert psig (kPa)>**.
 - b. Tube Type: **[Single][Distributing]**.
 - c. Condensing Capacity: **<Insert lb/h (g/s)>**.
 - d. Pressure Drop: **<Insert psig (kPa)>**.
- H. Outdoor-Air Refrigerant Coil:
 - 1. Ambient-Air Temperature: **<Insert deg F (deg C)>**.
 - 2. Coating: **[Baked phenolic][Cathodic epoxy]**.
 - 3. Fan Motor: **<Insert value>**.
 - 4. Number of Fans: **<Insert number>**.
 - 5. Refrigerant Type: **<Insert refrigerant type>**.
- I. Hot-Gas Reheat Coil:
 - 1. Heating Capacity: **<Insert Btu/h (kW)>**.
 - 2. Entering-Air Temperature: **<Insert deg F (deg C)>**.
 - 3. Air-Temperature Rise: **<Insert deg F (deg C)>**.
 - 4. Refrigerant Type: **<Insert refrigerant type>**.
- J. Electric-Resistance Heating Coil:
 - 1. Capacity: **<Insert kilowatts>**.
 - 2. Number of Steps: **<Insert number>**.
- K. Compressors:
 - 1. Number of Refrigerant Circuits: **[One][Two]<Insert number>**.
 - 2. Compressor Speed: **[Single][Variable]**.
 - 3. Suction Temperature: **<Insert deg F (deg C)>**.
 - 4. Power Input: **<Insert kilowatts>**.
 - 5. Seasonal Energy Efficiency Ratio (SEER): **<Insert value>**.
- L. Gas Furnace:
 - 1. Airflow: **<Insert cfm (L/s)>**.
 - 2. Gas Control Valve: **[Single stage][Two stage][Modulating]**.
 - 3. Minimum AFUE: **<Insert number>** percent.
 - 4. Minimum Thermal Efficiency: **<Insert number>** percent.
 - 5. Minimum Combustion Efficiency: **<Insert number>** percent.
 - 6. Input: **<Insert Btu/h (kW)>**.
 - 7. Output: **<Insert Btu/h (kW)>**.
 - 8. Entering-Air Temperature: **<Insert deg F (deg C)>**.
 - 9. Air-Temperature Rise: **<Insert deg F (deg C)>**.
- M. Dampers:

1. Outdoor-Air Damper: Linked galvanized-steel damper blades mechanically fastened to galvanized-steel axels and operating rod, for zero to [25][30]<Insert number> percent outdoor air[, with electric motorized damper operator][, 115 V][, 24 V].
2. Outdoor- and Return-Air Mixing Dampers: [Parallel-][Opposed-]blade galvanized-steel dampers mechanically fastened to galvanized-steel axels and operating rod in reinforced cabinet. Connect operating rods with common linkage[or gears] and interconnect so dampers operate simultaneously. [Include 24 V motorized damper operators.][Include 115 V motorized damper operators.]
3. Relief-Air Damper: Gravity actuated or motorized, as required by ASHRAE/IES 90.1.

N. Recirculating-Air Filters:

1. Type: <Insert type>.
2. Face Dimensions, Each: <Insert inches by inches (mm by mm)>.
3. Depth: <Insert inches (mm)>.
4. Number of Filters in Filter Bank: <Insert number> wide by <Insert number> high.
5. Access Location: [Side]<Insert location>.
6. Maximum or Rated Face Velocity: <Insert fpm (m/s)>.
7. Initial Resistance: <Insert inches wg (Pa)>.
8. Recommended Final Resistance: <Insert inches wg (Pa)>.
9. Minimum Efficiency Reporting Value and Average Arrestance:
 - a. MERV Rating and Corresponding Average Arrestance: [MERV 4]<Insert MERV rating>, and corresponding average arrestance in accordance with ASHRAE 52.2.
10. Minimum Efficiency Reporting Value:
 - a. MERV Rating: [MERV 6][MERV 13][MERV 13A]<Insert value>, in accordance with ASHRAE 52.2.

O. Outdoor-Air Filters:

1. Type: <Insert type>.
2. Face Dimensions, Each: <Insert inches by inches (mm by mm)>.
3. Depth: <Insert inches (mm)>.
4. Number of Filters in Filter Bank: <Insert number> wide by <Insert number> high.
5. Access Location: [Side]<Insert location>.
6. Maximum or Rated Face Velocity: <Insert fpm (m/s)>.
7. Initial Resistance: <Insert inches wg (Pa)>.
8. Recommended Final Resistance: <Insert inches wg (Pa)>.
9. Minimum Efficiency Reporting Value and Average Arrestance:
 - a. MERV Rating and Corresponding Average Arrestance: [MERV 4]<Insert MERV rating>, and corresponding average arrestance in accordance with ASHRAE 52.2.
10. Minimum Efficiency Reporting Value:
 - a. MERV Rating: [MERV 6][MERV 13][MERV 13A]<Insert value>, in accordance with ASHRAE 52.2.

P. Vibration Isolation and Seismic-Control Devices: <Insert device type>, with <Insert value> minimum deflection.**Q. Electrical Characteristics for Single-Point Connection:**

1. Voltage: [115][208][230][460]<Insert value> V.
2. Phase: [Single][Three].
3. Hertz: [60]<Insert value>.
4. Full-Load Amperes: <Insert value> A.
5. Minimum Circuit Ampacity: <Insert value> A.
6. Maximum Overcurrent Protection: <Insert value> A.

R. Attenuator Insertion Loss Rating (ILR):

1. 1st Octave: <Insert value> dB.
2. 2nd Octave: <Insert value> dB.
3. 3rd Octave: <Insert value> dB.
4. 4th Octave: <Insert value> dB.
5. 5th Octave: <Insert value> dB.
6. 6th Octave: <Insert value> dB.
7. 7th Octave: <Insert value> dB.
8. 8th Octave: <Insert value> dB.

2.3 PACKAGED, LARGE-CAPACITY, ROOFTOP AIR-CONDITIONING UNITS

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

1. [AAON]
2. [Addison]
3. [Allied Commercial]
4. [Daikin Applied]
5. [Duplicate Carrier Global Corporation]
6. [Engineered Air]
7. [Lennox]
8. [Rheem Manufacturing Company; Heating and Cooling Products]
9. [Trane]
10. [WaterFurnace International, Inc.]
11. [YORK; brand of Johnson Controls International plc, Building Solutions North America]
12. <Insert manufacturer's name>

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

1. [AAON]
2. [Addison]
3. [Allied Commercial]
4. [Daikin Applied]
5. [Duplicate Carrier Global Corporation]
6. [Engineered Air]
7. [Lennox]
8. [Rheem Manufacturing Company; Heating and Cooling Products]
9. [Trane]
10. [WaterFurnace International, Inc.]
11. [YORK; brand of Johnson Controls International plc, Building Solutions North America]
12. <Insert manufacturer's name>

C. Source Limitations: Obtain packaged, large-capacity, rooftop air-conditioning units from single manufacturer.

D. Unit Casings:

1. General Fabrication Requirements for Casings: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.
2. Double-Wall Construction:
 - a. Outside Casing Wall: **[ASTM A653/A653M galvanized steel]<Insert material>**, minimum **[18 gauges (1.3 mm)]<Insert value>** thick with **[manufacturer's standard finish][corrosion-resistant coating]<Insert special coating>**, with pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs.
 - b. Inside Casing Wall: **G90 (Z275)** coated, ASTM A653/A653M galvanized steel, **[0.034 inch (0.86 mm)][0.028 inch (0.7 mm)]<Insert dimension>** thick[, **perforated 40 percent free area**].
 - c. Floor Plate: **[G90 (Z275), ASTM A653/A653M galvanized steel]<Insert material>**, **[treadplate,]** minimum **[18 gauges (1.3 mm)]<Insert value>** thick.
 - d. Casing Insulation:
 - 1) Materials: **[Injected polyurethane foam][fiberglass]** insulation.
 - 2) Casing Panel R-Value: Minimum **<Insert value>**.
 - 3) Insulation Thickness: **[1 inch (25 mm)][2 inches (50 mm)]**.
 - 4) Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roof of unit.
3. Airstream Surfaces: Surfaces in contact with airstream to comply with requirements in ASHRAE 62.1.
4. Static-Pressure Classifications:
 - a. For Unit Sections Upstream of Fans: Minus **[2-inch wg (500 Pa)][3-inch wg (750 Pa)]<Insert value>**.
 - b. For Unit Sections Downstream and Including Fans: **[2-inch wg (500 Pa)][3-inch wg (750 Pa)][4-inch wg (1000 Pa)]<Insert value>**.
5. Panels and Doors:
 - a. Access Panels:
 - 1) Fabrication: Formed and reinforced with same materials and insulation thickness as casing.
 - 2) Fasteners: Two or more camlock types for panel lift-out operation. Arrangement to allow panels to be opened against air-pressure differential.
 - 3) Gasket: Neoprene, applied around entire perimeters of panel frames.
 - 4) Size: Large enough to allow inspection and maintenance of air-handling unit's internal components. Dimensions to be at least **[18 inches (450 mm)][24 inches (600 mm)]<Insert dimension>** wide by full height of unit casing up to a maximum height of **[60 inches (1500 mm)][72 inches (1800 mm)]<Insert dimension>**.
 - b. Doors:
 - 1) Hinges: A minimum of two ball-bearing hinges or stainless steel piano hinges and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against air-pressure differential.
 - 2) Gasket: Neoprene, applied around entire perimeters of panel frames.
 - 3) Size: Large enough to allow inspection and maintenance of air-handling unit's

internal components.

- c. Locations and Applications: Provide access doors to all locations indicated below unless limited dimensions of location make access door impractical. If door is impractical, provide panel.
 - 1) Fan Section: **[Inspection and access panels][and][doors]**.
 - 2) Access Section: Doors.
 - 3) Coil Section: Inspection and access panels.
 - 4) Damper Section: **[Inspection and access panels][Doors]**.
 - 5) Filter Section: **[Inspection and access panels][and][doors]**. Provide access door or panel large enough to allow periodic removal and installation of filters.
 - 6) Mixing Section: Doors.
 - d. Service Light: 100 W vaporproof fixture with switched junction box located **[outside][inside]** adjacent to door.
 - 1) Locations: **[Each section accessed with door][Fan section]<Insert location>**.
6. Condensate Drain Pans:
- a. Location: Each type of **[cooling coil][rotary heat exchanger]**.
 - b. Construction:
 - 1) Single-wall, **[ASTM A653/A653M galvanized-steel or noncorrosive polymer][stainless steel]** sheet.
 - 2) Double-wall, **[ASTM A653/A653M galvanized-steel or noncorrosive polymer][ASTM A240/A240M stainless steel]** sheet with space between walls filled with foam insulation and moisture-tight seal.
 - c. Drain Connection:
 - 1) Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on **[one end][both ends]** of pan.
 - 2) Minimum Connection Size: **[NPS 1 (DN 25)][NPS 2 (DN 50)]<Insert pipe size>**.
 - d. Slope: Minimum **[0.125-in./ft. (10-mm/mm)]<Insert value>** slope, **to comply with ASHRAE 62.1,** in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers and to direct water toward drain connection.
 - e. Length: Extend drain pan downstream from leaving face **[for distance to comply with ASHRAE 62.1]<Insert distance>**.
 - f. Width: Entire width of water producing device.
 - g. Depth: A minimum of **[2 inches (50 mm)]<Insert dimension>** deep.
 - h. Pan-Top Surface Coating for Galvanized-Steel Drain Pans: Asphaltic waterproofing compound.
 - i. Units with stacked coils are to have an intermediate drain pan to collect condensate from top coil, with piped drain to lower pan to prevent splashing.
- E. Fans, Drives, and Motors:
1. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.
 2. Supply-Air Fans: Centrifugal, rated in accordance with AMCA 210/ASHRAE 51; galvanized or painted steel; mounted on solid-steel shaft.

- a. Shafts: With field-adjustable alignment.
 - 1) Turned, ground, and polished hot-rolled steel with keyway.
 - b. Shaft Bearings:
 - 1) Heavy-duty, self-aligning, pillow-block type with an **[L-50]<Insert bearing life rating>** rated life of minimum **[100,000]<Insert number>** hours in accordance with ABMA 9.
 - c. Housings, Scroll Fans: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.
 - d. Bracing: Steel angle or channel supports for mounting and supporting **[fan scroll,]** wheel, motor, and accessories.
 - e. Centrifugal Fan Wheels: Inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically fastened to flange and backplate; steel or aluminum hub swaged to backplate and fastened to shaft with setscrews.
 - f. Mounting: For internal vibration isolation **[and seismic control]**. Factory-mount fans with manufacturer's standard **[restrained]** vibration isolation mounting devices having a minimum static deflection of **[1 inch (25 mm)]<Insert dimension>**.
 - g. Shaft Lubrication Lines: Extended to a location outside the casing.
 - h. Flexible Connector: Factory fabricated with a fabric strip minimum **3-1/2 inches (89 mm)** wide, attached to two strips of minimum **2-3/4-inch- (70-mm-)** wide by **0.028-inch- (0.7-mm-)** thick, **[galvanized-steel][aluminum]** sheet.
 - 1) Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives are to comply with UL 181, Class 1.
3. Drives, Direct: Factory-mounted, direct drive.
 4. Drives, Belt: Factory-mounted, V-belt drive; with adjustable alignment and belt tensioning and with **[1.5][1.25]** service factor based on fan motor.
 - a. Pulleys: Cast iron or cast steel with split, tapered bushing, dynamically balanced at the factory.
 - b. Belts: Oil resistant, non-sparking and nonstatic; in matched sets for multiple-belt drives.
 - c. Belt Guards: Comply with requirements specified by OSHA and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards"; **[0.146-inch- (2.7-mm-)]<Insert dimension>** thick, **[3/4-inch (20-mm)]<Insert dimension>** diamond-mesh wire screen, welded to steel angle frame; prime coated.
 5. Outdoor-Air-Refrigerant-Coil Fan: Propeller fan mounted on shaft of permanently lubricated **[two-speed][three-speed][ECM]** motors.
 6. Relief-Air Fan: **[Propeller][Forward curved][Backward inclined]**, shaft mounted on permanently lubricated motor.
 7. Motors:
 - a. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - b. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - c. Enclosure Type: **[Open, dripproof][Totally enclosed, fan cooled]<Insert type>**.
 - d. Enclosure Materials: **[Cast iron]<Insert material>**.
 - e. Motor Bearings: **<Insert requirements>**.
 - f. Unusual Service Conditions:

- 1) Ambient Temperature: **<Insert deg C>**.
 - 2) Altitude: **<Insert feet (m)>** above sea level.
 - 3) High humidity.
 - 4) **<Insert conditions>**.
- g. Efficiency: Premium efficient as defined in NEMA MG 1.
 - h. NEMA Design: **<Insert designation>**.
 - i. Motor Pulleys: Adjustable pitch for use with **[5]<Insert number>**-hp motors and smaller; fixed pitch for use with motors larger than **[5]<Insert number>** hp. Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions.
 - j. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.

F. Rotary Heat Exchangers:

1. Casing:
 - a. Galvanized steel, stainless steel, or aluminum with manufacturer's standard factory finish.
 - b. Integral purge section limiting carryover of exhaust air to between **[0.05 percent at 1.6-inch wg and 0.20 percent at 4-inch wg (0.5 percent at 400 Pa and 0.20 percent at 1000 Pa)]<Insert values>** differential pressure.
 - c. Casing seals on periphery of rotor, on duct divider, and on purge section.
 - d. Support vertical rotors on grease-lubricated ball bearings having extended grease fittings. Support horizontal rotors on tapered roller bearing.
2. Rotor - Aluminum or Polymer: Segmented wheel, strengthened with radial spokes[, **with nontoxic, noncorrosive, silica-gel desiccant coating**].
3. Rotor - Aluminum, Metallic, or Polymer: Aluminum, metallic, or polymer segmented wheel, strengthened with radial spokes impregnated with nonmigrating, water-selective, 3-angstrom molecular-sieve desiccant coating.
4. Drive: Fractional horsepower motor and gear reducer[, **with speed changed by variable-frequency controller**]. Permanently lubricated wheel bearings with an **[L-10]<Insert bearing life>[400,000 hours]<Insert hours>**.
5. Controls:
 - a. Starting relay, factory mounted and wired, and manual motor starter for field wiring.
 - b. Variable-frequency controller, factory mounted and wired, permitting input of field-connected 4- to 20 mA or 1- to 10 V control signal.
 - c. Variable-frequency controller, factory mounted and wired, with exhaust-air sensor to vary rotor speed and maintain exhaust temperature above freezing.
 - d. Variable-frequency controller, factory mounted and wired, with exhaust- and outdoor-air sensors, automatic changeover thermostat and set-point adjuster, to vary rotor speed and maintain[**exhaust temperature above freezing and**] air differential temperature above set point. Provide maximum rotor speed when exhaust-air temperature is less than outdoor-air temperature.
 - e. Control energy recovery to permit air economizer operation.
 - 1) Bypass dampers to assist energy recovery control.
 - f. Pilot-Light Indicator: Display rotor rotation and speed.
 - g. Speed Settings: Adjustable settings for maximum and minimum rotor speed limits.
 - h. Defrost cycle.
 - i. Integral purge section limiting carryover of exhaust air to between **[0.05 percent at 1.6-inch wg and 0.20 percent at 4-inch wg (0.05 percent at 400 Pa and 0.20 percent at 1000 Pa)]<Insert value>** differential pressure.

G. Coils:

1. General Requirements for Coils:
 - a. Comply with AHRI 410.
 - b. Fabricate coils section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
 - c. Coils are to not act as structural component of unit.
2. Supply-Air Refrigerant Coil:
 - a. Tubes: **[Copper]<Insert material>**.
 - b. Fins:
 - 1) Fin Spacing: Maximum **[8][10][12]<Insert spacing>** fins per inch (mm).
 - c. Fin and Tube Joints: Mechanical bond.
 - d. Headers: **[Seamless-copper headers with brazed connections]<Insert material and connections>**.
 - e. Frames: **[Galvanized steel][Stainless steel]<Insert material frame>**.
 - f. Coatings: **[None][Corrosion-resistant coating]**.
 - g. Ratings: Designed, tested, and rated in accordance with ASHRAE 33 and AHRI 410.
 - 1) Working Pressure: Minimum **300 psig (2070 kPa)**.
3. Supply-Air Hydronic Heating Coil:
 - a. Hot-Water Coils: **[Continuous circuit][Self-draining][Cleaning]**.
 - 1) Piping Connections: **[Threaded][Flanged]**, **[same end][opposite ends]** of coil.
 - 2) Tube Material: **[Copper]<Insert material>**.
 - 3) Fin Type: Plate.
 - 4) Fin Material: **[Aluminum][Copper]<Insert material>**.
 - 5) Fin Thickness: **<Insert inches (mm)>**.
 - 6) Fin and Tube Joint: **[Mechanical bond][Silver brazed]**.
 - 7) Headers:
 - a) Cast iron with **[cleaning plugs and]** drain and air vent tappings **[extended to exterior of unit]**.
 - b) Seamless copper tube with brazed joints, prime coated.
 - c) Fabricated steel, with brazed joints, prime coated.
 - d) Provide insulated cover to conceal exposed outside casings of headers.
 - 8) Frames: Channel frame, minimum **0.052-inch- (1.3-mm-)** thick galvanized steel.
 - 9) Coil Working-Pressure Ratings: **[200 psig (1380 kPa), 325 deg F (163 deg C)]<Insert value and temperature>**.
 - 10) Coating: **[None][Corrosion-resistant coating]**.
 4. Steam Heating Coil:
 - a. Steam Coils: **[Distributed][Single tube]**.
 - 1) Steam Outer-Tube Diameter: **<Insert inches (mm)>**.

- 2) Piping Connections: **[Threaded][Flanged]**, **[same end][opposite ends]** of coil.
 - 3) Tube Material: **[Copper]<Insert material>**.
 - 4) Fin Type: Plate.
 - 5) Fin Material: **[Aluminum][Copper]<Insert material>**.
 - 6) Fin Thickness: **<Insert inches (mm)>**.
 - 7) Fin and Tube Joint: **[Mechanical bond][Silver brazed]**.
 - 8) Headers:
 - a) Cast iron with **[cleaning plugs and]** drain and air vent tappings **[extended to exterior of unit]**.
 - b) Seamless copper tube with brazed joints, prime coated.
 - c) Fabricated steel, with brazed joints, prime coated.
 - d) Provide insulated cover to conceal exposed outside casings of headers.
 - 9) Frames: Channel frame, minimum **0.052-inch- (1.3-mm-)** thick galvanized steel.
 - 10) Coil Working-Pressure Ratings: **[200 psig (1380 kPa), 325 deg F (163 deg C)]<Insert value and temperature>**.
 - 11) Coating: **[None][Corrosion-resistant coating]**.
5. Outdoor-Air Refrigerant Coil:
- a. Tubes: **[Copper]<Insert material>**.
 - b. Fins:
 - 1) Material: **[Aluminum][Copper]<Insert material>**.
 - 2) Fin Spacing: Maximum **[8][10][12]<Insert spacing>** fins per **inch (mm)**.
 - c. Fin and Tube Joints: Mechanical bond.
 - d. Headers: **[Seamless-copper headers with brazed connections]<Insert material and connections>**.
 - e. Frames: **[Galvanized steel][Stainless steel]<Insert material frame>**.
 - f. Coatings: **[None][Corrosion-resistant coating]**.
 - g. Ratings: Designed, tested, and rated in accordance with ASHRAE 33 and AHRI 410.
 - 1) Working Pressure: Minimum **300 psig (2070 kPa)**.
6. Hot-Gas Reheat Refrigerant Coil:
- a. Tubes: **[Copper]<Insert material>**.
 - b. Fins:
 - 1) Material: **[Aluminum][Copper]<Insert material>**.
 - 2) Fin Spacing: Maximum **[8][10][12]<Insert spacing>** fins per **inch (mm)**.
 - c. Fin and Tube Joints: Mechanical bond.
 - d. Headers: **[Seamless-copper headers with brazed connections]<Insert material and connections>**.
 - e. Frames: **[Galvanized steel][Stainless steel]<Insert material frame>**.
 - f. Coatings: **[None][Corrosion-resistant coating]**.
 - g. Ratings: Designed, tested, and rated in accordance with ASHRAE 33 and AHRI 410.
 - 1) Working Pressure: Minimum **300 psig (2070 kPa)**.
 - h. Suction-discharge bypass valve.
7. Electric-Resistance Heating Coils: Comply with UL 1995.

- a. Casing Assembly: **[Slip-in][Flanged]** type with galvanized-steel frame.
- b. Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
- c. Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout, safety device; serviceable through terminal box without removing heater from coil section.
- d. Secondary Protection: Load-carrying, manually resetting or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
- e. Control Panel: **[Unit][Remote]** mounted with disconnecting means and overcurrent protection.
 - 1) **[Magnetic][Mercury]** contactor.
 - 2) Solid-state, stepless pulse controller.
 - 3) Toggle switches, one per step.
 - 4) Step controller.
 - 5) Time-delay relay.
 - 6) Pilot lights, one per step.
 - 7) Airflow proving switch.

H. Refrigerant Circuit Components:

1. Number of Refrigerant Circuits: **[One][Two]<Insert number>**.
2. Compressor: Hermetic, **[variable speed]** scroll, mounted on vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief, **and crankcase heater**.
3. Refrigeration Specialties:
 - a. Refrigerant: **[R-454B]<Insert refrigerant type>**.
 - b. Expansion valve with replaceable thermostatic element.
 - c. Refrigerant filter/dryer.
 - d. Manual-reset high-pressure safety switch.
 - e. Automatic-reset low-pressure safety switch.
 - f. Minimum off-time relay.
 - g. Automatic-reset compressor motor thermal overload.
 - h. Brass service valves installed in compressor suction and liquid lines.
 - i. Low-ambient kit high-pressure sensor.
 - j. Hot-gas reheat solenoid valve **[single stage][modulating]** with a replaceable magnetic coil.
 - k. Hot-gas bypass solenoid valve with a replaceable magnetic coil.
 - l. Four-way reversing solenoid valve with a replaceable magnetic coil, thermostatic expansion valves with bypass check valves, and a suction line accumulator.
 - 1) Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
 - 2) Seat: PTFE.
 - 3) End Connections: Threaded.
 - 4) Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with **1/2-inch (16-mm)** conduit adaptor, and **[24][115][208]** Vac coil.
 - 5) Working Pressure Rating: **[400 psig (2760 kPa)]<Insert pressure>**.
 - 6) Maximum Operating Temperature: **[240 deg F (116 deg C)]<Insert temperature>**.

I. Air Filtration:

1. Particulate air filtration is specified in Section 234100 "Particulate Air Filtration."
2. Panel Filters:

- a. Description: **[Flat, non-pleated][Pleated]**, factory-fabricated, self-supported, disposable air filters with holding frames.
 - b. Filter Unit Class: UL 900.
 - c. Media: Interlaced glass, synthetic or cotton fibers coated with nonflammable adhesive and antimicrobial coating.
 - d. Filter-Media Frame: **[Beverage board]<Insert material>** with perforated metal retainer, or metal grid, on outlet side.
3. Bag Filter:
- a. Description: Factory-fabricated, dry, extended-surface, self-supporting filters with holding frames in steel, basket-type retainers.
 - b. Filter Unit Class: UL 900.
 - c. Media: Fibrous material, with antimicrobial coating, constructed so individual pockets are maintained in tapered form by flexible internal supports under rated-airflow conditions.
 - d. Filter-Media Frame: **[Galvanized steel]<Insert material>**.
4. Cartridge Filters:
- a. Description: Factory-fabricated, **[adhesive-coated]** disposable, packaged air filters with media perpendicular to airflow, and with holding frames.
 - b. Filter Unit Class: UL 900.
 - c. Media: Fibrous material, with antimicrobial coating, constructed so individual pleats are maintained in pleated form under rated-airflow conditions by corrugated aluminum separators.
 - d. Filter Media Frame: **[Galvanized steel]<Insert material>**.
 - e. Adhesive: As recommended by adhesive manufacturer and with a VOC content of 80 g/L or less.

J. Gas Furnaces:

- 1. Description: Factory assembled, piped, and wired; complying with ANSI Z21.47/CSA 2.3 and NFPA 54.
- 2. CSA Approval: Designed and certified by and bearing label of CSA.
- 3. Burners: Stainless steel.
 - a. Rated Minimum Turndown Ratio: **[30 to 1]<Insert ratio>**.
 - b. Fuel: **[Natural][Propane]** gas.
 - c. Ignition: Electronically controlled electric spark or hot-surface igniter with flame sensor.
 - d. Gas Control Valve: **[Single stage][Two stage][Modulating]**.
 - e. Gas Train: Single-body, regulated, redundant, 24 V ac gas valve assembly containing pilot solenoid valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff.
 - f. High-Altitude Model Kit: For Project elevations more than **2000 ft. (610 m)** above sea level.
- 4. Heat-Exchanger and Drain Pan: Stainless steel.
- 5. Venting, Gravity: Gravity vented **[with vertical extension]**.
- 6. Venting, Power: Power vented, with integral, motorized centrifugal fan interlocked with gas valve **[with vertical extension]**.
- 7. Safety Controls:
 - a. Gas Manifold: Safety switches and controls complying with ANSI standards **[and][FM Global]<Insert insurer>**.

K. Antimicrobial UV Lamp System:

- 1. Description:

- a. UV-C lamp system consisting of power supply, power supply housing, wiring, UV lamp(s), lamp plug, lamp plug protector, encapsulated lamp, and lamp holder used for UV germicidal irradiation of cooling coil and condensate drain pan.
 - b. Factory installed and preengineered.
2. Standard: UL Category Control Number ABQK, HVAC accessories, air-duct mounted.
3. Lamps: High output, hot cathode.
4. Lamp-Holder Construction:
 - a. UV- and moisture-resistant materials and designed to connect the lamp to the plug.
 - b. Adjustable positioning.
5. Lamp-Clamp Construction:
 - a. UV- and moisture-resistant materials, watertight connection.
 - b. Adjustable positioning.
6. Lamp Protection: Hermetically sealed to provide protection against lamp breakage and to ensure lamp contents from a broken lamp are contained.
7. Lamp Output: UV-C energy, primarily at the 254 nm wavelength with a 360-degree energy distribution.
8. Access Door Interlocks: Automatic disconnect on all access doors into UV-installed casing sections to shield servicing personnel from contact with light.
9. Power Supply: UL-listed, single-point electrical connection[**with service disconnect**].
10. Power Consumption: Maximum of [15 W/sq. ft. (161 W/sq. m)]<Insert value>.

L. Sound-Attenuator Section:

1. General Requirements:
 - a. Factory fabricated.
 - b. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials with flame-spread index not exceeding 25 and smoke-developed index not exceeding 50; ASTM E84.
 - c. Airstream Surfaces: Surfaces in contact with airstream to comply with ASHRAE 62.1.
2. Shape: [Rectangular, straight][Round, straight][Rectangular, elbow][Round, elbow].
3. Rectangular Silencer Outer Casing: [Galvanized steel]<Insert material>.
4. Round Silencer Outer Casing: [Galvanized steel]<Insert material>.
5. Inner Casing and Baffles: [Galvanized steel]<Insert material>.
6. Principal Sound-Absorbing Mechanism:
 - a. Dissipative Type:[Polymer film-lined] absorptive fill material.
 - 1) Fill Material: [Inert and vermin-proof fibrous material]<Insert material type>.
 - b. Joints: Lock formed and sealed, continuously welded or flanged.

M. Dampers:

1. Comply with requirements in Section 230923.12 "Control Dampers."
2. Outdoor- and Return-Air Dampers: Low-leakage, double-skin, airfoil-blade, [galvanized-steel]<Insert material> dampers with compressible jamb seals and extruded-vinyl blade edge

seals in **[opposed][parallel]**-blade arrangement with **[zinc-plated]** steel operating rods rotating in **[sintered bronze or nylon]<Insert material>** bearings mounted in a single **[galvanized-steel]<Insert material>** frame, and with operating rods connected with a common linkage. Leakage rate must not exceed **[4 cfm/sq. ft. (20 L/s per sq. m) at 1-inch wg (250 Pa) and 8 cfm/sq. ft. (40 L/s per sq. m) at 4-inch wg (1.0 MPa)]<Insert requirement>** rated in accordance with AMCA 500-D.

3. Barometric relief dampers.
4. Damper Operators: Comply with requirements in Section 230923.12 "Control Dampers."
5. Electronic Damper Operators:
 - a. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
 - b. Electronic damper position indicator to have visual scale indicating percent of travel and 2 to 10 V dc, feedback signal.
 - c. Operator Motors:
 - 1) Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - 2) Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
 - 3) Permanent Split-Capacitor or Shaded-Pole Type: Gear trains are completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
 - d. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running torque of **150 in. x lbf (16.9 N x m)** and breakaway torque of **300 in. x lbf (33.9 N x m)**.
 - e. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running and breakaway torque of **150 in. x lbf (16.9 N x m)**.
 - f. Size dampers for running torque calculated as follows:
 - 1) Parallel-Blade Damper with Edge Seals: **7 inch-lb/sq. ft. (86.8 kg-cm/sq. m)** of damper.
 - 2) Opposed-Blade Damper with Edge Seals: **5 inch-lb/sq. ft. (62 kg-cm/sq. m)** of damper.
 - 3) Parallel-Blade Damper without Edge Seals: **4 inch-lb/sq. ft (49.6 kg-cm/sq. m)** of damper.
 - 4) Opposed-Blade Damper without Edge Seals: **3 inch-lb/sq. ft. (37.2 kg-cm/sq. m)** of damper.
 - 5) Dampers with 2- to 3-Inch wg (500 to 750 Pa) of Pressure Drop or Face Velocities of 1000 to 2500 fpm (5 to 13 m/s): Increase running torque by 1.5.
 - 6) Dampers with 3- to 4-Inch wg (750 to 1000 Pa) of Pressure Drop or Face Velocities of 2500 to 3000 fpm (13 to 15 m/s): Increase running torque by 2.0.
 - g. Coupling: V-bolt and V-shaped, toothed cradle.
 - h. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
 - i. Fail-Safe Operation: Mechanical, spring-return mechanism with external, manual gear release on nonspring-return actuators.
 - j. Power Requirements (Two-Position Spring Return): **[24 V dc][115 V ac][230 V ac]**.
 - k. Power Requirements (Modulating): Maximum 10 VA at 24 V ac or 8 W at 24 V dc.
 - l. Proportional Signal: 2 to 10 V dc or 4 to 20 mA, and 2 to 10 V dc position feedback signal.
 - m. Temperature Rating: **[Minus 22 to plus 122 deg F (Minus 30 to plus 50 deg C)][40 to 104 deg F (5 to 40 deg C)]**.
 - n. Run Time: **[12 seconds open, 5 seconds closed][30 seconds][60 seconds][120 seconds]**.

N. Electrical Power Connections:

1. RTU is to have a single connection of power to unit with[**unit-mounted disconnect switch accessible from outside unit and**] control-circuit transformer with built-in overcurrent protection.

O. Controls:

1. Control equipment is specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
2. Sequence of operation is specified [**in Section 230993.11 "Sequence of Operations for HVAC DDC."**][**on Drawings.**]
3. Unit Controls:
 - a. Control-voltage transformer.
 - b. Wall-mounted thermostat or sensor with the following features:
 - 1) Heat-cool-off switch.
 - 2) Fan on-auto switch.
 - 3) Fan-speed switch.
 - 4) [**Manual**][**Automatic**] changeover.
 - 5) Adjustable deadband.
 - 6) [**Concealed**][**Exposed**] set point.
 - 7) [**Concealed**][**Exposed**] indication.
 - 8) [**Degree F**][**Degree C**] indication for the following:
 - a) Space temperature.
 - b) Supply-air temperature.
 - c) Outdoor-air temperature.
 - d) Space set point.
 - 9) Unoccupied-period-override push button.
 - 10) Data entry and access port to input temperature[**and humidity**] set points, occupied and unoccupied periods, and output room temperature[**and humidity**], supply-air temperature, operating mode, and status.
 - c. Wall-mounted humidistat or sensor with the following features:
 - 1) [**Concealed**][**Exposed**] set point.
 - 2) [**Concealed**][**Exposed**] indication.
 - d. Annunciator Panel for Each Unit:
 - 1) Configuration: [**Remote wall-**][**Unit**] mounted.
 - 2) Lights to indicate power on, cooling, heating, fan running, filter dirty, and unit alarm or failure.
 - 3) DDC controller or programmable timer and interface with HVAC instrumentation and control system.
 - 4) Digital display of outdoor-air temperature, supply-air temperature, return-air temperature, economizer damper position, indoor-air quality, and control parameters.
4. Controller: [**Electronic**][**DDC**].

- a. Controller is to have volatile-memory backup.
- b. Safety Control Operation:
 - 1) Smoke Detectors: Stop fan and close outdoor-air damper if smoke is detected. Provide additional contacts for alarm interface to fire-alarm control panel.
 - 2) Firestats: Stop fan and close outdoor-air damper if air greater than **[130 deg F (54 deg C)]<Insert temperature>** enters unit. Provide additional contacts for alarm interface to fire-alarm control panel.
 - 3) Fire-Alarm Control Panel Interface: Provide control interface to coordinate with operating sequence described in **[Section 284600 "Fire Detection and Alarm"]****[and]****[Section 284614 "Single- and Multiple-Station Alarms."]**
 - 4) Low-Discharge Temperature: Stop fan and close outdoor-air damper if supply air temperature is less than **[40 deg F (4 deg C)]<Insert temperature>**.
 - 5) Defrost Control for Condenser Coil: Pressure differential switch to initiate defrost sequence.
- c. Scheduled Operation: Occupied and unoccupied periods on **[seven]****[365]**-day clock with a minimum of **[two]****[four]** programmable periods per day.
- d. Unoccupied Period:
 - 1) Heating Unoccupied: **[60 deg F (15.6 deg C)]<Insert unoccupied temperature>**.
 - 2) Cooling Unoccupied: **[78 deg F (25 deg C)]<Insert unoccupied temperature>****[System off]**.
 - 3) Override Operation: **[Two]****<Insert number>** hours.
- e. Supply Fan Operation:
 - 1) Occupied Periods: Run fan continuously.
 - 2) Unoccupied Periods: Cycle fan to maintain heating unoccupied temperature.
- f. Refrigerant Circuit Operation:
 - 1) Occupied Periods: Cycle or stage compressors**[, and operate hot-gas bypass]** to match compressor output to cooling load to maintain **[room]****[discharge]** temperature**[and humidity]**. Cycle condenser fans to maintain maximum hot-gas pressure. Operate low-ambient control kit to maintain minimum hot-gas pressure.
 - 2) Unoccupied Periods: **[Compressors off]****[Cycle compressors and condenser fans to maintain heating unoccupied temperature]****[and]****[cycle compressors and condenser fans to maintain cooling unoccupied temperature]**.
 - 3) Switch reversing valve for heating or cooling mode on air-to-air heat pump.
- g. Hot-Gas Reheat-Coil Operation:
 - 1) Occupied Periods: Humidistat opens hot-gas valve to provide hot-gas reheat, and cycles compressor.
 - 2) Unoccupied Periods: Reheat is not required.
- h. Gas Furnace Operation:
 - 1) Occupied Periods: **[Cycle]****[Stage]****[Modulate]** burner to maintain **[room]****[discharge]** temperature.
 - 2) Unoccupied Periods: Cycle burner to maintain unoccupied heating temperature.
 - 3) Operate supplemental gas furnace for heating with outdoor temperature below **[plus 25 deg F (minus 4 deg C)]<Insert temperature>**.
- i. Electric-Heating-Coil Operation:

- 1) Occupied Periods: **[Cycle][Stage][Modulate]** coil to maintain **[room][discharge]** temperature.
 - 2) Unoccupied Periods: Energize coil to maintain unoccupied heating temperature.
 - 3) Operate supplemental electric heating coil with compressor for heating with outdoor temperature below **[plus 25 deg F (minus 4 deg C)]<Insert temperature>**.
- j. Fixed Minimum Outdoor-Air Damper Operation:
- 1) Occupied Periods: Open to **[25]<Insert number>** percent.
 - 2) Unoccupied Periods: Close the outdoor-air damper.
- k. Economizer Outdoor-Air Damper Operation:
- 1) Economizer Cycle: Controller is to permit outdoor air-side economizer operation when **[outdoor-air temperature][outdoor-air enthalpy]** is lower than **[return-air temperature][return-air enthalpy]**. When this condition is untrue, outdoor damper is not permitted to open beyond minimum intake airflow setting. When air-side economizer cycle is in operation, outdoor-air volume is to be modulated to maintain mixed-air temperature no lower than **[unit supply-air temperature set point]<Insert temperature>**. Minimum outdoor airflow is not to be reduced below **[10 percent][25 percent][1000 cfm (472 L/s)]<Insert value>**.
 - 2) Morning Warmup Cycle:
 - a) For outdoor-air temperature lower than return-air temperature, close outdoor-air damper and open return-air damper.
 - b) For outdoor-air temperature higher than return-air temperature, open outdoor-air damper and close return-air damper.
 - 3) Morning Cool-Down Cycle:
 - a) For outdoor-air **[temperature][enthalpy]** higher than return-air **[temperature][enthalpy]**, close outdoor-air damper and open return-air damper.
 - b) For outdoor-air **[temperature][enthalpy]** lower than return-air **[temperature][enthalpy]**, open outdoor-air damper and close return-air damper.
 - 4) Building Outdoor-Air Flush Cycle: Open outdoor-air damper and close return-air damper.
 - 5) Occupied Periods: Open to **[10][25]<Insert number>** percent fixed minimum intake, and maximum 100 percent of fan capacity. Controller is to permit air-side economizer operation when **[outdoor-air temperature is less than return-air temperature][outdoor-air enthalpy is less than return-air enthalpy][outdoor-air temperature is less than 60 deg F (15 deg C)]<Insert temperature>**. Controller modulates outdoor-air and return-air dampers to maintain a mixed-air temperature of **[55 deg F (13 deg C)]<Insert temperature>**.
 - 6) Relief-Air Fan: Start relief-air fan with end switch on outdoor-air damper.
 - 7) Unoccupied Periods: Close outdoor-air damper and open return-air damper.
- l. Outdoor-Airflow Monitor: Accuracy maximum plus or minus 5 percent within 15 and 100 percent of total outdoor air. Monitor microprocessor to adjust for temperature, and output to range from **[2 to 10 V dc][4 to 20 mA]<Insert value>**.
- m. Carbon Dioxide Sensor Operation:

- 1) Occupied Periods: Reset minimum outdoor-air ratio down to minimum **[10]<Insert number>** percent to maintain maximum **[1000 ppm]<Insert value>** concentration.
 - 2) Unoccupied Periods: Close outdoor-air damper and open return-air damper.
- n. Terminal-Unit Relays: Provide heating- and cooling-mode changeover relays compatible with terminal control system required in Section 233600 "Air Terminal Units" and Section 230923 "Direct Digital Control (DDC) System for HVAC."
5. Interface Requirements for HVAC Instrumentation and Control System:
- a. Interface relay for scheduled operation.
 - b. Interface relay to provide indication of fault at the central workstation and diagnostic code storage.
 - c. Provide **[BACnet][or][LonWorks]** compatible interface for central HVAC control workstation for the following:
 - 1) Adjusting set points.
 - 2) Monitoring supply fan start, stop, and operation.
 - 3) Inquiring data to include the following:
 - a) Outdoor-air temperature[**and humidity**].
 - b) Outdoor-air damper position.
 - c) Supply-air temperature.
 - d) Mixed-air temperature.
 - e) Room-air temperature[**and humidity**].
 - 4) Monitoring occupied and unoccupied operations.
 - 5) Monitoring constant and variable motor loads.
 - 6) Monitoring variable-frequency drive operation.
 - 7) Monitoring cooling load.
 - 8) Monitoring economizer cycles.
 - 9) Monitoring air-distribution static pressure and ventilation air volume.

P. Roof Curbs:

1. Roof curbs with vibration isolators and wind or seismic restraints are specified in Section 230548 "Vibration and Seismic Controls for HVAC."
2. Wind and Seismic Restraints: Metal brackets compatible with the curb and casing, painted to match RTU, used to anchor unit to the curb, and designed for loads at Project site. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" and Section 018123 "Facility Seismic and Wind Criteria" for wind-load requirements.
3. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.
 - a. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
 - 1) Materials: ASTM C1071, Type I or II.
 - 2) Thickness: **[1 inch (25 mm)][1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert thickness>**.
 - b. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.
 - 1) Liner Adhesive: Comply with ASTM C916, Type I.
 - 2) Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when

- 3) applied as recommended by manufacturer and without causing leakage in cabinet. Liner materials applied in this location to have airstream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.
4. Curb Dimensions: Height of **[14 inches (355 mm)][24 inches (610 mm)][36 inches (910 mm)]<Insert height>.[Adaptable horizontal dimensions as required for existing roof openings.]**

Q. Accessories:

1. Electric heater with integral thermostat maintains minimum **50 deg F (10 deg C)** temperature in gas burner compartment.
2. Duplex, 115 V, ground-fault-interrupter outlet with 15 A overcurrent protection. Include transformer if required. **[Outlet is to be energized even if the unit main disconnect is open.]**
3. Low-ambient kit using **[staged][damper on][variable-speed]** condenser fans for operation down to **[35 deg F (1.7 deg C)]<Insert temperature>.**
4. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure loss.
5. Remote potentiometer to adjust minimum economizer damper position.
6. Return-air bypass damper.
7. Factory- or field-installed, demand-controlled ventilation.
8. Safeties:
 - a. Smoke detector.
 - b. Condensate overflow switch.
 - c. Phase-loss **[reversal]** protection.
 - d. High **[and low]** pressure control.
 - e. **[Gas furnace][Electric coil]** airflow-proving switch.
9. Coil guards of painted, galvanized-steel wire.
10. Hail guards of galvanized steel, painted to match casing.
11. Concentric diffuser with white louvers and polished aluminum return grilles, insulated diffuser box with mounting flanges, and interior transition.
12. Vertical vent extensions to increase the separation between the outdoor-air intake and the flue-gas outlet.
13. Door switches to disable heating or reset set point when open.
14. Outdoor-air intake weather hood **[with moisture eliminator]**.
15. Service Lights and Switch: Factory installed in **[fan section][fan and coil sections][each accessible section]<Insert locations>** with weatherproof cover. Factory wire lights to a single-point field connection.

R. Corrosion-Resistant Coating:

1. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating.
2. Corrosion-Resistant Coating: Coat with a corrosion-resistant coating capable of withstanding **[3000]<Insert time>-hour salt-spray test in accordance with ASTM B117.**
 - a. Standards:
 - 1) ASTM B117 for salt spray.
 - 2) ASTM D2794 for minimum impact resistance of **100 in-lb (11.3 N-m)**.
 - 3) ASTM D3359 for cross-hatch adhesion of 5B.

- b. Application: **[Immersion][Spray]**.
- c. Thickness: **[1 mil (0.025 mm)]<Insert value>**.
- d. Gloss: Minimum gloss of 60 on a 60-degree meter.

2.4 SOURCE QUALITY CONTROL

A. AHRI Compliance:

- 1. Comply with AHRI 340/360 for testing and rating energy efficiencies for RTUs.
- 2. Comply with AHRI 210/240 for testing and rating energy efficiencies for RTUs.
- 3. Comply with AHRI 270 for testing and rating sound performance for RTUs.
- 4. Comply with AHRI 1060 for testing and rating performance for air-to-air exchanger.

B. AMCA Certification:

- 1. Comply with AMCA 11 and bear the AMCA-Certified Ratings Seal for air and sound performance in accordance with AMCA 211 and AMCA 311.
- 2. Damper leakage tested in accordance with AMCA 500-D.
- 3. Operating Limits: Classify in accordance with AMCA 99.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of RTUs.
- B. Examine roughing-in for RTUs to verify actual locations of piping and duct connections before equipment installation.
- C. Examine roofs for suitable conditions where RTUs will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF PACKAGED, LARGE-CAPACITY, ROOFTOP AIR-CONDITIONING UNITS

- A. Roof Curb: Install on roof structure or concrete base, level and secure, in accordance with **[NRCA's "NRCA Roofing Manual: Membrane Roof Systems."][AHRI Guideline B.]** Install RTUs on curbs and coordinate roof penetrations and flashing with roof construction specified in Section 077200 "Roof Accessories." Secure RTUs to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts. Coordinate sizes and locations of roof curbs with actual equipment provided.
 - 1. Install normal-weight, **3000 psi (20.7 MPa)**, compressive strength (28-day) concrete mix inside roof curb, **[4 inches (100 mm)]<Insert dimension>** thick. Concrete, formwork, and reinforcement are specified with concrete.
- B. Unit Support: Install unit level on structural **[curbs][steel supports]**. Coordinate wall penetrations and flashing with wall construction. Secure RTUs to structural support with anchor bolts.
- C. Equipment Mounting:

1. Install RTUs on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

3.3 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to RTU, allow space for service and maintenance.
- C. Connect piping to unit mounted on vibration isolators with flexible connectors.
- D. Connect condensate drain pans using [NPS 1-1/4 (DN 32)]<Insert pipe size>, **ASTM B88, Type M (ASTM B88M, Type C)** copper tubing. Extend to nearest equipment or roof drain. Construct deep trap [of indicated depth] at connection to drain pan and install cleanouts at changes in direction.
- E. Gas Piping: Comply with applicable requirements in [Section 231123 "Facility Natural-Gas Piping."][Section 231126 "Facility Liquefied-Petroleum Gas Piping."] Connect gas piping to burner, full size of gas train inlet, and connect with union and shutoff valve with sufficient clearance for burner removal and service.
- F. Hot- and Chilled-Water Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.
- G. Steam and Condensate Piping: Comply with applicable requirements in Section 232213 "Steam and Condensate Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties." Install shutoff valve at steam supply connections, float and thermostatic trap, and union or flange at each coil return connection. Install gate valve and inlet strainer at supply connection of dry steam humidifiers, and inverted bucket steam trap to condensate return connection.
- H. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Install shutoff valve and union or flange at each supply and return connection.

3.4 DUCT CONNECTIONS

- A. Comply with duct installation requirements specified in other HVAC Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:
 1. Install ducts to termination at top of roof curb.
 2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
 3. Connect supply ducts to RTUs with flexible duct connectors specified in Section 233300 "Air Duct Accessories."
 4. Install return-air duct continuously through roof structure.

3.5 ELECTRICAL CONNECTIONS

- A. Connect electrical wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate is to be laminated acrylic or melamine plastic signs as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate is to be laminated acrylic or melamine plastic signs as layers of black with engraved white letters at least **1/2 inch (13 mm)** high.
 - 3. Locate nameplate where easily visible.

3.6 CONTROL CONNECTIONS

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

3.7 CLEANING

- A. After completing system installation and testing, adjusting, and balancing RTUs and air-distribution systems, clean RTUs internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.8 STARTUP SERVICE

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 - 2. Inspect for visible damage to unit casing.
 - 3. Inspect for visible damage to furnace combustion chamber.
 - 4. Inspect for visible damage to compressor, coils, and fans.
 - 5. Inspect internal insulation.
 - 6. Verify that labels are clearly visible.
 - 7. Verify that clearances have been provided for servicing.
 - 8. Verify that controls are connected and operable.
 - 9. Verify that filters are installed.
 - 10. Clean all coils and inspect for construction debris.
 - 11. Clean furnace flue and inspect for construction debris.
 - 12. Connect and purge gas line.
 - 13. Remove packing from vibration isolators.
 - 14. Inspect operation of barometric relief dampers.
 - 15. Verify lubrication on fan and motor bearings.
 - 16. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
 - 17. Adjust fan belts to proper alignment and tension.
 - 18. Start unit in accordance with manufacturer's written instructions.

- a. Start refrigeration system.
 - b. Do not operate below recommended low-ambient temperature.
 - c. Complete startup sheets and attach copy with Contractor's startup report.
19. Inspect and record performance of interlocks and protective devices; verify sequences of operation.
20. Operate unit for an initial period as recommended or required by manufacturer.
21. Perform the following operations for both minimum and maximum firing. Adjust burner for peak efficiency.
 - a. Measure gas pressure on manifold.
 - b. Inspect operation of power vents.
 - c. Measure combustion-air temperature at inlet to combustion chamber.
 - d. Measure flue-gas temperature at furnace discharge.
 - e. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
 - f. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
22. Calibrate thermostats.
23. Adjust and inspect high-temperature limits.
24. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
25. Start refrigeration system and measure and record the following when ambient is a minimum of **15 deg F (8 deg C)** above return-air temperature:
 - a. Coil leaving-air, dry- and wet-bulb temperatures.
 - b. Coil entering-air, dry- and wet-bulb temperatures.
 - c. Outdoor-air, dry-bulb temperature.
 - d. Outdoor-air-coil, discharge-air, dry-bulb temperature.
26. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
27. Measure and record the following minimum and maximum airflows. Plot fan volumes on fan curve.
 - a. Supply-air volume.
 - b. Return-air volume.
 - c. Relief-air volume.
 - d. Outdoor-air intake volume.
28. Simulate maximum cooling demand and inspect the following:
 - a. Compressor refrigerant suction and hot-gas pressures.
 - b. Short circuiting of air through condenser coil or from condenser fans to outdoor-air intake.
29. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:
 - a. High-temperature limit on gas-fired heat exchanger.
 - b. Low-temperature safety operation.
 - c. Filter high-pressure differential alarm.
 - d. Economizer to minimum outdoor-air changeover.
 - e. Relief-air fan operation.
 - f. Smoke and firestat alarms.

30. After startup and performance testing and prior to Substantial Completion, replace existing filters with new filters.

3.9 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.
- C. Occupancy Adjustments: When requested within [12]<Insert number> months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to [two]<Insert number> visits to Project during other-than-normal occupancy hours for this purpose.

3.10 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
 - 1. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
 - 2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 5. RTU will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

3.11 DEMONSTRATION

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

END OF SECTION 23 74 16 13



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SECTION 23 74 16 13A - SELF-CONTAINED AIR-CONDITIONERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: Self-contained air-conditioners.

1.2 DEFINITIONS

- A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.
- B. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for self-contained air-conditioners.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Sustainable design submittals.
- C. Shop Drawings:
 - 1. Include plans, elevations, sections, and **[mounting][attachment]** details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
 - 4. Include diagrams for power, signal, and control wiring.
- D. Samples for Initial Selection: For units with factory-applied color finishes.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Detail self-contained air-conditioners and adjacent equipment. Show support locations, type of support, weight on each support, required clearances, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Structural members to which self-contained air-conditioners will be attached.



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

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For self-contained air-conditioners to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Filters: **[One]<Insert number>** set(s) of filters for each unit.
 - 2. Fan Belts: **[One]<Insert number>** set(s) of belts for each unit.
 - 3. Gaskets: **[One]<Insert number>** set(s) for each access door.
 - 4. Fuses: **[One]<Insert number>** set(s) for each air-handling unit.

1.7 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An NRTL.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Comply with self-contained air-conditioner manufacturer's written instructions for handling.

1.9 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of self-contained air-conditioners that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period:
 - a. For Compressor: **[One][Five]<Insert number>** year(s) from date of Substantial Completion.
 - b. For Parts: **[One][Five]<Insert number>** year(s) from date of Substantial Completion.
 - c. For Labor: **[One][Five]<Insert number>** year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASHRAE Compliance:
 - 1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
 - 2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Ventilation Rate Procedures," and Section 7 - "Construction and Startup."
- C. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.
- D. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation[**and seismic restraints**], including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- E. Seismic Performance: Self-contained air-conditioners shall withstand the effects of earthquake motions determined according to [**ASCE/SEI 7**]**<Insert requirement>**.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."
 - 2. Component Importance Factor: [**1.5**][**1.0**].
 - 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.

2.2 CAPACITIES AND CHARACTERISTICS

- A. Cooling Capacity:
 - 1. Total: **<Insert number> Btu/h (kW)**.
 - 2. Sensible: **<Insert number> Btu/h (kW)**.
 - 3. Seasonal Energy-Efficiency Ratio: [**10.0**][**12.0**][**13.0**][**14.0**][**16.0**]**<Insert ratio>**.
 - 4. Energy-Efficiency Ratio: [**10.0**][**12.0**][**13.0**][**14.0**][**16.0**]**<Insert ratio>**.
 - 5. Entering-Air Temperature:
 - a. Dry Bulb: **<Insert number> deg F (deg C)**.
 - b. Wet Bulb: **<Insert number> deg F (deg C)**.
 - 6. Leaving-Air Temperature:
 - a. Dry Bulb: **<Insert number> deg F (deg C)**.
 - b. Wet Bulb: **<Insert number> deg F (deg C)**.
- B. Heating Capacity:
 - 1. Total: **<Insert number> Btu/h (kW)**.

2. Air-Temperature Rise: **<Insert number> deg F (deg C).**
3. Airflow:
 - a. High: **<Insert number> cfm (L/s).**
 - b. Low: **<Insert number> cfm (L/s).**
4. Hot Water:
 - a. Entering-Water Temperature: **<Insert number> deg F (deg C).**
 - b. Leaving-Water Temperature: **<Insert number> deg F (deg C).**
 - c. Water Flow: **<Insert number> gpm (L/s).**
 - d. Water Pressure Drop: **<Insert number> feet of head (kPa).**
5. Electric Heat:
 - a. Total Capacity: **<Insert number> Btu/h (kW).**
 - b. Air-Temperature Rise: **<Insert number> deg F (deg C).**
 - c. Control Steps: **[One][Two][Three]<Insert number>.**

C. Supply-Air Fan:

1. Size: **<Insert number> hp (W).**
2. Total Airflow:
 - a. High: **<Insert number> cfm (L/s).**
 - b. Low: **<Insert number> cfm (L/s).**
3. Outdoor Airflow: **<Insert number> cfm (L/s).**

D. Air-Cooled Condenser:

1. Number of Fans: **[Two][Four]<Insert number>.**
2. Motor Speed: **<Insert value> rpm.**
3. Motor Horsepower (Watts): **<Insert number> hp (W).**
4. Ambient Temperature: **<Insert number> deg F (deg C).**

E. Water-Cooled Condenser:

1. Entering-Water Temperature: **<Insert number> deg F (deg C).**
2. Leaving-Water Temperature: **<Insert number> deg F (deg C).**
3. Water Flow: **<Insert number> gpm (L/s).**
4. Water Pressure Drop: **<Insert number> feet of head (kW).**

F. Filters:

1. Type: **<Insert type>.**
2. Face Dimensions, each: **<Insert number> inches by inches (mm by mm).**
3. Depth: **<Insert number> inches (mm).**
4. Numbers of Filters, Wide by High: **<Insert number>.**
5. Maximum or Rated Face Velocity: **<Insert number> fpm (m/s).**
6. Initial Resistance: **<Insert number> inches wg (Pa).**
7. Recommended Final Resistance: **<Insert number> inches wg (Pa).**
8. Minimum Efficiency Reporting Value and Average Arrestance:

- a. MERV Rating: **[MERV 4]<Insert value>**, and corresponding average arrestance according to ASHRAE 52.2.
- 9. Minimum Efficiency Reporting Value:
 - a. MERV Rating: **[MERV 6][MERV 13]<Insert value>**, according to ASHRAE 52.2.
- G. Accessories:
 - 1. Manual outdoor-air damper.
 - 2. Motorized outdoor-air damper.
 - 3. Air-side economizer.
 - 4. Water-side economizer.
 - 5. Hot-gas bypass.
 - 6. Air Pressure Switch: Indicates when differential pressure exceeds set point representing dirty filters.
- H. Single-Point Electrical Characteristics:
 - 1. Volts: **[120][208][230][460]<Insert number> V.**
 - 2. Phase: **[Single][Three].**
 - 3. Hertz: 60 Hz.
 - 4. Full-Load Amperes: **<Insert number> A.**
 - 5. Minimum Circuit Ampacity: **<Insert number> A.**
 - 6. Maximum Overcurrent Protection: **<Insert number> A.**

2.3 SELF-CONTAINED AIR-CONDITIONERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Bard Manufacturing Company]**
 - 2. **[Carrier Global Corporation]**
 - 3. **[Daikin Applied]**
 - 4. **[Engineered Air]**
 - 5. **[Rheem Manufacturing Company; Heating and Cooling Products]**
 - 6. **[Trane Inc.]**
 - 7. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Bard Manufacturing Company]**
 - 2. **[Carrier Global Corporation]**
 - 3. **[Daikin Applied]**
 - 4. **[Engineered Air]**
 - 5. **[Rheem Manufacturing Company; Heating and Cooling Products]**
 - 6. **[Trane Inc.]**
 - 7. **<Insert manufacturer's name>**
- C. Description: Factory assembled, wired, and tested; and fully charged with refrigerant and oil.
- D. Configuration:



1. Horizontal, ceiling[-plenum] mounted.
2. Vertical, floor mounted; [vertical][and][horizontal] discharge.
3. Horizontal, ceiling mounted and vertical, floor mounted; [vertical][and][horizontal] discharge.

E. Disconnect Switch: Factory mounted [in control panel][on cabinet].

2.4 CABINET

A. Frame and Panels: Structural-steel frame with galvanized-steel panels and access doors or panels.

1. Exterior-Surface Finish: Factory painted in color selected by Architect.
2. Interior-Surface Finish: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

B. Insulation: [1-inch- (25-mm-) thick, glass-fiber duct liner complying with ASTM C1091 and having a microbial coating on cabinet interior and control panel.]<Insert insulation thickness and type>.

C. Return-Air Opening: Rear, [open][flange for duct connection].

D. Corrosion-Resistant Treatment: [None][Phenolic coating on unit interior and exterior]<Insert coating type and casing location>.

2.5 SUPPLY-AIR FAN

A. Fan Material: Galvanized steel.

B. Configuration: Double-width, double-inlet, [forward-curved][airfoil] centrifugal fan; statically and dynamically balanced. [Vertical][Horizontal] discharge with flexible discharge collar.

C. Drive: [Belt][, with permanently lubricated bearings][, with greaseable bearings][Direct, with fan and motor resiliently mounted].

D. Motor Type: [Multispeed, permanent split case][Open-dripproof][Totally enclosed fan-cooled][Electronically commutated variable speed]<Insert type> type.

E. Motor Sheave: [Fixed][Variable and adjustable] pitch, dynamically balanced, and selected to achieve specified rpm when set at midposition.

F. Fan Sheaves: [Variable][Fixed] pitch, dynamically balanced, bored to fit shafts, and keyed for initial startup.

G. Belt Rating: As recommended by manufacturer or a minimum of one and one-half times nameplate rating of motor.

H. Bearings: Grease lubricated with grease lines extended to exterior of unit[with L-50 life at 200,000 hours]<Insert life rating and hours>.

I. Variable-frequency motor controller complies with Section 262923 "Variable-Frequency Motor Controllers."

J. Variable-Frequency Motor Controller: Serving each fan.

1. Manufactured Units: Pulse-width modulated; **[constant torque][and][variable torque]<Insert application> for [Design A and Design B][inverter-duty] motors.**
2. Output Rating: Three phase; 10 to **[60 Hz, with voltage proportional to frequency throughout voltage range][66 Hz, with torque constant as speed changes];** maximum voltage equals input voltage.
3. Unit Operating Requirements:
 - a. Internal Adjustability:
 - 1) Minimum Speed: 5 to 25 percent of maximum rpm.
 - 2) Maximum Speed: 80 to 100 percent of maximum rpm.
 - 3) Acceleration: **[0.1 to 999.9]<Insert range> seconds.**
 - 4) Deceleration: **[0.1 to 999.9]<Insert range> seconds.**
 - 5) Current Limit: 30 to minimum of 150 percent of maximum rating.
 - b. Self-Protection and Reliability Features:
 - 1) Surge suppression.
 - 2) Loss of input signal protections.
 - 3) Under- and overvoltage trips.
 - 4) Variable-frequency motor controller and motor-overload/overtemperature protection.
 - 5) Critical frequency rejection.
 - 6) Loss-of-phase protection.
 - 7) Reverse-phase protection.
 - 8) Motor-temperature fault.
 - c. Bidirectional autospeed search.
 - d. Torque boost.
 - e. Motor temperature compensation at slow speeds.
 - 1) Panel-mounted operator station.
 - 2) Historical logging information and displays.
 - 3) Digital indicating devices.
 - f. Control Signal Interface: Electric.
 - g. Proportional Integral Derivative control interface.
 - h. DDC system for HVAC Protocols for Network Communications: **[ASHRAE 135]<Insert protocol type>.**
4. Line Conditioning:
 - a. Input line conditioning.
 - b. Output filtering.
 - c. EMI/RFI filtering.
5. Bypass Systems:
 - a. Bypass Mode: **[Manual operation only][Field-selectable automatic or manual].**
 - b. Bypass Controller:
 - 1) Two-contactor style, with bypass and output isolating contactors **[and isolating switch].**
 - 2) Three-contactor style, with bypass and input and output isolating contactors **[and isolating switch].**
 - c. Bypass Contactor Configuration: **[Full-voltage (across the line)][Reduced-voltage**

(autotransformer)]<Insert type> type.

- K. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - 1. Special Motor Features: Premium efficiency, as defined in Section 230500 "Common Work Results for HVAC."
 - 2. <Insert unique motor characteristics>.
- L. Isolation: Mount fan and motor on common subbase and mount assembly on spring isolators with minimum static deflection of [1 inch (25 mm)]<Insert deflection>.
- M. Outdoor-Air-Intake Accessories:
 - 1. Barometric Outdoor-Air Damper: Adjustable-blade damper allowing induction of up to 25 percent outdoor air when evaporator fan is running.
 - 2. Motorized Outdoor-Air Damper: Motorized, two-position blade damper allowing induction of up to 25 percent outdoor air; with spring-return, low-voltage damper motor.
 - 3. Energy-Recovery Ventilator: Assembly of desiccant-coated, heat-recovery wheels and centrifugal exhaust fans to transfer approximately [67]<Insert number> percent of the difference between the sensible and latent heat of outdoor and exhaust air; with <Insert type and depth> filter on outside-air inlet side to keep ventilator clean.
 - 4. Air-Side Economizer: Damper assembly allowing induction of up to 100 percent outdoor air to maintain a selected mixed-air temperature; and exhaust damper and spring-return, low-voltage, modulating damper motor with minimum position adjustment.

2.6 REFRIGERATION SYSTEM

- A. Compressor: Scroll type, hermetically sealed, 3600 rpm maximum, and resiliently mounted with positive lubrication and internal motor protection.
- B. Refrigerant Coils: [Indoor and outdoor for air-cooled units,]seamless copper tubes expanded into aluminum fins.
 - 1. Coating: [None][Corrosion resistant].
 - 2. Refrigerant Circuits: A separate circuit for each compressor, with externally equalized thermal-expansion valve[with adjustable superheat], filter dryer,[sight glass, high-pressure relief valve,] and charging valves.
 - 3. Mount coil assembly over sloped, stainless-steel drain pan[complying with ASHRAE 62.1][and][having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir].
 - 4. Refrigerant: [R-407C][or][R-410A].
 - 5. Refrigerant dryer.
 - 6. High-pressure switch.
 - 7. Low-pressure switch.
 - 8. Thermostat for coil freeze-up protection during low ambient temperature operation or loss of air.
 - 9. Low ambient temperature switch.
 - 10. Brass service valves installed in discharge and liquid lines.
- C. Water-Cooled Condenser:
 - 1. Description: Factory assembled and tested; tube-in-tube coaxial type with water-regulating valve.
 - 2. Tubing: [Nonferrous][Copper][Cupronickel][Steel] inner tube.
 - 3. Coating: [None][Corrosion resistant].

D. Water-Side Economizer Section:

1. Description: Factory assembled and tested; consisting of water coil, modulating valves, controls, piping with cleanouts, and access panels.
2. Water Coil: **[Two][Four]** rows, copper tube, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)**, and **[copper][cast-iron]** headers; having a two-position control valve.

2.7 HEATING COIL

- A. Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)**; having a two-position control valve.
- B. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements with refractory ceramic support bushings; automatic-reset thermal cutout; built-in magnetic contactors; manual-reset thermal cutout; airflow-proving device; and one-time fuses in terminal box for overcurrent protection.

2.8 CONTROLS

- A. Control equipment and sequence of operation are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."
- B. Control Package, Factory Wired: Including contactor, high- and low-pressure cutouts, internal-winding thermostat for compressor, control-circuit transformer, and noncycling reset relay.
 1. System Selector Switch: **[Heat-off-cool][Off-heat-auto-cool]**.
 2. Adjustable Thermostat: **[Unit mounted][Remote]** to control the following:
 - a. Supply fan.
 - b. Compressor.
 - c. Condenser.
 - d. Hot-water coil valve.
 - e. Electric heater.
 3. Time-Delay Relay: Delay in starting lag compressor to prevent power demand surges.
 4. Antirecycle Timer: Locks out the compressor for an interval of time to prevent rapid starting and stopping.
- C. Control Package, Microprocessor Control Panel: Controls unit functions as **[standalone][full BAS communication via BACnet MS/TP][full BAS communication via BACnet/IP][full BAS communication via LON][full BAS communication via MODBUS]**, including refrigeration and safety controls, with unit-mounted display, and the following:
 1. Supply fan.
 2. Supply-fan motor speed.
 3. Compressors.
 4. Air-cooled condenser.
 5. Cooling tower pump.
 6. Modulating, hot-water coil valve.
 7. Multistep, electric heater.
 8. Time-of-day control to cycle unit on and off.
 9. Night-heat, morning warm-up cycle.
 10. Economizer control.
 11. Panel-mounted control switch to operate unit in remote or local control mode or to stop or reset.

12. Panel-mounted indication of the following:
 - a. Operating status.
 - b. System diagnostics and safety alarms.
 - c. Supply-air temperature set point.
 - d. Zone heating-temperature set point.
 - e. Supply-air pressure set point.
 - f. Economizer minimum position set point.
 - g. Supply-air-pressure, high-limit set point.

2.9 MATERIALS

A. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for steel sheet.

B. Stainless Steel:

1. Manufacturer's standard grade for casing.
2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653/A653M.

D. Aluminum: ASTM B209.

E. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating.

F. Corrosion-Resistant Coating: Coat with a corrosion-resistant coating capable of withstanding a [3000]<Insert time>-hour salt-spray test according to ASTM B117.

1. Standards:

- a. ASTM B117 for salt spray.
- b. ASTM D2794 for minimum impact resistance of **100 in-lb (11.3 N-m)**.
- c. ASTM B3359 for cross-hatch adhesion of 5B.

2. Application: [Immersion][Spray].

3. Thickness: [1 mil (0.025 mm)]<Insert value>.
4. Gloss: Minimum gloss of 60 on a 60-degree meter.

2.10 SOURCE QUALITY CONTROL

A. AHRI Compliance:

1. AHRI 210/240 Certification: Units and their components shall be factory tested according to AHRI 210/240 and shall be listed and labeled by AHRI.
2. AHRI 340/360 Certification: Units and their components shall be factory tested according to AHRI 340/360 and shall be listed and labeled by AHRI.
3. AHRI 390 Certification: Units and their components shall be factory tested according to AHRI 390 and shall be listed and labeled by AHRI.

- B. ETL listed.
- C. Water Coils: Factory tested to minimum **300-psig (2070-kPa)** internal pressure while underwater according to AHRI 410 and ASHRAE 33.
- D. Refrigerant Coils: Factory tested to minimum **450-psig (3100-kPa)** internal pressure and to minimum **300-psig (2070-kPa)** internal pressure while underwater, according to AHRI 410 and ASHRAE 33.
- E. Water-Cooled Condenser: Refrigerant and water side factory tested to minimum **400-psig (2760 kPa)** internal pressure while underwater.
- F. Water-Side Economizer: Factory tested to minimum **300-psig (2070-kPa)** internal pressure while underwater.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Equipment Mounting:
 - 1. Install air-handling units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 2. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete."
 - 3. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 4. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548.13 "Vibration Controls for HVAC."
- B. Suspended Units: Suspend[**and brace**] units from structural-steel support frame using threaded steel rods and spring hangers. Comply with requirements for vibration isolation devices specified in [**Section 230548 "Vibration and Seismic Controls for HVAC."**][**Section 230548.13 "Vibration Controls for HVAC."**]
- C. Arrange installation of units to provide access space around units for service and maintenance.
- D. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.
- E. Connect duct to units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."
- F. Duct Connections: Duct installation requirements are specified in Section 233113 "Metal Ducts." Drawings indicate the general arrangement of ducts. Connect supply[**and return**] ducts to self-contained air-conditioners with flexible duct connectors. Flexible duct connectors are specified in Section 233300 "Air Duct Accessories."

3.2 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.



- B. Connect condensate drain pans using [NPS 1-1/4 (DN 32)]<Insert pipe size>, ASTM B88, Type M (ASTM B88M, Type C) copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.
- C. Hot-Water Coil Connections: Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Connect to supply and return coil with shutoff-duty valve and union or flange on the supply connection, and with throttling-duty valve and union or flange on the return connection.
- D. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Install shutoff valve and union or flange at each supply and return connection.
- E. Water-Cooled Condenser Connections: Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Connect to supply and return with shutoff-duty valve and union or flange on the supply connection, and with throttling-duty valve and union or flange on the return connection.
- F. Where installing piping adjacent to equipment, allow space for service and maintenance.
- G. Connect piping to units mounted on vibration isolators with flexible connectors.

3.3 ELECTRICAL CONNECTIONS

- A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

3.4 CONTROL CONNECTIONS

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

3.5 FIELD QUALITY CONTROL

- A. Testing Agency:
 - 1. Owner will engage a qualified testing agency to perform tests and inspections.
 - 2. Engage a qualified testing agency to perform tests and inspections.

- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
 - 1. Charge refrigerant coils with refrigerant and test for leaks.
 - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Units will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.

3.6 STARTUP SERVICE

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.

3.7 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing unit.

3.8 CLEANING

- A. After completing system installation and testing, adjusting, and balancing unit and after completing startup service, clean units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings; install new, clean filters.

3.9 DEMONSTRATION

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

END OF SECTION 23 74 16 13A



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SECTION 23 74 16 13B - UNIT VENTILATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Unit ventilators.
 - a. [Hydronic][Steam][Electric] heating coil.
 - b. [Hydronic][Steam][Electric] reheat coil.
 - c. [Hydronic][Direct-expansion refrigerant] cooling coil.

B. Related Requirements:

1. Section 238146.13 "Water-to-Air Heat Pumps" for ground-loop, water-source heat-pump-type unit ventilators.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product

1. Include rated capacities, operating characteristics, and furnished specialties and accessories for each unit type and configuration.

B. Sustainable Design Submittals:

1. Product Data: For energy performance.
2. Refrigerant: Product Data for refrigerants, indicating compliance with refrigerant management practices.
3. Product Data: For refrigerants, indicating compliance with refrigerant management practices.
4. Product data showing compliance with ASHRAE 62.1.

C. Shop Drawings:

1. Include plans, elevations, sections, and details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail anchorages and attachments to structure and to supported equipment.
4. Include diagrams for power, signal, and control wiring.

D. Samples for Initial Selection: For units with factory-applied color finishes.

E. Samples for Verification: For each type of unit ventilator[**and auxiliary shelves**] and cabinets indicated.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown

and coordinated with each other, based on input from installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which equipment will be attached.
3. Method of attaching hangers to building structure.
4. Size and location of initial access modules for acoustical tile.
5. Size and location of access panels in hard ceilings to provide access to concealed units.
6. Items penetrating finished ceiling, including the following:
 - a. Lighting fixtures.
 - b. Air outlets and inlets.
 - c. Speakers.
 - d. Sprinklers.
 - e. Access panels.
 - f. **<Insert item>**.
7. Perimeter moldings.

B. Seismic Qualification Certificates: For unit ventilators, accessories, and components, from manufacturer.

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

C. Field quality-control reports.

D. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

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

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Maintenance schedules and repair part lists for motors, coils, integral controls, and filters.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Unit Ventilator Filters: Furnish **<Insert number>** spare filter(s) for each filter installed.
2. Spare Cooling Chassis: Furnish **<Insert number>** spare integral cooling chassis for each size unit installed.



1.6 QUALITY ASSURANCE

- A. Comply with NFPA 70.
- B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.7 COORDINATION

- A. Coordinate layout and installation of unit ventilators and suspension system components with other construction that penetrates or is supported by ceilings, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.
- B. Coordinate size and location of wall sleeves for outdoor-air intake.

1.8 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of condensing units that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Compressor failure.
 - b. Condenser coil leak.
 - 2. Warranty Period: **[Four][Five][10]<Insert number>** years from date of Substantial Completion.
 - 3. Warranty Period (Compressor Only): **[Five][10]<Insert number>** years from date of Substantial Completion.
 - 4. Warranty Period (Condenser Coil Only): **[Five]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Factory-packaged and -tested units rated according to AHRI 840, ASHRAE 33, and UL 1995.

2.2 UNIT VENTILATORS

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

2. [Daikin Applied]
3. [Engineered Air]
4. [Nesbitt Aire, Inc.]
5. [Trane]
6. [Venmar; a brand of Nortek Air Solutions]
7. <Insert manufacturer's name>

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

1. [Carrier Global Corporation]
2. [Daikin Applied]
3. [Engineered Air]
4. [Nesbitt Aire, Inc.]
5. [Trane]
6. [Venmar; a brand of Nortek Air Solutions]
7. <Insert manufacturer's name>

C. Manufactured Units:

1. Description: Unit ventilators consisting of finished cabinet, filter, cooling coil, drain pan, supply-air fan and motor in [blow-][or][draw-]through configuration, and hydronic cooling coil.
2. Unit Ventilator Coil Configurations: [Row][Face] split.
 - a. Number of Heating Coils: [One] with two-pipe system.
 - b. Number of Cooling Coils: [One][Three] with [two][four]-pipe system.

D. Cabinets:

1. Insulation: Minimum [1/2-inch- (13-mm-)][1-inch- (25-mm-)]<Insert dimension> thick, [coated glass fiber][foil-covered, closed-cell foam][matte-finish, closed-cell foam] complying with ASTM C1071 and attached with adhesive complying with ASTM C916.
 - a. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E84 by a qualified testing agency.
 - b. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
2. Coil Section Insulation: Insulate coil section according to Section 230616 "HVAC Equipment Insulation."
 - a. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E84 by a qualified testing agency.
 - b. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
3. Main and Auxiliary Drain Pans: [Plastic][Insulated galvanized steel with plastic liner], formed as required by ASHRAE 62.1. [Drain pans shall be removable.]
4. Cabinet Frame and Access Panels: Welded-steel frame with removable panels fastened with hex-head tamperproof fasteners [and key-operated control and valve access doors].
 - a. Steel components exposed to moisture shall be [hot-dip galvanized after fabrication][baked-enamel finished][powder-coat finished].

5. Cabinet Finish:
 - a. Baked-on primer ready for field painting.
 - b. **[Baked enamel][Powder coat]**, in manufacturer's **[standard][custom]** color as selected by Architect.
6. Indoor-Supply-Air Grille: **[Steel][Aluminum]**, **[double deflection, adjustable][adjustable linear bar]**.
7. Return-Air Inlet: **[Front toe space][Back inlet with top inlet grille]**.
8. End Panels: Matching material and finish of unit ventilator.
9. Outdoor-Air Wall Box: Minimum **0.1265-inch- (3.2-mm-)** thick, aluminum, rain-resistant louver and box with integral eliminators and bird screen.
 - a. Louver Configuration: **[Horizontal][Vertical]**, rain-resistant louver.
 - b. Louver Material: **[Aluminum][Steel]**.
 - c. Bird Screen: **1/2-inch (13-mm)** mesh screen on interior side of louver.
 - d. Decorative Grille: On outside of intake.
 - e. Finish: **[Anodized aluminum][Baked enamel]**, color as selected by Architect from manufacturer's **[standard][custom]** colors.

E. Coils:

1. Test and rate unit ventilator coils according to ASHRAE 33.
2. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)**, rated for a minimum working pressure of **200 psig (1378 kPa)** and a maximum entering-water temperature of **220 deg F (104 deg C)**. Include manual air vent and drain valve.
3. Steam Coils: Copper **[distributing]** tube, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)**, rated for a minimum working pressure of **75 psig (517 kPa)**.
4. Electric-Resistance Heating Coils: Nickel-chromium heating wire or tubular elements in coil fins, free of expansion noise and hum, with fuses in terminal box for overcurrent protection and continuous limit controls for high-temperature protection. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.
5. Indoor Refrigerant Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)**, and brazed joints at fittings. Comply with AHRI 210/240, and leak test to minimum **450 psig (3105 kPa)** for a minimum **300-psig (2070-kPa)** working pressure. Include thermal expansion valve.

F. Indoor Fan:

1. Fan and Motor Board: Removable.
 - a. Fan: Forward curved, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.
 - b. Fan Shaft and Bearings: Hollow-steel shaft with permanently lubricated, resiliently mounted bearings.
 - c. Motor: Permanently lubricated, multispeed, resiliently mounted on motor board. Comply with requirements in Section 230500 "Common Work Results for HVAC."
 - d. Wiring Termination: Connect motor to chassis wiring with plug connection.

G. Dampers:

1. Mixing Dampers: Galvanized-steel blades with edge and end seals and nylon bearings; with **[electric][pneumatic]** actuator.
2. Outdoor-Air Dampers: Galvanized-steel blades with edge and end seals and nylon bearings; with **[electric][pneumatic]** actuator.
3. Face and Bypass Dampers: Galvanized-steel damper blades with edge and end seals and nylon

- bearings; with factory-mounted **[electric][pneumatic]** actuator.
4. Comply with ASHRAE/IES 90.1.

H. Accessories:

1. Exhaust Shutter: **[Barometric][Motorized, modulating]** type designed to limit room pressure to maximum **0.10-inch wg (25 kPa)** with **[steel][aluminum][fabric]** damper blades, including edge and end seals, in galvanized-steel frame with **[outdoor][and][interior]** wall grille.
2. Subbase: Sheet metal floor-mounting base with leveling screws and black enamel finish.
3. Insulated false back with gasket seals on wall and outdoor-air plenum.
 - a. Insulation: Minimum **[1/2-inch- (13-mm-)][1-inch- (25-mm-)]<Insert dimension>** thick, **[coated glass fiber][foil-covered, closed-cell foam][matte-finish, closed-cell foam]** complying with ASTM C1071 and attached with adhesive complying with ASTM C916.
 - 1) Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E84 by a qualified testing agency.
 - 2) Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
4. Return-air plenum, **6 inches (150 mm)** thick, designed to take return air from top inlet grilles in cabinets on both sides of unit ventilator with gasket seals on wall and outdoor-air plenum extension.
5. Duct flanges for supply-, return-, and outdoor-air connections.
6. Radiation Grille: **[Steel][Aluminum]**, **[linear-bar][stamped]** grille with finish to match discharge-air grille.
7. Filters:
 - a. Minimum Efficiency Reporting Value and Average Arrestance: According to ASHRAE 52.2.
 - b. Minimum Efficiency Reporting Value: According to ASHRAE 52.2.
 - c. Material:
 - 1) Washable foam, **[MERV 3]<Insert value>**.
 - 2) Glass fiber treated with adhesive, **[MERV 5]<Insert value>**.
 - 3) Pleated cotton-polyester media, **[MERV 7]<Insert value>**.
8. Energy Recovery Wheel:
 - a. Casing: Steel with manufacturer's standard paint coating and with the following:
 - 1) Integral purge section.
 - 2) Casing seals on periphery of rotor, on duct divider, and on purge section.
 - 3) Support rotor on grease-lubricated ball bearings with extended grease fittings. Mount horizontal wheels on tapered roller bearing.
 - b. Rotor: Corrugated-aluminum, segmented wheel strengthened with radial spokes, and having nontoxic, noncorrosive silica-gel desiccant coating. Construct media for passing maximum 800-micrometer solids and maximum 0.04 percent cross contamination by volume of exhaust air. Drive rotor with belt around outside of rotor.
 - c. Defrost Coils: Electric defrost coil in the exhaust airstream.
 - d. Drive: Fractional horsepower motor and gear reducer, with speed changed by adjustable variable frequency controller.
 - e. Inlet and Discharge Fans: Forward curved, centrifugal; resiliently mounted with flexible duct connections.

- 1) Motor and Drive: Permanently lubricated, direct driven. Comply with requirements in Section 230500 "Common Work Results for HVAC."
 - f. Filters: **1-inch- (25-mm-)** thick, disposable type, mounted in galvanized-steel frame upstream of energy recovery wheel in both supply and exhaust airstreams.
 - g. Electrical: Single electrical connection from attached unit ventilator.
- I. Factory Hydronic Piping Package:
1. Piping: **[ASTM B88, Type L (ASTM B88M, Type B)][ASTM B88, Type M (ASTM B88M Type C)]** copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet. Crossover piping, **[NPS 1-1/2 (DN 40)][NPS 2 (DN 50)]<Insert pipe size>** with shutoff valves.
 2. Control Valves: **[Electric][Pneumatic]** actuators compatible with terminal controller and building controls.
 - a. **[Two][Three]-way, [two-position][modulating]** control valve for dual-temperature-water coil.
 - b. **[Two][Three]-way, [two-position][modulating]** control valve for chilled-water coil.
 - c. **[Two][Three]-way, [two-position][modulating]** control valve for hot-water heating coil.
 - d. **[Two][Three]-way, [two-position][modulating]** control valve for hot-water reheat coil.
 3. Hose Kits: Minimum **400-psig (2758-kPa)** working pressure and operating temperatures from **33 to 211 deg F (0.5 to 99 deg C)**. Tag hose kits to equipment designations.
 - a. Length: **[24 inches (600 mm)][36 inches (900 mm)]<Insert dimension>**.
 - b. Minimum Diameter: Equal to unit ventilator connection size.
 4. Isolation Valves, Strainers, Unions, and Balance Valves:
 - a. Two-Piece Ball Valves: Bronze body with stainless-steel ball and stem and galvanized-steel lever handle for each supply and return connection. If balancing device is combination shutoff type with memory stop, isolation valve may be omitted on the return.
 - b. Calibrated-Orifice Balancing Valves: Bronze body, ball type; **125-psig (860-kPa)** working pressure, **250 deg F (121 deg C)** maximum operating temperature; with calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, threaded ends, and a memory stop to retain set position.
 - c. Automatic Flow-Control Valve: Brass or ferrous-metal body; **300-psig (2070-kPa)** working pressure at **250 deg F (121 deg C)**; with removable, corrosion-resistant, tamperproof, self-cleaning piston spring; factory set to maintain constant indicated flow with plus or minus 10 percent over differential pressure range of **2 to 80 psig (13.8 to 552 kPa)**.
 - d. Y-Pattern Hydronic Strainers: Cast-iron body (ASTM A126, Class B); **125-psig (860-kPa)** working pressure; with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum **NPS 1/2 (DN 15)** hose-end, full-port, ball-type blowdown valve in drain connection.
 - e. Wrought-Copper Unions: ASME B16.22.
- J. Integral Cooling Chassis:
1. Description: Assembly mounted within unit ventilator, factory assembled and tested; consisting of compressors, condenser coils, fans, motors, and refrigerant receivers; removable for maintenance, with plug and receptacle connections for control and power wiring. Construct, test, and rate condensing units according to AHRI 210/240 and ASHRAE 15.
 2. Casing: Galvanized steel with removable panels for access to controls and refrigerant piping.
 3. Exterior Louver: Extruded aluminum.
 4. Compressor: Hermetic, **[scroll][reciprocating]** type; internally isolated for vibration with factory-

installed safety devices as follows:

- a. Antirecycle timer.
 - b. High-pressure cutout.
 - c. Low-pressure cutout or loss-of-charge switch.
 - d. Internal thermal-overload protection.
 - e. Current- and voltage-sensitive safety devices.
5. Energy Efficiency: Equal to or greater than prescribed by ASHRAE/IES 90.1, "Energy Standard for Buildings except Low-Rise Residential Buildings."
 6. Refrigerant Piping Materials:
 - a. Drawn-Temper Copper Tube: **[ASTM B88, Type L (ASTM B88M, Type B)]**.
 - b. Annealed-Temper Copper Tube: **[ASTM B88, Type L (ASTM B88M, Type B)][ASTM B88, Type K (ASTM B88M, Type A)]**.
 - c. Wrought-Copper Fittings: ASME B16.22.
 7. Refrigerant: R-407C or R-410A.
 8. Low ambient controls to permit operation down to **45 deg F (7 deg C)**.
 9. Crankcase heater.
 10. Charging and service fittings.
 11. Filter dryer.
 12. Air-to-Air Heat Pump: Pilot-operated, sliding-type reversing valve with replaceable magnetic coil, and controls for air-to-air heat pump operation with supplemental heat.
 13. HGBP, constant-pressure expansion valve and controls to maintain continuous refrigeration system operation at 10 percent of full load.
 14. Condenser: Copper-tube, aluminum-fin coil, with liquid subcooler.
 15. Direct-Driven Condenser Fan: Forward curved, double width, centrifugal; thermoplastic or painted-steel wheels and galvanized-steel fan scrolls.
 16. Motor: Comply with requirements in Section 230500 "Common Work Results for HVAC."

K. Basic Unit Controls:

1. Control devices and operational sequences are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."
2. Control voltage transformer.
 - a. **[Wall-mounting][Unit-mounted]** thermostat with the following features.
 - 1) Heat-cool-off switch.
 - 2) Fan on-auto switch.
 - 3) Fan-speed switch.
 - 4) **[Manual][Automatic]** changeover.
 - 5) Adjustable deadband.
 - 6) **[Concealed][Exposed]** set point.
 - 7) **[Concealed][Exposed]** indication.
 - 8) **[Degree F][Degree C]** indication.
 - b. **[Wall-mounting][Unit-mounted]** humidistat.
 - 1) **[Concealed][Exposed]** set point.
 - 2) **[Concealed][Exposed]** indication.
 - c. **[Wall-mounting][Unit-mounted]** temperature sensor.

- d. Unoccupied-period-override push button.
 - e. Data entry and access port.
 - 1) Input data includes room temperature, and humidity set points and occupied and unoccupied periods.
 - 2) Output data includes room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.
3. DDC Terminal Controller:
- a. Safety Controls Operation: Freezestat shall stop fan and close outdoor-air damper if air less than **38 deg F (3 deg C)** enters coils.
 - b. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.
 - c. Unoccupied-Period-Override Operation: **[Two]<Insert number>** hours.
 - d. Dual-Temperature Coil Operation:
 - 1) Occupied Periods: When chilled water is available, **[open][modulate]** control valve if room temperature exceeds thermostat set point. When hot water is available, **[open][modulate]** control valve if room temperature falls below thermostat set point.
 - 2) Unoccupied Periods: When chilled water is available, close control valve. When hot water is available, **[open][modulate]** control valve if room temperature falls below thermostat setback temperature.
 - e. Hydronic Cooling-Coil Operation:
 - 1) Occupied Periods: **[Open][Modulate]** control valve to provide cooling if room temperature exceeds thermostat set point.
 - 2) Unoccupied Periods: Close control valve.
 - f. Refrigerant-Coil Operation:
 - 1) Occupied Periods: Start compressor to maintain room temperature.
 - 2) Unoccupied Periods: **[Stop compressor cooling][Cycle compressor for heating to maintain setback temperature]**.
 - g. Supplemental Heating-Coil Operation:
 - 1) Occupied Periods: **[Open control valve][Modulate control valve][Energize electric-resistance coil]** to provide heating if room temperature falls below thermostat set point.
 - 2) Unoccupied Periods: Start fan and **[open control valve][modulate control valve][energize electric-resistance coil]** if room temperature falls below setback temperature.
 - 3) Switch refrigerant-reversing valve to operate supplemental coil for heating when outdoor temperature is below **[25 deg F (4 deg C)]<Insert temperature>**.
 - h. Reheat-Coil Operation:
 - 1) Humidity Control for Occupied Periods: Humidistat **[opens control valve][modulates control valve][energizes electric-resistance coil]** to provide heating. As room temperature rises above set point, cooling-coil valve **[opens][modulates]** to maintain room temperature.
 - 2) Humidity Control for Unoccupied Periods: **[Close control valve][De-energize]**.
 - i. Outdoor-Air Damper Operation:

- 1) Open to **[25]<Insert number>** percent fixed minimum intake during occupied periods, and close during unoccupied periods.
- 2) Open to **[25]<Insert number>** percent fixed minimum intake, and maximum 100 percent of the fan capacity to comply with ASHRAE Cycle II during occupied periods, and close during unoccupied periods. Microprocessor controller shall permit air-side economizer operation when outdoor air is less than **[60 deg F (15 deg C)]<Insert temperature>**.
- j. Carbon Dioxide Sensor Operation: During occupied periods, reset minimum outdoor-air ratio down to minimum **[10]<Insert number>** percent to maintain maximum **[800-ppm]<Insert value>** concentration.
- k. Face-and-Bypass Damper Operation: Position damper to face of coils until room temperature equals thermostat set point; bypass after room-temperature set point is achieved.
- l. Cooling Lockout: During economizer cycle operation, block out cooling.
- m. HGBP: Open HGBP solenoid valve to maintain minimum suction pressure at compressor.
- n. Energy Recovery Wheel Operation:
 - 1) Factory-mounted and -wired, starting relay and manual motor starter for field wiring.
 - 2) Occupied period is established by **[remote signal][room occupancy sensor]**.
 - 3) Energy recovery wheel and inlet and discharge fans operate during occupied periods after room temperature set point has been achieved.
 - 4) Energy recovery wheel operates during occupied periods, but stops when unit ventilator controls call for cooling, and outdoor-air temperatures permit free air cooling.
 - 5) Energy recovery wheel and fans stop during unoccupied periods.
- o. Controller shall have volatile-memory backup.
4. Building Automation System (BAS) Interface Requirements:
 - a. Interface relay for scheduled operation.
 - b. Interface relay to provide indication of fault at the central workstation.
 - c. Provide **[BACnet][or][LonWorks]** interface for central BAS workstation for the following functions:
 - 1) Adjust set points.
 - 2) Unit ventilator start, stop, and operating status.
 - 3) Data inquiry to include **[outdoor-air damper position]**, supply- and room-air temperature **[and humidity]**.
 - 4) Occupied and unoccupied schedules.
5. Electrical Connection: Factory wire motors and controls for a single electrical connection.

2.3 METAL SHELVES AND CABINETS

- A. Include manufacturer's standard cabinets to match unit ventilators with required installation hardware as indicated:
 1. Open Shelving with Reinforced Shelves:
 - a. **[Return-air plenum][Radiation enclosure]** and aluminum bar grille with finish to match unit ventilator grille.
 - b. Through-piping enclosure with solid top.

2. Closed Shelving with Reinforced Shelves:
 - a. **[Return-air plenum][Radiation enclosure]** and aluminum bar grille with finish to match unit ventilator grille.
 - b. Through-piping enclosure with solid top.
 - c. Two sliding doors with key-operated locks.
 3. Utility compartment with access panel with key-operated lock.
 4. Wall and corner filler sections, and end panels finished to match shelving.
- B. Painted Finish: Manufacturer's **[standard][custom]** baked enamel, in color selected by Architect, applied to shelving before shipping.
- C. Cabinet Top: Plastic-laminate top in color and pattern selected by Architect from manufacturer's **[standard][custom]** colors.

2.4 CAPACITIES AND CHARACTERISTICS

- A. Fan:
1. Airflow: **<Insert cfm (L/s)>**.
 2. External Static Pressure: **<Insert inches wg (kPa)>**.
 3. Fan Speed: **<Insert rpm>**.
 4. Motor Horsepower: **<Insert horsepower>**.
 5. Drive: **[Direct][Belt]**.
- B. Cooling Capacity:
1. Total: **<Insert Btu/h (kW)>**.
 2. Sensible: **<Insert Btu/h (kW)>**.
 3. Entering-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
 4. Entering-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
- C. Chilled-Water Coil:
1. Water Flow: **<Insert gpm (L/s)>**.
 2. Water-Side Pressure Loss: **<Insert feet wg (kPa)>**.
 3. Entering-Water Temperature: **<Insert deg F (deg C)>**.
 4. Air-Side Pressure Drop: **<Insert inches wg (kPa)>**.
- D. Refrigerant Coil:
1. Suction Temperature: **<Insert deg F (deg C)>**.
 2. Air-Side Pressure Drop: **<Insert inches wg (kPa)>**.
- E. Condensing Unit:
1. Ambient Temperature: **<Insert deg F (deg C)>**.
 2. Compressor Power Input: **<Insert kilowatts>**.
 3. Cooling Energy Efficiency: **<Insert value>**. **[EER][SEER]**.
 4. Heating Coefficient of Performance: **<Insert value>**.
 5. Voltage/Phase/Hertz: **<Insert values>**.
 6. Full-Load Amperes: **<Insert value>**.
 7. Maximum Circuit Amperes: **<Insert value>**.
 8. Maximum Overcurrent Protection: **<Insert amperage>**.

- F. Heating Capacity:
1. Output: **<Insert Btu/h (kW)>**.
 2. Entering-Air Temperature: **<Insert deg F (deg C)>**.
 3. Air-Temperature Rise: **<Insert deg F (deg C)>**.
- G. Hot-Water Heating Coil:
1. Water Flow: **<Insert gpm (L/s)>**.
 2. Water-Side Pressure Loss: **<Insert feet wg (kPa)>**.
 3. Air-Side Pressure Drop: **<Insert inches wg (kPa)>**.
 4. Entering-Water Temperature: **<Insert deg F (deg C)>**.
- H. Steam Heating Coil:
1. Inlet Steam Pressure: **<Insert psig (kPa)>**.
 2. Condensing Capacity: **<Insert lb/h (g/s)>**.
 3. Air-Side Pressure Drop: **<Insert inches wg (kPa)>**.
- I. Electric-Resistance Heating Coil:
1. Capacity: **<Insert kilowatts>**.
 2. Number of Steps: **<Insert number>**.
 3. Air-Side Pressure Drop: **<Insert inches wg (kPa)>**.
- J. Reheat Capacity:
1. Output: **<Insert Btu/h (kW)>**.
 2. Entering-Air Temperature: **<Insert deg F (deg C)>**.
 3. Air-Temperature Rise: **<Insert deg F (deg C)>**.
- K. Filters:
1. Type: **[Washable foam][Coated glass fiber][Pleated cotton-polyester media]**.
 2. Maximum Face Velocity: **<Insert fpm (m/s)>**.
 3. Thickness: **[1 inch (25 mm)][2 inches (50 mm)]<Insert dimension>**.
- L. Energy Recovery Exhaust:
1. Airflow: **<Insert cfm (L/s)>**.
 2. Entering-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
 3. Entering-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
 4. Leaving-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
 5. Leaving-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
 6. Air-Side Pressure Drop: **<Insert inches wg (kPa)>**.
 7. Fan Motor Horsepower: **<Insert horsepower>**.
- M. Energy Recovery Outdoor Air:
1. Airflow: **<Insert cfm (L/s)>**.
 2. Entering-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
 3. Entering-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
 4. Leaving-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
 5. Leaving-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
 6. Air-Side Pressure Drop: **<Insert inches wg (kPa)>**.

- 7. Motor Horsepower: **<Insert horsepower>**.
- N. Energy Recovery Wheel:
 - 1. Heat-Transfer Efficiency: **<Insert percent>**.
 - 2. Drive Motor Horsepower: **<Insert horsepower>**.
- O. Electrical Characteristics for Single-Point Connection:
 - 1. Voltage/Phase/Hertz: **<Insert values>**.
 - 2. Full-Load Amperes: **<Insert value>**.
 - 3. Maximum Circuit Amperes: **<Insert value>**.
 - 4. Maximum Overcurrent Protection: **<Insert amperage>**.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas, with Installer present, to receive unit ventilators for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping and electrical connections to verify actual locations before unit ventilator installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF UNIT VENTILATORS

- A. Install unit ventilators to comply with NFPA 90A.
- B. Suspend horizontal unit ventilators from structure with threaded steel rods and minimum **[0.25-inch (6.35-mm) static-deflection, elastomeric vibration isolation hanger][1.0-inch (25-mm) static-deflection spring hangers]**. Vibration isolators are specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."
- C. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices **[48 inches (1220 mm)][60 inches (1525 mm)]<Insert dimension>** above finished floor.
- D. Comply with requirements in Section 236200 "Packaged Compressor and Condenser Units" for condensing units matched to refrigerant cooling coil packaged in unit ventilators.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
 - 1. Install piping adjacent to machine to allow service and maintenance.
 - 2. Connect piping to unit ventilator factory hydronic piping package. Install piping package if shipped loose.
 - 3. Connect condensate drain to indirect waste.



- B. Install refrigerant piping as required by Section 232300 "Refrigerant Piping," and add refrigerant as required to compensate for length of piping.
- C. Connect supply-air and return-air ducts to unit ventilators with flexible duct connectors specified in Section 233300 "Air Duct Accessories." Comply with safety requirements in UL 1995 for duct connections.
- D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections **[with the assistance of a factory-authorized service representative]**:
 - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
 - 3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
 - 4. Record temperatures entering and leaving energy recovery wheel when outdoor-air temperature is a minimum of **15 deg F (8.3 deg C)** higher, or **20 deg F (11 deg C)** lower, than room temperature.
- D. Remove and replace malfunctioning units and retest as specified above.
- E. Prepare test and inspection reports.

3.5 ADJUSTING

- A. Adjust initial temperature and humidity set points.
- B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to **[two]<Insert number>** visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

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

END OF SECTION 23 74 16 13B



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 74 16 13	23 74 00 00	Outdoor, Semi-Custom Air-Handling Units
23 74 16 13	23 74 00 00a	Outdoor, Custom Air-Handling Units
23 74 16 13	23 74 00 00b	Dedicated Outdoor-Air Units



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SECTION 23 74 23 00 - PACKAGED, INDIRECT-FIRED, OUTDOOR, HEATING-ONLY MAKEUP-AIR UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Packaged, indirect-fired, outdoor, heating-only makeup air units.

1.2 ACTION SUBMITTALS

A. Product Data: For each outdoor, indirect, gas-fired, heating-only, makeup air unit.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Include unit dimensions and weight.
4. Fans:
 - a. Include certified fan-performance curves with system operating conditions indicated.
 - b. Include certified fan-sound power ratings.
 - c. Include fan construction and accessories.
 - d. Include motor ratings, electrical characteristics, and motor accessories.
5. Include filters with performance characteristics.
6. Include direct, gas-fired burners with performance characteristics.
7. Include dampers, including housings, linkages, and operators.

B. Sustainable Design Submittals:

1. Product data showing compliance with ASHRAE 62.1.
2. Product Data: For air filtration performance.
3. Product Data: For adhesives, mastics, and sealants, indicating VOC content.
4. Laboratory Test Reports: For adhesives, mastics, and sealants, indicating compliance with requirements for low-emitting materials.

C. Shop Drawings: For each outdoor, indirect, gas-fired heating and ventilating unit.

1. Include plans, elevations, sections, and **[mounting][attachment]** details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of gas-fired heating and ventilating units, as well as procedures and diagrams.
4. Include diagrams for power, signal, and control wiring.

D. Delegated Design Submittal: For vibration isolation **[and seismic restraints]** indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the

qualified professional engineer responsible for their preparation.

1. Include design calculations for selecting vibration isolators[**and seismic restraints**] and for designing vibration isolation bases.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
- B. Sample Warranty: For manufacturer's warranty.
- C. Seismic Qualification Data: Certificates, for outdoor, indirect, gas-fired, makeup air units, accessories, and components, from manufacturer.
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
 4. Restraint of internal components.
- D. Product Certificates: Submit certification that specified equipment will withstand wind forces identified in "Performance Requirements" Article and in Section 230548 "Vibration and Seismic Controls for HVAC."
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of wind force and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- E. Startup service reports.
- F. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For indirect, gas-fired, makeup air units to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Filters: **[One]<Insert number>** set(s) for each unit.
 2. Gaskets: **[One]<Insert number>** set(s) for each access door.
 3. Fan Belts: **[One]<Insert number>** set(s) for each unit.

1.6 WARRANTY

- A. Warranty: Manufacturer agrees to repair or replace components of indirect, gas-fired heating and ventilating units that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Entire Unit: Manufacturer's standard, but not less than **[one]<Insert number>** year(s) from date of Substantial Completion.
 - 2. Warranty Period for Heat Exchangers: Not less than **[five]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of units and components.
- C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- E. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation[**and seismic restraints**], including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- F. Seismic Performance: Indoor, indirect gas-fired, heating and ventilating units shall withstand the effects of earthquake motions determined according to **[ASCE/SEI 7]<Insert requirement>**.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."
 - 2. Component Importance Factor: **[1.5][1.0]**.
 - 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.

2.2 CAPACITIES AND CHARACTERISTICS

- A. Fan:
 - 1. Discharge Configuration: **[Horizontal][Vertical]**.
 - 2. Airflow in CFM (L/s): **<Insert quantity>**.
 - 3. External Static Pressure: **<Insert inches wg (kPa)>**.
 - 4. Maximum RPM: **<Insert number>**.
 - 5. Minimum Size: **<Insert inches (mm)>**.
 - 6. Altitude: **<Insert feet (m)>**.

B. Fan Motor:

1. Horsepower: **<Insert value>**.
2. RPM: **<Insert value>**.
3. Service Factor: **<Insert value>**.
4. Speed: **[Single][Two]**.

C. Single-Point Electrical Connection:

1. Volts: **[120][240][277][480]<Insert value> V**.
2. Phase: **[Single][Three]**.
3. Hertz: 60.
4. Full-Load Amperes: **<Insert value> A**.
5. Minimum Circuit Ampacity: **<Insert value> A**.
6. Maximum Overcurrent Protection: **<Insert value> A**.

D. Indirect-Fired Gas Burner:

1. Minimum Combustion Efficiency: **<Insert percentage>**.
2. Entering-Air Temperature: **<Insert deg F (deg C)>**.
3. Leaving-Air Temperature: **<Insert deg F (deg C)>**.
4. Airflow: **<Insert cfm (L/s)>**.
5. Gas Input: **<Insert MBh (kW)>**.
6. Burner Output: **<Insert MBh (kW)>**.
7. Number of Stages: **<Insert value>**.
8. Minimum Inlet Pressure: **<Insert inches wg (Pa)>**.
9. Maximum Inlet Pressure: **<Insert inches wg (Pa)>**.
10. Gas Piping Connection Size: **<Insert NPS (DN)>**.
11. Vent Diameter: **<Insert inches (mm)>**.

E. Filters:

1. Type: **<Insert type>**.
2. Face Dimensions, Each: **<Insert inches by inches (mm by mm)>**.
3. Depth: **<Insert inches (mm)>**.
4. Number of Filters in Filter Bank: **<Insert number>** wide by **<Insert number>** high.
5. Access Location: **[Side]<Insert location>**.
6. Maximum or Rated Face Velocity: **<Insert fpm (m/s)>**.
7. Initial Resistance: **<Insert inches wg (Pa)>**.
8. Recommended Final Resistance: **<Insert inches wg (Pa)>**.
9. Minimum Efficiency Reporting Value and Average Arrestance:
 - a. MERV Rating and Corresponding Average Arrestance: **[MERV 1][MERV 2][MERV 3][MERV 4]**, and corresponding average arrestance according to ASHRAE 52.2.
10. Minimum Efficiency Reporting Value:
 - a. MERV Rating: **[MERV 6][MERV 13]<Insert value>**, according to ASHRAE 52.2.

2.3 PACKAGED, INDIRECT-FIRED, OUTDOOR, HEATING-ONLY MAKEUP-AIR UNITS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide**

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

1. [AbsolutAire, Inc.]
2. [Applied Air, a Mestek company]
3. [Banza; a brand of Specified Air Solutions]
4. [BessamAire, Inc.]
5. [Cambridge Air Solutions]
6. [Cambridge Engineering, Inc]
7. [CaptiveAire Systems]
8. [Des Champs Technologies]
9. [Energy Jet U.S.]
10. [Engineered Air]
11. [Greenheck Fan Corporation]
12. [Hastings HVAC]
13. [I.C.E. Manufacturing Ltd.; Industrial Commercial Equipment - I.C.E. (US), Inc.]
14. [Jackson & Church HVAC Global]
15. [LCSysytems]
16. [Modine Manufacturing Company]
17. [Nortek Air Solutions]
18. [Powrmatic, Inc.]
19. [Rapid Engineering, Inc.]
20. [REZNOR, a brand of Nortek Global HVAC]
21. [Sterling HVAC Products; a Mestek company]
22. [Temprite, a brand of Mestek]
23. [Titan Air]
24. [Trane Inc.]
25. [Weather-Rite, a brand of Specified Air Solutions]
26. <Insert manufacturer's name>

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

1. [AbsolutAire, Inc.]
2. [Applied Air, a Mestek company]
3. [Banza; a brand of Specified Air Solutions]
4. [BessamAire, Inc.]
5. [Cambridge Air Solutions]
6. [Cambridge Engineering, Inc]
7. [CaptiveAire Systems]
8. [Des Champs Technologies]
9. [Energy Jet U.S.]
10. [Engineered Air]
11. [Greenheck Fan Corporation]
12. [Hastings HVAC]
13. [I.C.E. Manufacturing Ltd.; Industrial Commercial Equipment - I.C.E. (US), Inc.]
14. [Jackson & Church HVAC Global]
15. [LCSysytems]
16. [Modine Manufacturing Company]
17. [Nortek Air Solutions]
18. [Powrmatic, Inc.]
19. [Rapid Engineering, Inc.]
20. [REZNOR, a brand of Nortek Global HVAC]
21. [Sterling HVAC Products; a Mestek company]
22. [Temprite, a brand of Mestek]

**Packaged, Indirect-Fired, Outdoor, Heating-Only Makeup-
Air Units**

- 23. [Titan Air]
- 24. [Trane Inc.]
- 25. [Weather-Rite, a brand of Specified Air Solutions]
- 26. <Insert manufacturer's name>

C. Unit Casings:

- 1. General Fabrication Requirements for Casings:
 - a. Forming: Form walls, roofs, and floors with at least two breaks at each joint.
 - b. Casing Joints: Sheet metal screws or pop rivets, factory sealed with water-resistant sealant.
 - c. Makeup Air Unit Mounting Frame: Formed galvanized-steel channel or structural channel supports, designed for low deflection, welded with integral lifting lugs.
- 2. Configuration: Horizontal unit with [top][horizontal][bottom] discharge for [roof-mounting][concrete-base] installation.
- 3. Double-Wall Construction:
 - a. Outside Casing Wall: [Galvanized steel]<Insert material>, minimum [18 gauge (1.3 mm)]<Insert value> thick, with [manufacturer's standard finish]<Insert special coating>.
 - b. Inside Casing Wall:
 - 1) Inside Casing, Burner Section: [Galvanized steel]<Insert material>, solid, minimum [14-gauge (0.759-mm)]<Insert number> thick steel.
 - 2) Inside Casing, All Other Sections: [Galvanized steel]<Insert material>[solid][perforated] steel.
 - c. Floor Plate: [Galvanized steel]<Insert material>, minimum [18 gauge (1.3 mm)]<Insert value> thick.
 - d. Casing Insulation:
 - 1) Materials: [Glass-fiber blanket or board insulation, Type I or Type II ASTM C1071]<Insert insulation type>.
 - 2) Casing Panel R-Value: Minimum <Insert value>.
 - 3) Insulation Thickness: [1 inch (25 mm)][2 inches (50 mm)].
 - 4) Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roof of unit.
 - e. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.
- 4. Panels and Doors:
 - a. Panels:
 - 1) Fabrication: Formed and reinforced, with same materials and insulation thickness as casing.
 - 2) Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against airflow.
 - 3) Gasket: Neoprene, applied around entire perimeters of panel frames.
 - 4) Size: Large enough to allow unobstructed access for inspection and maintenance of unit's internal components.

- b. Doors:
 - 1) Fabrication: Formed and reinforced with same materials and insulation thickness as casing.
 - 2) Hinges: A minimum of two ball-bearing hinges or stainless steel piano hinge and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against airflow. Provide safety latch retainers on doors so that doors do not open uncontrollably.
 - 3) Gasket: Neoprene, applied around entire perimeters of panel frames.
 - 4) Size: Large enough to allow unobstructed access for inspection and maintenance of unit's internal components.
- c. Locations and Applications:
 - 1) Fan Section: **[Inspection and access panels][Doors][Doors and inspection and access panels]**.
 - 2) Access Section: Doors.
 - 3) Gas-Fired Burner Section: **[Inspection and access panels][Doors]**.
 - 4) Damper Section: **[Inspection and access panels][Doors]**.
 - 5) Filter Section: **[Inspection and access panels][Doors]** large enough to allow periodic removal and installation of filters.
 - 6) Mixing Section: Doors.
- d. Service Light: 100-W vaporproof fixture with switched junction box located **[outside][inside]** adjacent to door.
 - 1) Locations: **[Each section accessed with door][Fan section]<Insert location>**.

D. Outdoor-Air Intake Hood:

- 1. Type: Manufacturer's standard hood or louver.
- 2. Materials: Match cabinet.
- 3. Bird Screen: Comply with requirements in ASHRAE 62.1.
- 4. Filter: Aluminum, **1 inch (25 mm)** cleanable.
- 5. Configuration: Designed to inhibit wind-driven rain and snow from entering unit.

E. Roof Curbs:

- 1. Roof curbs with vibration isolators and wind or seismic restraints are specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 2. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.
- a. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
 - 1) Materials: ASTM C 1071, Type I or Type II.
 - 2) Thickness: **[1 inch (25 mm)][1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension>**.
 - b. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.
 - 1) Liner Adhesive: Comply with ASTM C 916, Type I.
 - 2) Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when

Packaged, Indirect-Fired, Outdoor, Heating-Only Makeup-



- 3) applied as recommended by manufacturer and without causing leakage in cabinet. Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.

3. Curb Height: **[14 inches (355 mm)][24 inches (610 mm)][36 inches (910 mm)]<Insert dimension>**.
4. Wind and Seismic Restraints: Metal brackets compatible with the curb and casing, painted to match unit, used to anchor unit to the curb, and designed for loads at Project site. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for wind-load requirements.

F. Fans, Drives, and Motors:

1. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.
2. Fans: Centrifugal, rated according to AMCA 210; galvanized steel; mounted on solid-steel shaft.
 - a. Shafts: With field-adjustable alignment.
 - b. Shaft Bearings: Heavy-duty[, **self-aligning, permanently lubricated ball bearings**][, **pillow-block bearings**] with an **[L50]<Insert bearing life rating>** rated life of **[100,000]<Insert number>** hours according to ABMA 9.
 - c. Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.
 - d. Mounting: For internal vibration isolation[**and seismic control**]. Factory-mount fans with manufacturer's standard[**restrained**] vibration isolation mounting devices having a minimum static deflection of **[1 inch (25 mm)]<Insert dimension>**.
 - e. Shaft Lubrication Lines: Extended to a location outside the casing.
 - f. Flexible Connector: Factory fabricated with a fabric strip minimum **3-1/2 inches (89 mm)** wide, attached to two strips of minimum **2-3/4-inch- (70-mm-)** wide by **0.028-inch- (0.7-mm-)** thick, galvanized-steel sheet.
 - 1) Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.
3. Drives: Factory-mounted V-belt drive, with adjustable alignment and belt tensioning, and with **[1.5][1.25]** service factor based on fan motor.
 - a. Pulleys: Cast iron or cast steel with split, tapered bushing, dynamically balanced at the factory.
 - b. Belts: Oil resistant, non-sparking and nonstatic; in matched sets for multiple-belt drives.
 - c. Belt Guards: Comply with requirements specified by OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards"; **[0.146-inch- (2.7-mm-)]<Insert dimension>** thick, **[3/4-inch (20-mm)]<Insert dimension>** diamond-mesh wire screen, welded to steel angle frame; prime coated.
4. Motors:
 - a. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - b. Motor Sizes: Maximum sizes as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - c. Enclosure: **[Open, dripproof][Totally enclosed, fan cooled]<Insert type>**.
 - d. Enclosure Materials: **[Cast iron]<Insert material>**.

- e. Motor Bearings: **<Insert requirements>**.
- f. Unusual Service Conditions:
 - 1) Ambient Temperature: **<Insert deg C>**.
 - 2) Altitude: **<Insert feet (m)>** above sea level.
 - 3) High humidity.
 - 4) **<Insert conditions>**.
- g. Efficiency: Premium efficient as defined in NEMA MG 1.
- h. NEMA Design: **<Insert designation>**.
- i. Motor Pulleys: Adjustable pitch for use with **[5]<Insert number>**-hp motors and smaller; fixed pitch for use with motors larger than **[5]<Insert number>** hp. Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions.

G. Air Filtration:

- 1. Particulate air filtration is specified in Section 234100 "Particulate Air Filtration."
- 2. Panel Filters:
 - a. Description: **[Flat, non-pleated][Pleated]** factory-fabricated, self-supported, disposable air filters with holding frames.
 - b. Filter Unit Class: UL 900.
 - c. Media: Interlaced glass, synthetic or cotton fibers coated with nonflammable adhesive and antimicrobial coating.
 - d. Filter-Media Frame: **[Beverage board]<Insert material>** with perforated metal retainer, or metal grid, on outlet side.
- 3. Cleanable Filters:
 - a. Cleanable metal mesh.
- 4. Adhesive, Sustainability Projects: As recommended by air-filter manufacturer and with a VOC content of 80 g/L or less.
- 5. Adhesive, LEED for Schools Projects: As recommended by air-filter manufacturer and that complies with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- 6. Side-Access Filter Mounting Frames:
 - a. Particulate Air Filter Frames: Match inner casing and outer casing material, and insulation thickness. **[Galvanized steel]<Insert material>** track.
 - 1) Sealing: Incorporate positive-sealing device to ensure seal between gasketed material on channels to seal top and bottom of filter cartridge frames to prevent bypass of unfiltered air.

H. Dampers:

- 1. Comply with requirements in Section 230923.12 "Control Dampers."
- 2. Outdoor- and Return-Air Dampers: Low-leakage, double-skin, airfoil-blade, **[galvanized-steel]<Insert material>** dampers with compressible jamb seals and extruded-vinyl blade edge seals in **[opposed][parallel]**-blade arrangement with **[zinc-plated]** steel operating rods rotating in **[sintered bronze or nylon]<Insert material>** bearings mounted in a single **[galvanized-steel]<Insert material>** frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed **4 cfm/sq. ft. (20 L/s per sq. m)** at 1-inch wg (**250 Pa**) and 8

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Air Units

- cfm/sq. ft. (40 L/s per sq. m) at 4-inch wg (1.0 MPa) rated in accordance with AMCA 500D).**
3. Damper Operators: Comply with requirements in Section 230923.12 "Control Dampers."
 4. Electronic Damper Operators:
 - a. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
 - b. Electronic damper position indicator shall have visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
 - c. Operator Motors:
 - 1) Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - 2) Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
 - 3) Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
 - d. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running torque of **150 in. x lbf (16.9 N x m)** and breakaway torque of **300 in. x lbf (33.9 N x m)**.
 - e. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running and breakaway torque of **150 in. x lbf (16.9 N x m)**.
 - f. Size dampers for running torque calculated as follows:
 - 1) Parallel-Blade Damper with Edge Seals: **7 inch-lb/sq. ft. (86.8 kg-cm/sq. m)** of damper.
 - 2) Opposed-Blade Damper with Edge Seals: **5 inch-lb/sq. ft. (62 kg-cm/sq. m)** of damper.
 - 3) Parallel-Blade Damper without Edge Seals: **4 inch-lb/sq. ft (49.6 kg-cm/sq. m)** of damper.
 - 4) Opposed-Blade Damper without Edge Seals: **3 inch-lb/sq. ft. (37.2 kg-cm/sq. m)** of damper.
 - 5) Dampers with 2- to 3-Inch wg (500 to 750 Pa) of Pressure Drop or Face Velocities of 1000 to 2500 fpm (5 to 13 m/s): Increase running torque by 1.5.
 - 6) Dampers with 3- to 4-Inch wg (750 to 1000 Pa) of Pressure Drop or Face Velocities of 2500 to 3000 fpm (13 to 15 m/s): Increase running torque by 2.0.
 - g. Coupling: V-bolt and V-shaped, toothed cradle.
 - h. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
 - i. Fail-Safe Operation: Mechanical, spring-return mechanism with external, manual gear release on nonspring-return actuators.
 - j. Power Requirements (Two-Position Spring Return): **[24 V dc][120 V ac][230 V ac]**.
 - k. Power Requirements (Modulating): Maximum 10 VA at 24 V ac or 8 W at 24 V dc.
 - l. Proportional Signal: 2 to 10 V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
 - m. Temperature Rating: **[Minus 22 to plus 122 deg F (Minus 30 to plus 50 deg C)][40 to 104 deg F (5 to 40 deg C)]**.
 - n. Run Time: **[12 seconds open, 5 seconds closed][30 seconds][60 seconds][120 seconds]**.
 - I. Indirect-Fired Gas Burner:
 1. Description: Factory assembled, piped, and wired; and complying with ANSI Z21.47 and with NFPA 54.

2. CSA Approval: Designed and certified by and bearing label of CSA.
 3. Burners: **[Aluminized steel with stainless steel inserts][Stainless steel]**.
 - a. Rated Minimum Turndown Ratio: **[30 to 1]<Insert ratio>**.
 - b. Fuel: **[Natural][Propane]** gas.
 - c. Ignition: Electronically controlled electric spark with flame sensor.
 - d. Gas Control Valve: **[Single stage][Two stage][Modulating]**.
 - e. Gas Train: Regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, **[hydraulic][electronic]**-modulating temperature control valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.
 - f. High-Altitude Model Kit: For Project elevations more than **2000 feet (610 m)** above sea level.
 4. Venting, Gravity: Gravity vented.
 5. Venting, Power: Power vented, with integral, motorized centrifugal fan interlocked with gas valve.
 6. Heat Exchanger: **[Aluminized][Stainless]** steel.
 7. Heat-Exchanger Drain Pan: Stainless steel.
 8. Safety Controls:
 - a. Gas Manifold: Safety switches and controls complying with ANSI standards **[and][FM Global]<Insert insurer>**.
 - b. Vent Flow Verification: **[Differential pressure switch to verify open vent][Flame rollout switch]**.
 - c. High Limit: Thermal switch or fuse to stop burner.
 - d. Purge-period timer shall automatically delay burner ignition and bypass low-limit control.
 - e. Airflow Proving Switch: Differential pressure switch senses correct airflow before energizing pilot.
 - f. Automatic-Reset, High-Limit Control Device: Stops burner and closes main gas valve if high-limit temperature is exceeded.
 - g. Safety Lockout Switch: Locks out ignition sequence if burner fails to light after three tries. Controls are reset manually by turning the unit off and on.
 - h. Control Transformer: 24 V ac.
- J. Unit Control Panel:
1. Factory-wired, fuse-protected control transformer, connection for power supply and field-wired unit to remote control panel.
 2. Control Panel: **[Surface-mounted][Recessed, with trim ring,]** remote panel, with engraved plastic cover and the following lights and switches:
 - a. **[On-off][On-off-auto]** fan switch.
 - b. Heat-vent-off switch.
 - c. Supply-fan operation indicating light.
 - d. Heating operation indicating light.
 - e. Thermostat.
 - f. Damper position potentiometer.
 - g. Dirty-filter indicating light operated by unit-mounted differential pressure switch.
 - h. Safety-lockout indicating light.
 - i. Enclosure: NEMA 250, **[Type 1][Type 3R][Type 4][Explosion proof]**.

K. Controls:

1. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC" for control equipment and sequence of operation.

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2. Control Devices:
 - a. Remote Thermostat: Adjustable room thermostat with temperature readout.
 - b. Remote Setback Thermostat: Adjustable room thermostat without temperature readout.
 - c. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
 - d. Fire-Protection Thermostats: Fixed or adjustable settings to operate at not less than **75 deg F (24 deg C)** above normal maximum operating temperature.
 - e. Timers, Seven Day:
 - 1) Programming-switch timer with synchronous-timing motor and seven-day dial.
 - 2) Continuously charged, nickel-cadmium-battery-driven, eight-hour, power-failure carryover.
 - 3) Multiple-switch trippers.
 - 4) Minimum of two and maximum of eight signals per day with two normally open and two normally closed output contacts.
 - f. Timers, Solid State:
 - 1) Programmable time control with four separate programs.
 - 2) 24-hour battery carryover; individual on-off-auto switches for each program.
 - 3) 365-day calendar with 20 programmable holidays.
 - 4) Choice of fail-safe operation for each program.
 - 5) System fault alarm.
 - g. Ionization-Type Smoke Detectors:
 - 1) 24-V dc, nominal.
 - 2) Self-restoring.
 - 3) Plug-in arrangement.
 - 4) Integral visual-indicating light.
 - 5) Sensitivity that can be tested and adjusted in place after installation.
 - 6) Integral addressable module.
 - 7) Remote controllability.
 - 8) Responsive to both visible and invisible products of combustion.
 - 9) Self-compensating for changes in environmental conditions.
3. Fan Control, Interlocked: Fan to start automatically with exhaust fan(s) to which this heating and ventilating unit is associated for makeup air.
4. Fan Control, Timer: Timer starts and stops indirect-fired heating and ventilating unit and exhaust fan(s).
5. Outdoor-Air Damper Control, 100 Percent Outdoor-Air Units: Outdoor-air damper shall open when supply fan starts, and close when fan stops.
6. Mixed Outdoor- and Return-Air Damper Control: When fan is running, outdoor- and return-air dampers shall modulate to supply minimum outdoor air as follows:
 - a. Minimum **[30]<Insert number>** percent outdoor air.
 - b. Outdoor-air quantity adjusted by potentiometer on control panel.
 - c. Outdoor-air quantity to maintain minimum building static pressure.
7. Temperature Control:
 - a. Operates gas valve to maintain discharge-air temperature with factory-mounted sensor in blower outlet.

- b. Operates gas valve to maintain space temperature with wall-mounting, field-wired sensor[**with temperature adjustment**],[**and unit-mounted control adjustment**][**and adjustment on remote-control panel**].
 - c. Timer shall select remote setback thermostat to maintain space temperature at [50 deg F (10 deg C)]<Insert temperature>.
 - d. Burner Control, Stepped: Two or four steps of control using one or two burner sections in series.
 - e. Burner Control, Modulating: 20 to 100 percent modulation of the firing rate. 10 to 100 percent with dual burner units.
- 8. Interface with DDC System for HVAC: Factory-installed hardware and software to enable the DDC system for HVAC to monitor, control, and display status and alarms of heating and ventilating unit.
 - a. Hardwired Points:
 - 1) Room temperature.
 - 2) Discharge-air temperature.
 - 3) Burner operating.
 - b. [ASHRAE 135.1 (BACnet)][LonTalk][Modbus][Industry-accepted, open-protocol]<Insert type of interface> communication interface with the DDC system for HVAC shall enable the DDC system for HVAC operator to remotely control and monitor the heating and ventilating unit from an operator workstation. Control features and monitoring points displayed locally at heating and ventilating unit control panel shall be available through the DDC system for HVAC.

L. Accessories:

- 1. Electric heater with integral thermostat maintains minimum **50 deg F (10 deg C)** temperature in gas burner compartment.
- 2. Duplex, 115-V, ground-fault-interrupter outlet with 15-A overcurrent protection. Include transformer if required. [**Outlet shall be energized even if the unit main disconnect is open.**]
- 3. Low-ambient kit using [staged][damper on][variable-speed] condenser fans for operation down to [35 deg F (1.7 deg C)]<Insert temperature>.
- 4. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure loss.
- 5. Coil guards of painted, galvanized-steel wire.
- 6. Hail guards of galvanized steel, painted to match casing.

2.4 MATERIALS

A. Steel:

- 1. ASTM A36/A36M for carbon structural steel.
- 2. ASTM A568/A568M for steel sheet.

B. Stainless Steel:

- 1. Manufacturer's standard grade for casing.
- 2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653/A653M.

Packaged, Indirect-Fired, Outdoor, Heating-Only Makeup-Air Units

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping, ducts, and electrical systems to verify actual locations of connections before equipment installation.
- C. Verify cleanliness of airflow path to include inner-casing surfaces, filters, coils, turning vanes, fan wheels, and other components.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF PACKAGED, INDIRECT-FIRED, OUTDOOR, HEATING-ONLY MAKEUP-AIR UNITS

- A. Roof Curb: Install on roof structure or concrete base, level and secure, according to **[NRCA's "NRCA Roofing Manual: Membrane Roof Systems."]****[AHRI Guideline B.]** Install units on curbs and coordinate roof penetrations and flashing with roof construction specified in Section 077200 "Roof Accessories." Secure units to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts. Coordinate sizes and locations of roof curbs with actual equipment.
- B. Unit Support: Install unit level on structural **[curbs][steel supports]**. Coordinate roof penetrations and flashing with roof construction. Secure units to structural support with anchor bolts. Coordinate sizes and locations of **[curbs][steel supports]** with actual equipment provided.
 - 1. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 2. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- C. Install gas-fired units in accordance with NFPA 54.
- D. Install controls and equipment shipped by manufacturer for field installation with indirect, gas-fired heating and ventilating units.

3.3 PIPING CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
 - 1. Gas Piping: Comply with requirements in **[Section 231123 "Facility Natural-Gas Piping."]****[Section 231126 "Facility Liquefied-Petroleum Gas Piping."]** Connect gas piping with shutoff valve and union, and with sufficient clearance for burner removal and service. Make final connections of gas piping to unit with corrugated, stainless steel tubing flexible connectors complying with ANSI LC 1/CSA 6.26 equipment connections.
- B. Drain: Comply with requirements in Section 221316 "Sanitary Waste and Vent Piping" for traps and accessories on piping connections to condensate drain pans under condensing heat exchangers.

- C. Where installing piping adjacent to heating and ventilating units, allow space for service and maintenance.

3.4 DUCTWORK CONNECTIONS

- A. Duct Connections: Connect supply[**and return**] ducts to indirect-fired heating and ventilating units with flexible duct connectors. Comply with requirements in Section 233300 "Air Duct Accessories" for flexible duct connectors.

3.5 ELECTRICAL CONNECTIONS

- A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch (13 mm)** high.

3.6 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.7 STARTUP SERVICE

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.
- B. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
 - 1. Inspect for visible damage to burner combustion chamber.
 - 2. Inspect casing insulation for integrity, moisture content, and adhesion.
 - 3. Verify that clearances have been provided for servicing.
 - 4. Verify that controls are connected and operable.
 - 5. Verify that filters are installed.
 - 6. Purge gas line.
 - 7. Inspect and adjust vibration isolators[**and seismic restraints**].
 - 8. Verify bearing lubrication.
 - 9. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
 - 10. Adjust fan belts to proper alignment and tension.

- C. Start unit according to manufacturer's written instructions.
1. Complete startup sheets and attach copy with Contractor's startup report.
 2. Inspect and record performance of interlocks and protective devices; verify sequences.
 3. Operate unit for run-in period recommended by manufacturer.
 4. Perform the following operations for both minimum and maximum firing, and adjust burner for peak efficiency:
 - a. Measure gas pressure at manifold.
 - b. Measure combustion-air temperature at inlet to combustion chamber.
 - c. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
 5. Calibrate thermostats.
 6. Adjust and inspect high-temperature limits.
 7. Inspect dampers, if any, for proper stroke and interlock with return-air dampers.
 8. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
 9. Measure and record airflow. Plot fan volumes on fan curve.
 10. Verify operation of remote panel, including pilot-operation and failure modes. Inspect the following:
 - a. High-limit heat.
 - b. Alarms.
 11. After startup and performance testing, change filters, verify bearing lubrication, and adjust belt tension.
 12. Verify drain-pan performance.
 13. Verify outdoor-air damper operation.

3.8 ADJUSTING

- A. Adjust initial temperature set points.
- B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- C. Occupancy Adjustments: When requested within [12]<Insert number> months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to [two]<Insert number> visits to Project during other-than-normal occupancy hours for this purpose.

3.9 CLEANING

- A. After completing system installation and testing, adjusting, and balancing makeup air unit and air-distribution systems and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.



3.10 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections[**with the assistance of a factory-authorized service representative**].
- D. Units will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.

3.11 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain heating and ventilating units.

END OF SECTION 23 74 23 00



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23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 74 23 00	23 74 00 00	Outdoor, Semi-Custom Air-Handling Units
23 74 23 00	23 74 00 00a	Outdoor, Custom Air-Handling Units
23 74 23 00	23 74 00 00b	Dedicated Outdoor-Air Units



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SECTION 23 74 23 13 - PACKAGED, DIRECT-FIRED, OUTDOOR, HEATING-ONLY MAKEUP-AIR UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Packaged, direct-fired, outdoor, heating-only makeup-air units.

1.2 ACTION SUBMITTALS

A. Product Data: For each outdoor, direct, gas-fired heating-only, makeup air unit.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Include unit dimensions and weight.
4. Include cabinet material, metal thickness, finishes, insulation, and accessories.
5. Fans:
 - a. Include certified fan-performance curves with system operating conditions indicated.
 - b. Include certified fan-sound power ratings.
 - c. Include fan construction and accessories.
 - d. Include motor ratings, electrical characteristics, and motor accessories.
6. Include filters with performance characteristics.
7. Include direct, gas-fired burners with performance characteristics.
8. Include dampers, including housings, linkages, and operators.

B. Sustainable Design Submittals:

1. Product data showing compliance with ASHRAE 62.1.
2. Product Data: For air filtration performance.
3. Product Data: For adhesives, mastics, and sealants, indicating VOC content.
4. Laboratory Test Reports: For adhesives, mastics, and sealants, indicating compliance with requirements for low-emitting materials.

C. Shop Drawings: For each outdoor, direct, gas-fired, heating-only, makeup air unit.

1. Include plans, elevations, sections, and **[mounting][attachment]** details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of gas-fired heating and ventilating units, as well as procedures and diagrams.
4. Include diagrams for power, signal, and control wiring.

D. Delegated Design Submittal: For vibration isolation **[and seismic restraints]** indicated to comply with

**Packaged, Direct-Fired, Outdoor, Heating-Only Makeup-Air
Units**

performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Include design calculations for selecting vibration isolators[**and seismic restraints**] and for designing vibration isolation bases.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
- B. Sample Warranty: For manufacturer's warranty.
- C. Seismic Qualification Data: Certificates for outdoor, direct, gas-fired, heating-only, makeup air units, accessories, and components, from manufacturer.
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
 4. Restraint of internal components.
- D. Product Certificates: Submit certification that specified equipment will withstand wind forces identified in "Performance Requirements" Article and in Section 230548 "Vibration and Seismic Controls for HVAC."
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of wind force and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- E. Startup service reports.
- F. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For direct, gas-fired, heating-only, makeup air units to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Filters: **[One]<Insert number>** set(s) for each unit.
 2. Gaskets: **[One]<Insert number>** set(s) for each access door.



3. Fan Belts: **[One]<Insert number>** set(s) for each unit.

1.6 WARRANTY

- A. Warranty: Manufacturer agrees to repair or replace components of direct-fired heating and ventilating units that fail in materials or workmanship within specified warranty period.
 1. Warranty Period for Entire Unit: Manufacturer's standard, but not less than **[one]<Insert number>** year(s) from date of Substantial Completion.
 2. Warranty Period for Burners: Manufacturer's standard, but not less than **[five][10]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of units and components.
- C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- E. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation[**and seismic restraints**], including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- F. Seismic Performance: Indoor, indirect gas-fired, heating and ventilating units shall withstand the effects of earthquake motions determined according to **[ASCE/SEI 7]<Insert requirement>**.
 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."
 2. Component Importance Factor: **[1.5][1.0]**.
 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.

2.2 CAPACITIES AND CHARACTERISTICS

- A. Fan:
 1. Discharge Configuration: **[Horizontal][Vertical]**.
 2. Airflow in CFM (L/s): **<Insert quantity>**.
 3. External Static Pressure: **<Insert inches wg (kPa)>**.

4. Maximum RPM: **<Insert number>**.
5. Minimum Size: **<Insert inches (mm)>**.
6. Altitude: **<Insert feet (m)>**.

B. Fan Motor:

1. Horsepower: **<Insert value>**.
2. RPM: **<Insert value>**.
3. Service Factor: **<Insert value>**.
4. Speed: **[Single][Two]**.

C. Single-Point Electrical Connection:

1. Volts: **[120][240][277][480]<Insert value> V**.
2. Phase: **[Single][Three]**.
3. Hertz: 60.
4. Full-Load Amperes: **<Insert value> A**.
5. Minimum Circuit Ampacity: **<Insert value> A**.
6. Maximum Overcurrent Protection: **<Insert value> A**.

D. Direct-Fired Gas Burner:

1. Minimum Combustion Efficiency: **<Insert percentage>**.
2. Entering-Air Temperature: **<Insert deg F (deg C)>**.
3. Leaving-Air Temperature: **<Insert deg F (deg C)>**.
4. Airflow: **<Insert cfm (L/s)>**.
5. Gas Input: **<Insert MBh (kW)>**.
6. Burner Output: **<Insert MBh (kW)>**.
7. Number of Stages: **<Insert value>**.
8. Minimum Inlet Pressure: **<Insert inches wg (Pa)>**.
9. Maximum Inlet Pressure: **<Insert inches wg (Pa)>**.
10. Gas Piping Connection Size: **<Insert NPS (DN)>**.
11. Vent Diameter: **<Insert inches (mm)>**.

E. Filters:

1. Type: **<Insert type>**.
2. Face Dimensions, Each: **<Insert inches by inches (mm by mm)>**.
3. Depth: **<Insert inches (mm)>**.
4. Number of Filters, Wide by High: **<Insert number>**.
5. Access Location: **[Side]<Insert location>**.
6. Maximum or Rated Face Velocity: **<Insert fpm (m/s)>**.
7. Initial Resistance: **<Insert inches wg (Pa)>**.
8. Recommended Final Resistance: **<Insert inches wg (Pa)>**.

F. Minimum Efficiency Reporting Value and Average Arrestance:

1. MERV Rating and Corresponding Average Arrestance: **[MERV 1][MERV 2][MERV 3][MERV 4]**, and corresponding average arrestance according to ASHRAE 52.2.

G. Minimum Efficiency Reporting Value:

1. MERV Rating: **[MERV 6][MERV 13]<Insert value>**, according to ASHRAE 52.2.



2.3 PACKAGED, DIRECT-FIRED, OUTDOOR, HEATING-ONLY MAKEUP-AIR UNITS

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

1. **[AbsolutAire, Inc.]**
2. **[Applied Air, a Mestek company]**
3. **[Banza; a brand of Specified Air Solutions]**
4. **[BessamAire, Inc.]**
5. **[Cambridge Air Solutions]**
6. **[Cambridge Engineering, Inc]**
7. **[CaptiveAire Systems]**
8. **[Energy Jet U.S.]**
9. **[Engineered Air]**
10. **[Greenheck Fan Corporation]**
11. **[Hastings HVAC]**
12. **[I.C.E. Manufacturing Ltd.; Industrial Commercial Equipment - I.C.E. (US), Inc.]**
13. **[Jackson & Church HVAC Global]**
14. **[LCSysytems]**
15. **[Modine Manufacturing Company]**
16. **[Powrmatic, Inc.]**
17. **[Rapid Engineering, Inc.]**
18. **[REZNOR, a brand of Nortek Global HVAC]**
19. **[Sterling HVAC Products; a Mestek company]**
20. **[Temprite, a brand of Mestek]**
21. **[Titan Air]**
22. **[Trane Inc.]**
23. **[Weather-Rite, a brand of Specified Air Solutions]**
24. **<Insert manufacturer's name>**

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

1. **[AbsolutAire, Inc.]**
2. **[Applied Air, a Mestek company]**
3. **[Banza; a brand of Specified Air Solutions]**
4. **[BessamAire, Inc.]**
5. **[Cambridge Air Solutions]**
6. **[Cambridge Engineering, Inc]**
7. **[CaptiveAire Systems]**
8. **[Energy Jet U.S.]**
9. **[Engineered Air]**
10. **[Greenheck Fan Corporation]**
11. **[Hastings HVAC]**
12. **[I.C.E. Manufacturing Ltd.; Industrial Commercial Equipment - I.C.E. (US), Inc.]**
13. **[Jackson & Church HVAC Global]**
14. **[LCSysytems]**
15. **[Modine Manufacturing Company]**
16. **[Powrmatic, Inc.]**
17. **[Rapid Engineering, Inc.]**
18. **[REZNOR, a brand of Nortek Global HVAC]**
19. **[Sterling HVAC Products; a Mestek company]**
20. **[Temprite, a brand of Mestek]**
21. **[Titan Air]**

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- 22. [Trane Inc.]
- 23. [Weather-Rite, a brand of Specified Air Solutions]
- 24. <Insert manufacturer's name>

C. Unit Casings:

- 1. General Fabrication Requirements for Casings:
 - a. Forming: Form walls, roofs, and floors with at least two breaks at each joint.
 - b. Casing Joints: Sheet metal screws or pop rivets, factory sealed with water-resistant sealant.
 - c. Makeup Air Unit Mounting Frame: Formed galvanized-steel channel or structural channel supports, designed for low deflection, welded with integral lifting lugs.
- 2. Configuration: Horizontal unit with [top][horizontal][bottom] discharge for [roof-mounting][concrete-base] installation.
- 3. Double-Wall Construction:
 - a. Outside Casing Wall: [Galvanized steel]<Insert material>, minimum [18 gauge (1.3 mm)]<Insert value> thick, with [manufacturer's standard finish]<Insert special coating>.
 - b. Inside Casing Wall:
 - 1) Inside Casing, Burner Section: [Galvanized steel]<Insert material>, solid, minimum [14-gauge- (0.759-mm-)]<Insert number> thick steel.
 - 2) Inside Casing, All Other Sections: [Galvanized steel]<Insert material>[solid][perforated] steel.
 - c. Floor Plate: [Galvanized steel]<Insert material>, minimum [18 gauge (1.3 mm)]<Insert value> thick.
 - d. Casing Insulation:
 - 1) Materials: [Glass-fiber blanket or board insulation, Type I or Type II ASTM C1071]<Insert insulation type>.
 - 2) Casing Panel R-Value: Minimum <Insert value>.
 - 3) Insulation Thickness: [1 inch (25 mm)][2 inches (50 mm)].
 - 4) Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roof of unit.
 - e. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.
- 4. Panels and Doors:
 - a. Panels:
 - 1) Fabrication: Formed and reinforced, with same materials and insulation thickness as casing.
 - 2) Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against airflow.
 - 3) Gasket: Neoprene, applied around entire perimeters of panel frames.
 - 4) Size: Large enough to allow unobstructed access for inspection and maintenance of unit's internal components.

- b. Doors:
 - 1) Fabrication: Formed and reinforced with same materials and insulation thickness as casing.
 - 2) Hinges: A minimum of two ball-bearing hinges or stainless steel piano hinge and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against airflow. Provide safety latch retainers on doors so that doors do not open uncontrollably.
 - 3) Gasket: Neoprene, applied around entire perimeters of panel frames.
 - 4) Size: Large enough to allow unobstructed access for inspection and maintenance of unit's internal components.
- c. Locations and Applications:
 - 1) Fan Section: **[Inspection and access panels][Doors][Doors and inspection and access panels]**.
 - 2) Access Section: Doors.
 - 3) Gas-Fired Burner Section: **[Inspection and access panels][Doors]**.
 - 4) Damper Section: **[Inspection and access panels][Doors]**.
 - 5) Filter Section: **[Inspection and access panels][Doors]** large enough to allow periodic removal and installation of filters.
 - 6) Mixing Section: Doors.
- d. Service Light: 100-W vaporproof fixture with switched junction box located **[outside][inside]** adjacent to door.
 - 1) Locations: **[Each section accessed with door][Fan section]<Insert location>**.

D. Outdoor-Air Intake Hood:

- 1. Type: Manufacturer's standard hood or louver.
- 2. Materials: Match cabinet.
- 3. Bird Screen: Comply with requirements in ASHRAE 62.1.
- 4. Filter: Aluminum, **[1 inch (25 mm)][2 inches (50 mm)]<Insert dimension>** cleanable.
- 5. Configuration: Designed to inhibit wind-driven rain and snow from entering unit.

E. Roof Curbs:

- 1. Roof curbs with vibration isolators and wind or seismic restraints are specified in Section 230548 "Vibration and Seismic Controls for HVAC."
- 2. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.
 - a. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
 - 1) Materials: ASTM C1071, Type I or Type II.
 - 2) Thickness: **[1 inch (25 mm)][1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension>**.
 - b. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.
 - 1) Liner Adhesive: Comply with ASTM C916, Type I.
 - 2) Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when

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- 3) applied as recommended by manufacturer and without causing leakage in cabinet. Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.

3. Curb Height: **[14 inches (355 mm)][24 inches (610 mm)][36 inches (910 mm)]<Insert dimension>**.
4. Wind and Seismic Restraints: Metal brackets compatible with the curb and casing, painted to match unit, used to anchor unit to the curb, and designed for loads at Project site. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for wind-load requirements.

F. Fans, Drives, and Motors:

1. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.
2. Fans: Centrifugal, rated according to AMCA 210; galvanized steel; mounted on solid-steel shaft.
 - a. Shafts: With field-adjustable alignment.
 - b. Shaft Bearings: Heavy-duty[, **self-aligning, permanently lubricated ball bearings**][, **pillow-block bearings**] with an **[L50]<Insert bearing life rating>** rated life of **[100,000]<Insert number>** hours according to ABMA 9.
 - c. Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.
 - d. Mounting: For internal vibration isolation[**and seismic control**]. Factory-mount fans with manufacturer's standard[**restrained**] vibration isolation mounting devices having a minimum static deflection of **[1 inch (25 mm)]<Insert dimension>**.
 - e. Shaft Lubrication Lines: Extended to a location outside the casing.
 - f. Flexible Connector: Factory fabricated with a fabric strip minimum **3-1/2 inches (89 mm)** wide, attached to two strips of minimum **2-3/4-inch- (70-mm-)** wide by **0.028-inch- (0.7-mm-)** thick, galvanized-steel sheet.
 - 1) Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.
3. Drives: Factory-mounted V-belt drive, with adjustable alignment and belt tensioning, and with **[1.5][1.25]** service factor based on fan motor.
 - a. Pulleys: Cast iron or cast steel with split, tapered bushing, dynamically balanced at the factory.
 - b. Belts: Oil resistant, non-sparking and nonstatic; in matched sets for multiple-belt drives.
 - c. Belt Guards: Comply with requirements specified by OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards"; **[0.146-inch- (2.7-mm-)]<Insert dimension>** thick, **[3/4-inch (20-mm)]<Insert dimension>** diamond-mesh wire screen, welded to steel angle frame; prime coated.
4. Motors:
 - a. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - b. Motor Sizes: Maximum sizes as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - c. Enclosure: **[Open, dripproof][Totally enclosed, fan cooled]<Insert type>**.
 - d. Enclosure Materials: **[Cast iron]<Insert material>**.

- e. Motor Bearings: **<Insert requirements>**.
- f. Unusual Service Conditions:
 - 1) Ambient Temperature: **<Insert deg C>**.
 - 2) Altitude: **<Insert feet (m)>** above sea level.
 - 3) High humidity.
 - 4) **<Insert conditions>**.
- g. Efficiency: Premium efficient as defined in NEMA MG 1.
- h. NEMA Design: **<Insert designation>**.
- i. Motor Pulleys: Adjustable pitch for use with **[5]<Insert number>**-hp motors and smaller; fixed pitch for use with motors larger than **[5]<Insert number>** hp. Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions.

G. Air Filtration:

- 1. Particulate air filtration is specified in Section 234100 "Particulate Air Filtration."
- 2. Panel Filters:
 - a. Description: **[Flat, non-pleated][Pleated]** factory-fabricated, self-supported, disposable air filters with holding frames.
 - b. Filter Unit Class: UL 900.
 - c. Media: Interlaced glass, synthetic or cotton fibers coated with nonflammable adhesive and antimicrobial coating.
 - d. Filter-Media Frame: **[Beverage board]<Insert material>** with perforated metal retainer, or metal grid, on outlet side.
- 3. Cleanable Filters:
 - a. Cleanable metal mesh.
- 4. Adhesive, Sustainability Projects: As recommended by air-filter manufacturer and with a VOC content of 80 g/L or less.
- 5. Adhesive, LEED for Schools Projects: As recommended by air-filter manufacturer and that complies with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- 6. Side-Access Filter Mounting Frames:
 - a. Particulate Air Filter Frames: Match inner casing and outer casing material, and insulation thickness. **[Galvanized steel]<Insert material>** track.
 - 1) Sealing: Incorporate positive-sealing device to ensure seal between gasketed material on channels to seal top and bottom of filter cartridge frames to prevent bypass of unfiltered air.

H. Dampers:

- 1. Comply with requirements in Section 230923.12 "Control Dampers."
- 2. Outdoor- and Return-Air Dampers: Low-leakage, double-skin, airfoil-blade, **[galvanized-steel]<Insert material>** dampers with compressible jamb seals and extruded-vinyl blade edge seals in **[opposed][parallel]**-blade arrangement with **[zinc-plated]** steel operating rods rotating in **[sintered bronze or nylon]<Insert material>** bearings mounted in a single **[galvanized-steel]<Insert material>** frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed **4 cfm/sq. ft. (20 L/s per sq. m)** at 1-inch wg (**250 Pa**) and 8

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cfm/sq. ft. (40 L/s per sq. m) at 4-inch wg (1.0 MPa) rated in accordance with AMCA 500D.

3. Damper Operators: Comply with requirements in Section 230923.12 "Control Dampers."
4. Electronic Damper Operators:
 - a. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
 - b. Electronic damper position indicator shall have visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
 - c. Operator Motors:
 - 1) Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - 2) Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
 - 3) Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
 - d. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running torque of **150 in. x lbf (16.9 N x m)** and breakaway torque of **300 in. x lbf (33.9 N x m)**.
 - e. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running and breakaway torque of **150 in. x lbf (16.9 N x m)**.
 - f. Size dampers for running torque calculated as follows:
 - 1) Parallel-Blade Damper with Edge Seals: **7 inch-lb/sq. ft. (86.8 kg-cm/sq. m)** of damper.
 - 2) Opposed-Blade Damper with Edge Seals: **5 inch-lb/sq. ft. (62 kg-cm/sq. m)** of damper.
 - 3) Parallel-Blade Damper without Edge Seals: **4 inch-lb/sq. ft. (49.6 kg-cm/sq. m)** of damper.
 - 4) Opposed-Blade Damper without Edge Seals: **3 inch-lb/sq. ft. (37.2 kg-cm/sq. m)** of damper.
 - 5) Dampers with 2- to 3-Inch wg (500 to 750 Pa) of Pressure Drop or Face Velocities of 1000 to 2500 fpm (5 to 13 m/s): Increase running torque by 1.5.
 - 6) Dampers with 3- to 4-Inch wg (750 to 1000 Pa) of Pressure Drop or Face Velocities of 2500 to 3000 fpm (13 to 15 m/s): Increase running torque by 2.0.
 - g. Coupling: V-bolt and V-shaped, toothed cradle.
 - h. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
 - i. Fail-Safe Operation: Mechanical, spring-return mechanism with external, manual gear release on nonspring-return actuators.
 - j. Power Requirements (Two-Position Spring Return): **[24 V dc][120 V ac][230 V ac]**.
 - k. Power Requirements (Modulating): Maximum 10 VA at 24 V ac or 8 W at 24 V dc.
 - l. Proportional Signal: 2 to 10 V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
 - m. Temperature Rating: **[Minus 22 to plus 122 deg F (Minus 30 to plus 50 deg C)][40 to 104 deg F (5 to 40 deg C)]**.
 - n. Run Time: **[12 seconds open, 5 seconds closed][30 seconds][60 seconds][120 seconds]**.
- I. Direct-Fired Gas Burner:
 1. Description: Factory assembled, piped, and wired; and complying with ANSI Z21.47 and with NFPA 54.

2. CSA Approval: Designed and certified by and bearing label of CSA.
 3. Burners: **[Aluminized steel with stainless steel inserts][Stainless steel]**.
 - a. Rated Minimum Turndown Ratio: **[30 to 1]<Insert ratio>**.
 - b. Fuel: **[Natural][Propane]** gas.
 - c. Ignition: Electronically controlled electric spark with flame sensor.
 - d. Gas Control Valve: **[Single stage][Two stage][Modulating]**.
 - e. Gas Train: Regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, **[hydraulic][electronic]**-modulating temperature control valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.
 - f. High-Altitude Model Kit: For Project elevations more than **2000 feet (610 m)** above sea level.
 4. Safety Controls:
 - a. Gas Manifold: Safety switches and controls complying with ANSI standards **[and][FM Global]<Insert insurer>**.
 - b. Vent Flow Verification: **[Differential pressure switch to verify open vent][Flame rollout switch]**.
 - c. High Limit: Thermal switch or fuse to stop burner.
 - d. Purge-period timer shall automatically delay burner ignition and bypass low-limit control.
 - e. Airflow Proving Switch: Differential pressure switch senses correct airflow before energizing pilot.
 - f. Automatic-Reset, High-Limit Control Device: Stops burner and closes main gas valve if high-limit temperature is exceeded.
 - g. Safety Lockout Switch: Locks out ignition sequence if burner fails to light after three tries. Controls are reset manually by turning the unit off and on.
 - h. Control Transformer: 24 V ac.
- J. Unit Control Panel:
1. Factory-wired, fuse-protected control transformer, connection for power supply and field-wired unit to remote control panel.
 2. Control Panel: **[Surface-mounted][Recessed, with trim ring,]** remote panel, with engraved plastic cover and the following lights and switches:
 - a. **[On-off][On-off-auto]** fan switch.
 - b. Heat-vent-off switch.
 - c. Supply-fan operation indicating light.
 - d. Heating operation indicating light.
 - e. Thermostat.
 - f. Damper position potentiometer.
 - g. Dirty-filter indicating light operated by unit-mounted differential pressure switch.
 - h. Safety-lockout indicating light.
 - i. Enclosure: NEMA 250, **[Type 1][Type 3R][Type 4][Explosion proof]**.
- K. Controls:
1. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC" for control equipment and sequence of operation.
 2. Control Devices:
 - a. Remote Thermostat: Adjustable room thermostat with temperature readout.
 - b. Remote Setback Thermostat: Adjustable room thermostat without temperature readout.

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- c. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
- d. Fire-Protection Thermostats: Fixed or adjustable settings to operate at not less than **75 deg F (24 deg C)** above normal maximum operating temperature.
- e. Timers, Seven Day:
 - 1) Programming-switch timer with synchronous-timing motor and seven-day dial.
 - 2) Continuously charged, nickel-cadmium-battery-driven, eight-hour, power-failure carryover.
 - 3) Multiple-switch trippers.
 - 4) Minimum of two and maximum of eight signals per day with two normally open and two normally closed output contacts.
- f. Timers, Solid State:
 - 1) Programmable time control with four separate programs.
 - 2) 24-hour battery carryover.
 - 3) Individual on-off-auto switches for each program.
 - 4) 365-day calendar with 20 programmable holidays.
 - 5) Choice of fail-safe operation for each program.
 - 6) System fault alarm.
- g. Ionization-Type Smoke Detectors:
 - 1) 24-V dc, nominal.
 - 2) Self-restoring.
 - 3) Plug-in arrangement.
 - 4) Integral visual-indicating light.
 - 5) Sensitivity that can be tested and adjusted in place after installation.
 - 6) Integral addressable module.
 - 7) Remote controllability.
 - 8) Responsive to both visible and invisible products of combustion.
 - 9) Self-compensating for changes in environmental conditions.
- 3. Fan Control, Interlocked: Fan to start with exhaust fan(s) to which this heating and ventilating unit is associated for makeup air.
- 4. Fan Control, Timer: Timer starts and stops direct-fired heating and ventilating unit and exhaust fan(s).
- 5. Outdoor-Air Damper Control, 100 Percent Outdoor-Air Units: Outdoor-air damper shall open when supply fan starts, and close when fan stops.
- 6. Mixed Outdoor- and Return-Air Damper Control: When fan is running, outdoor- and return-air dampers shall modulate to supply minimum outdoor air as follows:
 - a. Minimum **[30]<Insert number>** percent outdoor air.
 - b. Outdoor-air quantity adjusted by potentiometer on control panel.
 - c. Outdoor-air quantity to maintain minimum building static pressure.
- 7. Temperature Control:
 - a. Operates gas valve to maintain discharge-air temperature with factory-mounted sensor in blower outlet.
 - b. Operates gas valve to maintain space temperature with wall-mounting, field-wired sensor[**with temperature adjustment,**][**and unit-mounted control adjustment**][**and adjustment on remote-control panel**].

- c. Timer shall select remote setback thermostat to maintain space temperature at [50 deg F (10 deg C)]<Insert temperature>.
 - d. Burner Control, Stepped: Two or four steps of control using one or two burner sections in series.
 - e. Burner Control, Modulating: 20 to 100 percent modulation of the firing rate. 10 to 100 percent with dual burner units.
8. Interface with DDC System for HVAC: Factory-installed hardware and software to enable the DDC system for HVAC to monitor, control, and display status and alarms of heating and ventilating unit.
- a. Hardwired Points:
 - 1) Room temperature.
 - 2) Discharge-air temperature.
 - 3) Burner operating.
 - b. [ASHRAE 135.1 (BACnet)][LonTalk][Modbus][Industry-accepted, open-protocol]<Insert type of interface> communication interface with the DDC system for HVAC shall enable the DDC system for HVAC operator to remotely control and monitor the heating and ventilating unit from an operator workstation. Control features and monitoring points displayed locally at heating and ventilating unit control panel shall be available through the DDC system for HVAC.

L. Accessories:

- 1. Electric heater with integral thermostat maintains minimum 50 deg F (10 deg C) temperature in gas burner compartment.
- 2. Duplex, 115-V, ground-fault-interrupter outlet with 15-A overcurrent protection. Include transformer if required. [Outlet shall be energized even if the unit main disconnect is open.]
- 3. Low-ambient kit using [staged][damper on][variable-speed] condenser fans for operation down to [35 deg F (1.7 deg C)]<Insert temperature>.
- 4. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure loss.
- 5. Coil guards of painted, galvanized-steel wire.
- 6. Hail guards of galvanized steel, painted to match casing.

2.4 MATERIALS

A. Steel:

- 1. ASTM A36/A36M for carbon structural steel.
- 2. ASTM A568/A568M for steel sheet.

B. Stainless Steel:

- 1. Manufacturer's standard grade for casing.
- 2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653/A653M.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping, ducts, and electrical systems to verify actual locations of piping and electrical connections before equipment installation.
- C. Verify cleanliness of airflow path to include inner-casing surfaces, filters, coils, turning vanes, fan wheels, and other components.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF PACKAGED, DIRECT-FIRED, OUTDOOR, HEATING-ONLY MAKEUP-AIR UNITS

- A. Roof Curb: Install on roof structure or concrete base, level and secure, according to **[NRCA's "NRCA Roofing Manual: Membrane Roof Systems."][AHRI Guideline B.]** Install units on curbs and coordinate roof penetrations and flashing with roof construction specified in Section 077200 "Roof Accessories." Secure units to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts. Coordinate sizes and locations of roof curbs with actual equipment.
- B. Unit Support: Install unit level on structural **[curbs][steel supports]**. Coordinate roof penetrations and flashing with roof construction. Secure units to structural support with anchor bolts. Coordinate sizes and locations of **[curbs][steel supports]** with actual equipment provided.
 - 1. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 2. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- C. Install gas-fired units according to NFPA 54, "National Fuel Gas Code."
- D. Install controls and equipment shipped by manufacturer for field installation with direct-fired heating and ventilating units.

3.3 PIPING CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
 - 1. Gas Piping: Comply with requirements in **[Section 231123 "Facility Natural-Gas Piping."][Section 231126 "Facility Liquefied-Petroleum Gas Piping.]** Connect gas piping with shutoff valve and union, and with sufficient clearance for burner removal and service. Make final connections of gas piping to unit with corrugated, stainless steel tubing flexible connectors complying with ANSI LC 1/CSA 6.26 equipment connections.
- B. Drain: Comply with requirements in Section 221316 "Sanitary Waste and Vent Piping" for traps and accessories on piping connections to condensate drain pans under condensing heat exchangers.

- C. Where installing piping adjacent to heating and ventilating units, allow space for service and maintenance.

3.4 DUCT CONNECTIONS

- A. Duct Connections: Connect supply[**and return**] ducts to direct-fired heating and ventilating units with flexible duct connectors. Comply with requirements in Section 233300 "Air Duct Accessories" for flexible duct connectors.

3.5 ELECTRICAL CONNECTIONS

- A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch (13 mm)** high.

3.6 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.7 STARTUP SERVICE

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.
- B. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
 - 1. Inspect for visible damage to burner combustion chamber.
 - 2. Inspect casing insulation for integrity, moisture content, and adhesion.
 - 3. Verify that clearances have been provided for servicing.
 - 4. Verify that controls are connected and operable.
 - 5. Verify that filters are installed.
 - 6. Purge gas line.
 - 7. Inspect and adjust vibration isolators[**and seismic restraints**].
 - 8. Verify bearing lubrication.
 - 9. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
 - 10. Adjust fan belts to proper alignment and tension.

- C. Start unit according to manufacturer's written instructions.
1. Complete startup sheets and attach copy with Contractor's startup report.
 2. Inspect and record performance of interlocks and protective devices; verify sequences.
 3. Operate unit for run-in period recommended by manufacturer.
 4. Perform the following operations for both minimum and maximum firing, and adjust burner for peak efficiency:
 - a. Measure gas pressure at manifold.
 - b. Measure combustion-air temperature at inlet to combustion chamber.
 - c. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
 5. Calibrate thermostats.
 6. Adjust and inspect high-temperature limits.
 7. Inspect dampers, if any, for proper stroke and interlock with return-air dampers.
 8. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
 9. Measure and record airflow. Plot fan volumes on fan curve.
 10. Verify operation of remote panel, including pilot-operation and failure modes. Inspect the following:
 - a. High-limit heat.
 - b. Alarms.
 11. After startup and performance testing, change filters, verify bearing lubrication, and adjust belt tension.
 12. Verify drain-pan performance.
 13. Verify outdoor-air damper operation.

3.8 ADJUSTING

- A. Adjust initial temperature set points.
- B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- C. Occupancy Adjustments: When requested within [12]<Insert number> months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to [two]<Insert number> visits to Project during other-than-normal occupancy hours for this purpose.

3.9 CLEANING

- A. After completing system installation and testing, adjusting, and balancing makeup air unit and air-distribution systems and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.



3.10 FIELD QUALITY CONTROL

- A. Testing Agency:
 - 1. Owner will engage a qualified testing agency to perform tests and inspections.
 - 2. Engage a qualified testing agency to perform tests and inspections
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections[**with the assistance of a factory-authorized service representative**].
- D. Units will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.

3.11 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain heating and ventilating units.

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23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 74 23 13	23 74 00 00	Outdoor, Semi-Custom Air-Handling Units
23 74 23 13	23 74 00 00a	Outdoor, Custom Air-Handling Units
23 74 23 13	23 74 23 00	Packaged, Indirect-Fired, Outdoor, Heating-Only Makeup-Air Units
23 74 23 13	23 74 00 00b	Dedicated Outdoor-Air Units



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SECTION 23 81 00 00 - VARIABLE-REFRIGERANT-FLOW HVAC SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: VRF HVAC systems.
 - 1. VRF indoor units.
 - 2. VRF outdoor units.
 - 3. System controls.
 - 4. System refrigerant and oil.
 - 5. VRF system condensate drain piping.
 - 6. System hydronic piping.
 - 7. System refrigerant piping.
 - 8. Metal hangers and supports.
 - 9. Metal strut support systems.
 - 10. Fastener systems.
 - 11. Rooftop-mounted strut support systems.
 - 12. Equipment stands, outdoor type.
 - 13. Piping and tubing insulation.
 - 14. System control cable.

1.2 DEFINITIONS

- A. Air-Conditioning System Operation: System capable of operation with all zones in cooling only.
- B. Heat-Pump System Operation: System capable of operation with all zones in either heating or cooling, but not with simultaneous heating and cooling zones that transfer heat between zones.
- C. Heat Recovery System Operation: System capable of operation with simultaneous heating and cooling zones that transfer heat between zones.
- D. HRCU: Heat Recovery Control Unit. HRCUs are used in heat recovery VRF HVAC systems to manage and control refrigerant between indoor units to provide simultaneous heating and cooling zones. "Heat Recovery Control Unit" is the term used by ASHRAE for what different manufacturers term as "branch circuit controller," "branch selector box," "changeover box," "flow selector unit," "mode change unit," and other such terms.
- E. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.
- F. Plenum: A space forming part of the air distribution system to which one or more air ducts are connected. An air duct is a passageway, other than a plenum, for transporting air to or from HVAC equipment.
- G. Three-Pipe System Design: One high-pressure refrigerant vapor line, one low-pressure refrigerant vapor line, and one refrigerant liquid line connect a single outdoor unit or multiple manifold outdoor units in a single system to associated system HRCUs. One liquid line and refrigerant vapor line connect HRCUs to associated indoor units.

- H. Two-Pipe System Design: One refrigerant vapor line and one refrigerant liquid line connect a single outdoor unit or multiple manifold outdoor units in a single system to associated system HRCUs. One refrigerant liquid line and refrigerant vapor line connect HRCUs to associated indoor units. HRCUs used in two pipe systems act as an intermediate heat exchanger and include diverting valves and gas/liquid separators to move high- and low-pressure refrigerant between indoor units.
- I. VRF: Variable refrigerant flow.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference [at Project site][by web conference]<Insert location> .

1.4 ACTION SUBMITTALS

- A. Product Data: For each specified system and assembly, including components and accessories.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for indoor and outdoor units [and for HRCUs] .
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - 3. Include operating performance at design conditions and at extreme maximum and minimum outdoor ambient conditions.
 - 4. Include description of system controllers, dimensions, features, control interfaces and connections, power requirements, and connections.
 - 5. Include system operating sequence of operation in narrative form for each unique indoor- and outdoor-unit [and HRCU] control.
 - 6. Include description of control software features.
 - 7. Include total refrigerant required and a comprehensive breakdown of refrigerant required by each system installed.
 - 8. Include refrigerant type and data sheets showing compliance with requirements indicated.
 - 9. For system design software.
 - 10. Indicate location and type of service access.
- B. Shop Drawings: For VRF HVAC systems.
 - 1. Include plans, elevations, sections, and [mounting][attachment] details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
 - 4. Include diagrams and details of refrigerant piping and tubing showing installation requirements for manufacturer-furnished divided flow fittings.
 - 5. Include diagrams for power, signal, and control wiring.
- C. Samples for Initial Selection: For fully and partially exposed indoor units with factory finishes viewable by occupants.
 - 1. Include a Sample for each unique finish with unit identification, detailed description of application, and cross-referenced floor plans showing locations.

D. Delegated Design Submittals:

1. Include design calculations for selecting vibration isolators [**and seismic restraints**] and for designing vibration isolation bases.
2. Include design calculations with corresponding diagram of refrigerant piping and tubing sizing for each system installed.
3. Include design calculations with corresponding floor plans indicating that refrigerant concentration limits are within allowable limits of ASHRAE 15 and governing codes.
4. Include calculations showing that system travel distance for refrigerant piping and controls cabling are within horizontal and vertical travel distances set by manufacturer. Provide a comparison table for each system installed.

E. Sustainable Design Submittals:

1. Product Data: Indicating compliance with minimum energy performance requirements.
2. Product Data: For minimum energy performance.
3. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
4. Product data indicating compliance with ASHRAE/IES 90.1.
5. Air-Balance Report: Documentation indicating that the Work complies with ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
6. TAB Report: Documentation indicating that the Work complies with ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."
7. HVAC Flush Report: Documentation indicating that building HVAC system flush complies with Green Globes v1.4, Section 3.1.2.4 - "IAQ during Construction."
8. Refrigerant: Product Data for refrigerants, indicating compliance with refrigerant management practices.
9. Product Data: For refrigerants, indicating compliance with refrigerant management practices.
10. Product Data for EA Credit "Optimize Energy Performance": Indicating that system complies with efficiency requirements.
11. Product Data for EA Credit "Enhanced Refrigerant Management": Indicating that products comply with requirements for refrigerant management.
12. Product Data for EA Credit "Enhanced Refrigerant Management": Indicating that products comply with requirements for refrigerant management.
13. Product Data: For continuous metering equipment for energy consumption.
14. Product Data for EA Credit "Advanced Energy Metering": For continuous metering equipment.
15. Product Data: For continuous metering equipment for energy consumption.
16. Product Data for EQ Credit "Acoustic Performance": Documentation indicating that systems and equipment comply.
17. Product Data for EQ Credit "Acoustic Performance": Documentation indicating that systems and equipment comply.
18. Thermal Comfort: Product data indicating that systems, equipment, and controls comply.
19. Thermal Comfort: Product data indicating that systems, equipment, and controls comply.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, elevations, sections, and details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Structural floors, roofs and associated members to which equipment, piping, [**ductwork,**] cables, and conduit will be attached.
3. Size and location of initial access modules for acoustical tile.
4. Wall-mounted controllers located in finished space showing relationship to light switches, fire-alarm devices, and other installed devices.



5. Size and location of access doors and panels installed behind walls and inaccessible ceilings for products installed behind walls and requiring access.
6. Items penetrating finished ceiling including the following:
 - a. Luminaires.
 - b. Air outlets and inlets.
 - c. Speakers.
 - d. Sprinklers.
 - e. Service access panels.

B. Product Certificates: For VRF HVAC system components.

C. Product Test Reports: Where tests are required, for each product, for tests performed by **[manufacturer and witnessed by a qualified testing agency][or][a qualified testing agency]** .

D. Source Quality Control Reports: For specified tests and inspections.

E. Field Quality Control Reports: For specified tests and inspections.

F. Qualification Statements:

1. For Installer: Certificate from VRF HVAC system manufacturer certifying that Installer has successfully completed prerequisite training administered by manufacturer for proper installation of systems, including but not limited to, equipment, piping, controls, and accessories indicated and furnished for installation.

- a. Retain copies of Installer certificates on-site and make available on request.

2. For VRF HVAC system manufacturer.

3. For VRF HVAC system provider.

G. Seismic Qualification Statements: Certificates, for equipment, **<Insert products,>** accessories, and components, from manufacturer.

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

H. Sample Warranties: For specified special warranties.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For VRF HVAC systems.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On CD or DVD, USB media, or approved cloud storage platform, complete with data files.
3. Device address list.

4. Printout of software application and graphic screens.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Extra Stock Material: Furnish extra materials [, **from the same production run,**] to Owner that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Filters:
 - a. **[One]<Insert number>** set(s) for each unit with replaceable filters.
 - b. **[One]<Insert number>** set(s) for each unit type and unique size of washable filters.
 2. Indoor Units: **[One]<Insert number>** for each unique size and type installed.
 3. Controllers for Indoor Units: **[One]<Insert number>** for each unique controller type installed.

1.8 QUALITY ASSURANCE

- A. Manufacturer Qualifications:
 1. Nationally recognized manufacturer of VRF HVAC systems and products.
 2. Shipped VRF HVAC systems with similar requirements to those indicated for a continuous period of **[five][10]<Insert number>** years within time of bid.
 3. VRF HVAC systems and products that have been successfully tested and in use on at least **[three][five]<Insert number>** completed projects.
 4. Having complete published catalog literature, installation, and operation and maintenance manuals for all products intended for use.
 5. Having full-time in-house employees for the following:
 - a. Product research and development.
 - b. Product and application engineering.
 - c. Product manufacturing, testing, and quality control.
 - d. Technical support for system installation training, startup, commissioning, and troubleshooting of installations.
 - e. Owner training.
- B. Factory-Authorized Service Representative Qualifications:
 1. Authorized representative of, and trained by, VRF HVAC system manufacturer.
 2. In-place facility located within **<Insert distance>** of Project.
 3. Demonstrated past experience with products being installed for period within **[three][five]<Insert number>** consecutive years before time of bid.
 4. Demonstrated past experience on **[five]<Insert number>** projects of similar complexity, scope, and value.
 - a. Each person assigned to Project must have demonstrated past experience.
 5. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
 6. Service and maintenance staff assigned to support Project during warranty period.
 7. Product parts inventory to support ongoing system operation for a period of not less than **[five]<Insert number>** years after Substantial Completion.
 8. VRF HVAC system manufacturer's backing to take over execution of Work if necessary to comply with requirements indicated. Include Project-specific written letter, signed by manufacturer's



corporate officer, if requested.

- C. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by VRF HVAC system manufacturer.
 - 1. Each employee must be certified by manufacturer for proper installation of systems, including, but not limited to, equipment, piping, controls, and accessories indicated and furnished for installation.
 - 2. Installer certification must be valid and current for duration of Project.
 - 3. Retain copies of Installer certificates on-site and make available on request.
 - 4. Each person assigned to Project must have demonstrated past experience.
 - a. Demonstrated past experience with products being installed for period within **[three][five]<Insert number>** consecutive years before time of bid.
 - b. Demonstrated past experience on **[five]<Insert number>** projects of similar complexity, scope, and value.
- D. ISO Compliance: System equipment and components furnished by VRF HVAC system manufacturer are to be manufactured in an ISO 9001 and ISO 14001 facility.

1.9 MOCKUPS

- A. Build mockups to set quality standards for materials and execution.
 - 1. Build mockups to show a finished installation for each of the following applications:
 - a. For each different indoor unit type with exposed surfaces viewable by occupants.
 - 2. Mockups are to be operational.
 - 3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Owner specifically approves such deviations by Change Order.
 - 4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.10 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store products in a clean and dry place.
- B. Comply with manufacturer's written rigging and installation instructions for unloading and moving to final installed location.
- C. Handle products carefully to prevent damage, breaking, denting, and scoring. Do not install damaged products.
- D. Protect products from weather, dirt, dust, water, construction debris, and physical damage.
 - 1. Retain factory-applied coverings on equipment to protect finishes during construction and remove just prior to operating unit.
 - 2. Cover unit openings before installation to prevent dirt and dust from entering inside of units. If required to remove coverings during unit installation, reapply coverings over openings after unit installation and remove just prior to operating unit.

- E. Replace installed products damaged during construction.

1.11 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace equipment and components that fail(s) in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Structural failures.
 - b. Faulty operation.
 - c. Deterioration of metals, metal finishes, and other materials beyond normal weathering and use.
 - 2. Warranty Period:
 - a. For Compressor: **[Five][Seven][10]<Insert number>** year(s) from date of Substantial Completion.
 - b. For Parts, Including Controls: **[Five][Seven][10]<Insert number>** year(s) from date of Substantial Completion.
 - c. For Labor: **[Five][Seven][10]<Insert number>** year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional **[engineer][specialist]** , as defined in Section 014000 "Quality Requirements," to design complete and operational VRF HVAC system(s).
 - 1. Provide system refrigerant calculations.
 - a. Refrigerant concentration limits must be within allowable limits of ASHRAE 15 and governing codes.
 - b. Indicate compliance with manufacturer's maximum vertical and horizontal travel distances. Prepare a comparison table for each system showing calculated distances compared to manufacturer's maximum allowed distances.
 - 2. Include a mechanical ventilation system and gas detection system as required to comply with ASHRAE 15 and governing codes.
 - 3. System Refrigerant Piping and Tubing:
 - a. Arrangement: Arrange piping to interconnect indoor units [, **HRCUs,**] and outdoor unit(s) in compliance with manufacturer requirements and requirements.
 - b. Routing: Conceal piping above ceilings and behind walls to maximum extent possible.
 - c. Sizing: Size piping system, using a software program acceptable to manufacturer, to provide performance requirements indicated. Consider requirements to accommodate future change requirements.
 - 4. System Controls:
 - a. Network arrangement.
 - b. Network interface with other building systems.

- c. Product selection.
- d. Sizing.

B. Service Access:

- 1. Provide and document service access requirements.
- 2. Locate equipment, system isolation valves, and other system components that require service and inspection in easily accessible locations. Avoid locations that are difficult to access if possible.
- 3. Where serviceable components are installed behind walls and above inaccessible ceilings, provide finished assembly with access doors or panels to gain access. Properly size the openings to allow for service, removal, and replacement.
- 4. If less than full and unrestricted access is provided, locate components within an **18-inch (450-mm)** reach of the finished assembly.
- 5. Where ladder access is required to service elevated components, provide an installation that provides for sufficient access within ladder manufacturer's written instructions for use.
- 6. Comply with OSHA regulations.

C. System Design and Installation Requirements:

- 1. Design and install systems indicated in accordance with manufacturer's written instructions.
- 2. Where manufacturer's requirements differ from requirements indicated, contact Architect for direction. The most stringent requirements should apply unless otherwise directed in writing by Architect.

D. System Adaptability to Future Changes: Arrange and size system refrigerant piping to accommodate future changes to system without having to resize and replace existing refrigerant piping.

- 1. Future changes to system(s) are indicated on Drawings.
- 2. Each branch circuit is to accommodate addition of **[one][two]<Insert number>** indoor unit(s) with unit capacity equal to **[largest][smallest][average]<Insert capacity requirement>** indoor unit connected to the branch circuit.
- 3. Each branch circuit is to accommodate deletion of **[one][two]<Insert number>** indoor unit(s) with unit capacity equal to **[largest][smallest][average]<Insert capacity requirement>** indoor unit connected to the branch circuit.

E. Isolation of Equipment: Provide isolation valves to isolate each **[HRCU,]** indoor unit and outdoor unit for service, removal, and replacement without interrupting system operation.

F. System Capacity Ratio: The sum of connected capacity of all indoor units is to be within the following range of outdoor-unit rated capacity:

- 1. Not less than **[50][60]<Insert number>** percent.
- 2. Not more than **[130][150]<Insert number>** percent.
- 3. Range acceptable to manufacturer.

G. System Turndown: Stable operation down to **[20]<Insert number>** percent of outdoor-unit capacity.

H. System Auto Refrigerant Charge: Each system is to have an automatic refrigerant charge function to ensure the proper amount of refrigerant is installed in system.

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

J. AHRI Compliance: System and equipment performance certified in accordance with AHRI 1230 **[and**

products listed in AHRI directory] .

K. ASHRAE Compliance:

1. ASHRAE 15: For safety code for mechanical refrigeration.
2. ASHRAE 62.1: For indoor air quality.
3. ASHRAE 135: For control network protocol with remote communication.
4. ASHRAE/IES 90.1: For system and component energy efficiency.

L. UL Compliance: Comply with UL 1995.

M. Outdoor Conditions:

1. Suitable for outdoor ambient conditions encountered.
 - a. Design equipment and supports to withstand wind loads of governing code **[and ASCE/SEI 7]<Insert requirement>** .
 - b. Design equipment and supports to withstand snow and ice loads of governing code **[and ASCE/SEI 7]<Insert requirement>** .
 - c. Provide corrosion-resistant coating for components and supports where located in coastal or industrial climates that are known to be harmful to materials and finishes.
2. Maximum System Operating Outdoor Temperature: **[See Drawings]<Insert value>** .
3. Minimum System Operating Outdoor Temperature: **[See Drawings]<Insert value>** .

N. Seismic Performance: VRF HVAC system(s) is to withstand the effects of earthquake motions determined in accordance with **[ASCE/SEI 7]<Insert requirement>** .

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

O. Sound Performance: Sound levels generated by operating HVAC equipment must be within requirements indicated.

1. Indoor: **[See Drawings.][Within design guidelines of "2023 ASHRAE Handbook - HVAC Applications."]<Insert values.>**
2. Outdoor: **[See Drawings][Within ordinance of governing authorities]<Insert values>** .

P. Thermal Movements: Allow for controlled thermal movements from ambient, surface, and system temperature changes.

Q. Capacities and Characteristics: As indicated on Drawings.

2.2 VRF HVAC SYSTEMS

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

1. **[Carrier Global Corporation]**

2. [Daikin Applied]
3. [Fujitsu General America, Inc.]
4. [Johnson Controls, Inc.]
5. [Lennox]
6. [LG Electronics USA, Inc.; LG Electronics Inc.]
7. [Mitsubishi Electric Cooling and Heating]
8. [Panasonic Corporation of North America]
9. [Samsung HVAC]
10. [Trane Inc.]
11. <Insert manufacturer's name>

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

1. [Carrier Global Corporation]
2. [Daikin Applied]
3. [Fujitsu General America, Inc.]
4. [Johnson Controls, Inc.]
5. [Lennox]
6. [LG Electronics USA, Inc.; LG Electronics Inc.]
7. [Mitsubishi Electric Cooling and Heating]
8. [Panasonic Corporation of North America]
9. [Samsung HVAC]
10. [Trane Inc.]
11. <Insert manufacturer's name>

C. Source Limitations: Obtain products from single source from single manufacturer including, but not limited to, the following:

1. Indoor and outdoor units, including accessories.
2. Controls and software.
3. HRCUs.
4. Refrigerant isolation valves.
5. Specialty refrigerant pipe fittings.

D. System Description: Direct-expansion (DX) VRF HVAC system(s) with variable capacity in response to varying cooling and heating loads. System is to consist of multiple indoor units, [**HRCUs**,] outdoor unit(s), piping, controls, and electrical power to make complete operating system(s) complying with requirements indicated.

1. [Two-pipe][or][three-pipe] system design.
2. System(s) operation, [air conditioning][heat pump][or][heat recovery] as indicated on Drawings.
3. Each system has one refrigerant circuit shared by all indoor units connected to system.

E. VRF Indoor Units:

1. VRF Indoor Unit - Concealed, Ceiling-Mounted Units for Ducting:
 - a. Description: Factory-assembled [**and -tested**] complete unit with components, piping, wiring, and controls required for mating to ductwork, piping, power, and controls field connections.
 - b. Cabinet:
 - 1) Material: [Galvanized][or][painted] steel.

- 2) Insulation: Manufacturer's standard internal insulation [, **complying with ASHRAE 62.1,**] to provide thermal resistance and prevent condensation.
 - 3) Duct Connections: Extended collar or flange, or designated exterior cabinet surface, designed for attaching field-installed ductwork.
 - 4) Mounting: Manufacturer-designed provisions for field installation.
 - 5) Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.
- c. DX Coil Assembly:
- 1) Coil Casing: Aluminum, galvanized, or stainless steel.
 - 2) Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
 - 3) Coil Tubes: Copper, of diameter and thickness required by performance.
 - 4) Expansion Valve: Electronic modulating type with linear or proportional characteristics.
 - 5) Unit Internal Tubing: Copper tubing with brazed joints.
 - 6) Unit Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
 - 7) Field Piping Connections: Manufacturer's standard.
 - 8) Factory Charge: Dehydrated air or nitrogen.
 - 9) Testing: Factory pressure tested and verified to be without leaks.
- d. Drain Assembly:
- 1) Pan: Non-ferrous material, with bottom sloped to low point drain connection.
 - 2) Condensate Removal: Unit-mounted pump or other integral lifting mechanism, capable of lifting drain water to an elevation above top of cabinet.
 - 3) Field Piping Connection: Non-ferrous material [**with threaded NPT**] .
- e. Fan and Motor Assembly:
- 1) Fan(s):
 - a) Direct-drive arrangement.
 - b) Single or multiple fans connected to a common motor shaft and driven by a single motor.
 - c) Fabricated from non-ferrous components or ferrous components with corrosion-resistant finish.
 - d) Wheels statically and dynamically balanced.
 - 2) Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
 - 3) Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
 - 4) Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
 - 5) Vibration Control: Integral isolation to dampen vibration transmission.
- f. Filter Assembly:
- 1) Access: Bottom, side, or rear to accommodate field installation without removing ductwork and to accommodate filter replacement without need for tools.
 - 2) Efficiency: [**ASHRAE 52.2, MERV 7**][**ASHRAE 52.2, MERV 11**][**ASHRAE 52.2, MERV 13**]**<Insert efficiency>** .
 - 3) Media: [**If more than one filter type is indicated, Contractor has option to**

choose.]

- a) Replaceable: Extended surface, panel, or cartridge with antimicrobial treatment fiber media.
 - b) Washable: Manufacturer's standard filter with antimicrobial treatment.
- g. Unit Accessories:
- 1) Outdoor Air Ventilation Kit: Connection, motorized damper, and control sized to allow sequence of operation indicated on Drawings.
 - 2) Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.
- h. Unit Controls:
- 1) Enclosure: Metal, suitable for indoor locations.
 - 2) Factory-Installed Controller: Configurable digital control.
 - 3) Factory-Installed Sensors:
 - a) Unit inlet air temperature.
 - b) Coil entering refrigerant temperature.
 - c) Coil leaving refrigerant temperature.
 - 4) Field-Customizable I/O Capability:
 - a) Analog Inputs: **[Two][Three][Four]<Insert number>** for use in customizable control strategies.
 - b) Digital Inputs: **[Two][Three][Four]<Insert number>** for use in customizable control strategies.
 - c) Digital Outputs: **[Two][Three][Four]<Insert number>** for use in customizable control strategies.
 - 5) Features and Functions:
 - a) Self-diagnostics.
 - b) Time delay.
 - c) Auto-restart.
 - d) External static pressure control.
 - e) Auto operation mode.
 - f) Manual operation mode.
 - g) Filter service notification.
 - h) Power consumption display.
 - i) Drain-assembly, high-water-level safety shutdown and notification.
 - j) Run test switch.
 - 6) Communication: Network communication with other indoor and outdoor units.
 - 7) Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 - 8) Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
- i. Unit Electrical:
- 1) Enclosure: Metal, suitable for indoor locations.
 - 2) Field Connection: Single-point connection to power unit and integral controls.

- 3) Disconnecting Means: Factory-mounted circuit breaker or switch.
- 4) Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
- 5) Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
- 6) Raceways: Enclose line voltage wiring in [**metal**] raceways.

2. VRF Indoor Unit - Concealed, Floor-Mounted Units For Ducting:

- a. Description: Factory-assembled [**and -tested**] complete unit with components, piping, wiring, and controls required for mating to ductwork, piping, power, and controls field connections.
- b. Cabinet:
 - 1) Material: [**Galvanized**][or][**painted**] steel.
 - 2) Insulation: Manufacturer's standard internal insulation [, **complying with ASHRAE 62.1,**] to provide thermal resistance and prevent condensation.
 - 3) Duct Connections: Extended collar or flange, or designated exterior cabinet surface, designed for attaching field-installed ductwork.
 - 4) Mounting: Manufacturer-designed provisions for field installation.
 - 5) Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.
- c. DX Coil Assembly:
 - 1) Coil Casing: Aluminum, galvanized, or stainless steel.
 - 2) Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
 - 3) Coil Tubes: Copper, of diameter and thickness required by performance.
 - 4) Expansion Valve: Electronic modulating type with linear or proportional characteristics.
 - 5) Unit Internal Tubing: Copper tubing with brazed joints.
 - 6) Unit Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
 - 7) Field Piping Connections: Manufacturer's standard.
 - 8) Factory Charge: Dehydrated air or nitrogen.
 - 9) Testing: Factory pressure tested and verified to be without leaks.
- d. Drain Assembly:
 - 1) Pan: Non-ferrous material, with bottom sloped to low point drain connection.
 - 2) Condensate Removal: Unit-mounted pump or other integral lifting mechanism, capable of lifting drain water to an elevation above top of cabinet.
 - 3) Field Piping Connection: Non-ferrous material [**with threaded NPT**] .
- e. Fan and Motor Assembly:
 - 1) Fan(s):
 - a) Direct-drive arrangement.
 - b) Single or multiple fans connected to a common motor shaft and driven by a single motor.
 - c) Materials: Non-ferrous components or ferrous components with corrosion-resistant finish.
 - d) Statically and dynamically balanced.

- 2) Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
 - 3) Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
 - 4) Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
 - 5) Vibration Control: Integral isolation to dampen vibration transmission.
- f. Filter Assembly:
- 1) Access: Bottom, side, or rear to accommodate field installation without removing ductwork and to accommodate filter replacement without need for tools.
 - 2) Efficiency: **[ASHRAE 52.2, MERV 7][ASHRAE 52.2, MERV 11][ASHRAE 52.2, MERV 13]<Insert efficiency>** .
 - 3) Media: **[If more than one filter type is indicated, Contractor has option to choose.]**
 - a) Replaceable: Extended surface, panel, or cartridge with antimicrobial treatment fiber media.
 - b) Washable: Manufacturer's standard filter with antimicrobial treatment.
- g. Unit Accessories:
- 1) Outdoor Air Ventilation Kit: Connection, motorized damper, and control sized to allow sequence of operation indicated on Drawings.
 - 2) Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.
- h. Unit Controls:
- 1) Enclosure: Metal, suitable for indoor locations.
 - 2) Factory-Installed Controller: Configurable digital control.
- i. Factory-Installed Sensors:
- 1) Unit inlet air temperature.
 - 2) Coil entering refrigerant temperature.
 - 3) Coil leaving refrigerant temperature.
- j. Field-Customizable I/O Capability:
- 1) Analog Inputs: **[Two][Three][Four]<Insert number>** for use in customizable control strategies.
 - 2) Digital Inputs: **[Two][Three][Four]<Insert number>** for use in customizable control strategies.
 - 3) Digital Outputs: **[Two][Three][Four]<Insert number>** for use in customizable control strategies.
- k. Features and Functions:
- 1) Self-diagnostics.
 - 2) Time delay, auto-restart.
 - 3) External static pressure control.
 - 4) Auto operation mode.
 - 5) Manual operation mode.

- 6) Filter service notification.
 - 7) Power consumption display.
 - 8) Drain-assembly, high-water-level safety shutdown and notification.
 - 9) Run test switch.
- l. Communication: Network communication with other indoor units and outdoor unit(s).
- m. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
- n. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
- o. Unit Electrical:
- 1) Enclosure: Metal, similar to enclosure, and suitable for indoor locations.
 - 2) Field Connection: Single-point connection to power unit and integral controls.
 - 3) Disconnecting Means: Factory-mounted circuit breaker or switch.
 - 4) Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
 - 5) Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 - 6) Raceways: Enclose line voltage wiring in [**metal**] raceways.
3. VRF Indoor Unit - Exposed, Floor Mounted:
- a. Description: Factory-assembled [**and -tested**] complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.
- b. Cabinet:
- 1) Material: Painted steel, or coated steel frame covered by a plastic cabinet, with an architectural acceptable finish suitable for tenant occupancy on exposed surfaces.
 - 2) Insulation: Manufacturer's standard internal insulation [, **complying with ASHRAE 62.1,**] to provide thermal resistance and prevent condensation.
 - 3) Mounting: Manufacturer-designed provisions for field installation.
 - 4) Internal Access: Removable panels of adequate size for field access to internal components for inspection, cleaning, service, and replacement.
- c. DX Coil Assembly:
- 1) Coil Casing: Aluminum, galvanized, or stainless steel.
 - 2) Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
 - 3) Coil Tubes: Copper, of diameter and thickness required by performance.
 - 4) Expansion Valve: Electronic modulating type with linear or proportional characteristics.
 - 5) Unit Internal Tubing: Copper tubing with brazed joints.
 - 6) Unit Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
 - 7) Field Piping Connections: Manufacturer's standard.
 - 8) Factory Charge: Dehydrated air or nitrogen.
 - 9) Testing: Factory pressure tested and verified to be without leaks.
- d. Drain Assembly:
- 1) Pan: Non-ferrous material, with bottom sloped to low point drain connection.
 - 2) Condensate Removal: Gravity.
- a) If a floor drain is not available at unit, provide unit with field-installed

condensate pump accessory.

- 3) Field Piping Connection: Non-ferrous material [**with threaded NPT**] .
- e. Fan and Motor Assembly:
 - 1) Fan(s):
 - a) Direct-drive arrangement.
 - b) Single or multiple fans connected to a common motor shaft and driven by a single motor.
 - c) Materials: Non-ferrous components or ferrous components with corrosion-resistant finish.
 - d) Statically and dynamically balanced.
 - 2) Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
 - 3) Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
 - 4) Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
 - 5) Vibration Control: Integral isolation to dampen vibration transmission.
- f. Filter Assembly:
 - 1) Access: Front, to accommodate filter replacement without the need for tools.
 - 2) Efficiency: **<Insert efficiency>** .
 - 3) Washable Media: Manufacturer's standard filter with antimicrobial treatment.
- g. Grille Assembly: Manufacturer's standard discharge grille [**with field-adjustable air pattern**] mounted in top of unit cabinet.
- h. Unit Accessories:
 - 1) Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.
 - 2) Condensate Pump: Integral reservoir and control with electrical power connection through unit power.
- i. Unit Controls:
 - 1) Enclosure: Manufacturer's standard, and suitable for indoor locations.
 - 2) Factory-Installed Controller: Configurable digital control.
 - 3) Factory-Installed Sensors:
 - a) Unit inlet air temperature.
 - b) Coil entering refrigerant temperature.
 - c) Coil leaving refrigerant temperature.
 - 4) Field-Customizable I/O Capability:
 - a) Analog Inputs: **[Two][Three][Four]<Insert number>** for use in customizable control strategies.
 - b) Digital Inputs: **[Two][Three][Four]<Insert number>** for use in customizable control strategies.
 - c) Digital Outputs: **[Two][Three][Four]<Insert number>** for use in customizable control strategies.

control strategies.

- 5) Features and Functions:
 - a) Self-diagnostics.
 - b) Time delay.
 - c) Auto-restart.
 - d) External static pressure control.
 - e) Auto operation mode.
 - f) Manual operation mode.
 - g) Filter service notification
 - h) Power consumption display.
 - i) Drain-assembly, high-water-level safety shutdown and notification.
 - j) Run test switch.
- 6) Communication: Network communication with other indoor units and outdoor unit(s).
- 7) Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
- 8) Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

j. Unit Electrical:

- 1) Enclosure: Manufacturer's standard, and suitable for indoor locations.
- 2) Field Connection: Single-point connection to power entire unit and integral controls.
- 3) Disconnecting Means: Factory-mounted circuit breaker or switch.
- 4) Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
- 5) Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
- 6) Raceways: Enclose line voltage wiring in [**metal**] raceways.

4. VRF Indoor Unit - Exposed, Wall Mounted:

- a. Description: Factory-assembled [**and -tested**] complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.
- b. Cabinet:
 - 1) Material: Painted steel, or coated steel frame covered by a plastic cabinet, with an architectural acceptable finish suitable for tenant occupancy on exposed surfaces.
 - 2) Insulation: Manufacturer's standard internal insulation [, **complying with ASHRAE 62.1,**] to provide thermal resistance and prevent condensation.
 - 3) Mounting: Manufacturer-designed provisions for field installation.
 - 4) Internal Access: Removable panels of adequate size for field access to internal components for inspection, cleaning, service, and replacement.
- c. DX Coil Assembly:
 - 1) Coil Casing: Aluminum, galvanized, or stainless steel.
 - 2) Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
 - 3) Coil Tubes: Copper, of diameter and thickness required by performance.
 - 4) Expansion Valve: Electronic modulating type with linear or proportional characteristics.
 - 5) Unit Internal Tubing: Copper tubing with brazed joints.
 - 6) Unit Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to

- prevent condensation.
- 7) Field Piping Connections: Manufacturer's standard.
- 8) Factory Charge: Dehydrated air or nitrogen.
- 9) Testing: Factory pressure tested and verified to be without leaks.
- d. Drain Assembly:
 - 1) Pan: Non-ferrous material, with bottom sloped to low point drain connection.
 - 2) Condensate Removal: Gravity.
 - a) If a floor drain is not available at unit, provide unit with field-installed condensate pump accessory.
 - 3) Field Piping Connection: Non-ferrous material [**with threaded NPT**] .
- e. Fan and Motor Assembly:
 - 1) Fan(s):
 - a) Direct-drive arrangement.
 - b) Single or multiple fans connected to a common motor shaft and driven by a single motor.
 - c) Fabricated from non-ferrous components or ferrous components with corrosion protection finish.
 - d) Wheels statically and dynamically balanced.
 - 2) Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
 - 3) Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
 - 4) Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
 - 5) Vibration Control: Integral isolation to dampen vibration transmission.
- f. Filter Assembly:
 - 1) Access: Front, to accommodate filter replacement without the need for tools.
 - 2) Efficiency: **<Insert efficiency>** .
 - 3) Washable Media: Manufacturer's standard filter with antimicrobial treatment.
- g. Grille Assembly: Manufacturer's standard discharge grille [**with field-adjustable air pattern**] mounted in top [**or front face**] of unit cabinet.
- h. Unit Accessories:
 - 1) Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.
 - 2) Condensate Pump: Integral reservoir and control with electrical power connection through unit power.
- i. Unit Controls:
 - 1) Enclosure: Manufacturer's standard, and suitable for indoor locations.
 - 2) Factory-Installed Controller: Configurable digital control.
 - 3) Factory-Installed Sensors: [**Unit inlet air temperature**][**Coil entering refrigerant temperature**][**Coil leaving refrigerant temperature**] **<Insert sensor>** .

- 4) Field-Customizable I/O Capability:
 - a) Analog Inputs: **[Two][Three][Four]<Insert number>** for use in customizable control strategies.
 - b) Digital Inputs: **[Two][Three][Four]<Insert number>** for use in customizable control strategies.
 - c) Digital Outputs: **[Two][Three][Four]<Insert number>** for use in customizable control strategies.
 - 5) Features and Functions: Self-diagnostics, time delay, auto-restart [, **external static pressure control**][, **auto operation mode**][, **manual operation mode**][, **filter service notification**][, **power consumption display**][, **drain-assembly, high-water-level safety shutdown and notification**][, **run test switch**]**<Insert function>** .
 - 6) Communication: Network communication with other indoor units and outdoor unit(s).
 - 7) Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 - 8) Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
- j. Unit Electrical:
- 1) Enclosure: Manufacturer's standard, and suitable for indoor locations.
 - 2) Field Connection: Single-point connection to power entire unit and integral controls.
 - 3) Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
 - 4) Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
 - 5) Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 - 6) Raceways: Enclose line voltage wiring in [**metal**] raceways to comply with NFPA 70.
5. VRF Indoor Unit - Recessed, Ceiling Mounted:
- a. Description: Factory-assembled [**and -tested**] complete unit with components, piping, wiring, and controls required for mating to ductwork, piping, power, and controls field connections.
 - b. Cabinet:
 - 1) Material: Painted steel, or coated steel frame covered by a plastic cabinet, with an architectural acceptable finish suitable for tenant occupancy on exposed surfaces.
 - 2) Insulation: Manufacturer's standard internal insulation [, **complying with ASHRAE 62.1,**] to provide thermal resistance and prevent condensation.
 - 3) Mounting: Manufacturer-designed provisions for field installation.
 - 4) Internal Access: Removable panels of adequate size for field access to internal components for inspection, cleaning, service, and replacement.
 - c. DX Coil Assembly:
 - 1) Coil Casing: Aluminum, galvanized, or stainless steel.
 - 2) Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
 - 3) Coil Tubes: Copper, of diameter and thickness required by performance.
 - 4) Expansion Valve: Electronic modulating type with linear or proportional characteristics.

- 5) Internal Tubing: Copper tubing with brazed joints.
 - 6) Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
 - 7) Field Piping Connections: Manufacturer's standard.
 - 8) Factory Charge: Dehydrated air or nitrogen.
 - 9) Testing: Factory pressure tested and verified to be without leaks.
- d. Drain Assembly:
- 1) Pan: Non-ferrous material, with bottom sloped to low point drain connection.
 - 2) Condensate Removal: Unit-mounted pump or other integral lifting mechanism, capable of lifting drain water to an elevation above top of cabinet.
 - 3) Field Piping Connection: Non-ferrous material [**with threaded NPT**] .
- e. Fan and Motor Assembly:
- 1) Fan(s):
 - a) Direct-drive arrangement.
 - b) Single or multiple fans connected to a common motor shaft and driven by a single motor.
 - c) Fabricated from non-ferrous components or ferrous components with corrosion protection finish.
 - d) Wheels statically and dynamically balanced.
 - 2) Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
 - 3) Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
 - 4) Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
 - 5) Vibration Control: Integral isolation to dampen vibration transmission.
- f. Filter Assembly:
- 1) Access: Bottom, to accommodate filter replacement without the need for tools.
 - 2) Efficiency: **[ASHRAE 52.2, MERV 7][ASHRAE 52.2, MERV 11][ASHRAE 52.2, MERV 13]<Insert efficiency>** .
 - 3) Media: [**If more than one filter type is indicated, Contractor has option to choose.**]
 - a) Replaceable: Extended surface, panel, or cartridge with antimicrobial treatment fiber media.
 - b) Washable: Manufacturer's standard filter with antimicrobial treatment.
- g. Discharge-Air Grille Assembly: Mounted in bottom of unit cabinet.
- 1) Discharge Pattern: One-, two-, three-, or four-way throw as indicated on Drawings.
 - 2) Discharge Pattern Adjustment: Field-adjustable limits for up and down range of motion.
 - 3) Discharge Pattern Closure: Ability to close individual discharges of units with multiple patterns.
 - 4) Motorized Vanes: Modulating up and down flow pattern for uniform room air distribution.
 - 5) Additional Branch Supply Duct Connection: Sheet metal knockout for optional

connection to one additional supply branch duct.

- h. Return-Air Grille Assembly: Manufacturer's standard grille mounted in bottom of unit cabinet.
 - i. Outdoor Air Ventilation Connection: Sheet metal knockout for optional connection to outdoor air ventilation duct.
 - j. Unit Accessories:
 - 1) Outdoor Air Ventilation Kit: Connection, motorized damper, and control to satisfy unit control sequence of operation indicated on Drawings.
 - 2) Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.
 - k. Unit Controls:
 - 1) Enclosure: Manufacturer's standard, and suitable for indoor locations.
 - 2) Factory-Installed Controller: Configurable digital control.
 - l. Factory-Installed Sensors: **[Unit inlet air temperature][Coil entering refrigerant temperature][Coil leaving refrigerant temperature]<Insert sensor>** .
 - m. Field-Customizable I/O Capability:
 - 1) Analog Inputs: **[Two][Three][Four]<Insert number>** for use in customizable control strategies.
 - 2) Digital Inputs: **[Two][Three][Four]<Insert number>** for use in customizable control strategies.
 - 3) Digital Outputs: **[Two][Three][Four]<Insert number>** for use in customizable control strategies.
 - n. Features and Functions: Self-diagnostics, time delay, auto-restart [, **external static pressure control**][, **auto operation mode**][, **manual operation mode**][, **filter service notification**][, **power consumption display**][, **drain-assembly, high-water-level safety shutdown and notification**][, **run test switch**]**<Insert function>** .
 - o. Communication: Network communication with other indoor units and outdoor unit(s).
 - p. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 - q. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 - r. Unit Electrical:
 - 1) Enclosure: Manufacturer's standard, and suitable for indoor locations.
 - 2) Field Connection: Single-point connection to power entire unit and integral controls.
 - 3) Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
 - 4) Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
 - 5) Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 - 6) Raceways: Enclose line voltage wiring in [**metal**] raceways to comply with NFPA 70.
6. VRF Indoor Unit - Suspended, Ceiling-Mounted:
- a. Description: Factory-assembled [**and -tested**] complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.
 - b. Cabinet:

- 1) Material: Painted steel, or coated steel frame covered by a plastic cabinet, with an architectural acceptable finish suitable for tenant occupancy on exposed surfaces.
 - 2) Insulation: Manufacturer's standard internal insulation [, **complying with ASHRAE 62.1,**] to provide thermal resistance and prevent condensation.
 - 3) Mounting: Manufacturer-designed provisions for field installation.
 - 4) Internal Access: Removable panels of adequate size for field access to internal components for inspection, cleaning, service, and replacement.
- c. DX Coil Assembly:
- 1) Coil Casing: Aluminum, galvanized, or stainless steel.
 - 2) Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
 - 3) Coil Tubes: Copper, of diameter and thickness required by performance.
 - 4) Expansion Valve: Electronic modulating type with linear or proportional characteristics.
 - 5) Internal Tubing: Copper tubing with brazed joints.
 - 6) Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
 - 7) Field Piping Connections: Manufacturer's standard.
 - 8) Factory Charge: Dehydrated air or nitrogen.
 - 9) Testing: Factory pressure tested and verified to be without leaks.
- d. Drain Assembly:
- 1) Pan: Non-ferrous material, with bottom sloped to low point drain connection.
 - 2) Condensate Removal: Gravity.
 - a) If a floor drain is not available at unit, provide unit with field-installed condensate pump accessory.
 - 3) Field Piping Connection: Non-ferrous material [**with threaded NPT**] .
- e. Fan and Motor Assembly:
- 1) Fan(s):
 - a) Direct-drive arrangement.
 - b) Single or multiple fans connected to a common motor shaft and driven by a single motor.
 - c) Fabricated from non-ferrous components or ferrous components with corrosion protection finish.
 - d) Wheels statically and dynamically balanced.
 - 2) Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
 - 3) Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
 - 4) Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
 - 5) Vibration Control: Integral isolation to dampen vibration transmission.
- f. Filter Assembly:
- 1) Access: Front, to accommodate filter replacement without the need for tools.

- 2) Efficiency: **<Insert efficiency>** .
 - 3) Washable Media: Manufacturer's standard filter with antimicrobial treatment.
- g. Discharge-Air Grille Assembly: Mounted in front of unit cabinet.
- 1) Discharge Pattern: One-way throw.
 - 2) Discharge Pattern Adjustment: Field-adjustable limits for range of pattern.
 - 3) Motorized Vanes: Modulating up and down flow pattern for uniform room air distribution.
- h. Return-Air Grille Assembly: Manufacturer's standard.
- i. Outdoor Air Ventilation Connection: Sheet metal knockout for optional connection to outdoor air ventilation duct.
- j. Unit Accessories:
- 1) Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.
 - 2) Condensate Pump: Integral reservoir and control with electrical power connection through unit power.
- k. Unit Controls:
- 1) Enclosure: Manufacturer's standard, and suitable for indoor locations.
 - 2) Factory-Installed Controller: Configurable digital control.
 - 3) Factory-Installed Sensors: **[Unit inlet air temperature][Coil entering refrigerant temperature][Coil leaving refrigerant temperature]<Insert sensor>** .
- l. Field-Customizable I/O Capability:
- 1) Analog Inputs: **[Two][Three][Four]<Insert number>** for use in customizable control strategies.
 - 2) Digital Inputs: **[Two][Three][Four]<Insert number>** for use in customizable control strategies.
 - 3) Digital Outputs: **[Two][Three][Four]<Insert number>** for use in customizable control strategies.
- m. Features and Functions: Self-diagnostics, time delay, auto-restart [, **external static pressure control**][, **auto operation mode**][, **manual operation mode**][, **filter service notification**][, **power consumption display**][, **drain-assembly, high-water-level safety shutdown and notification**][, **run test switch**]**<Insert function>** .
- n. Communication: Network communication with other indoor units and outdoor unit(s).
- o. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
- p. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
- q. Unit Electrical:
- 1) Enclosure: Manufacturer's standard, and suitable for indoor locations.
 - 2) Field Connection: Single-point connection to power entire unit and integral controls.
 - 3) Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
 - 4) Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
 - 5) Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 - 6) Raceways: Enclose line voltage wiring in [**metal**] raceways to comply with NFPA

70.

7. VRF Indoor Unit - Hydronic Heat Exchangers:

- a. Description: Factory-assembled [**and -tested**] complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.
- b. Cabinet:
 - 1) Material: [**Galvanized**][or][**painted**] steel.
 - 2) Insulation: Manufacturer's standard internal insulation to provide thermal resistance and prevent condensation.
 - 3) Mounting: Manufacturer-designed provisions for field installation.
 - 4) Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.
- c. Heat-Exchanger Assembly:
 - 1) Single or dual, brazed plate heat exchanger with performance indicated on Drawings.
 - 2) Expansion Valve: Electronic modulating type with linear or proportional characteristics.
 - 3) Internal Tubing: Copper tubing with brazed joints.
 - 4) Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
 - 5) Field Piping Connections: Manufacturer's standard.
 - 6) Factory Charge: Dehydrated air or nitrogen.
 - 7) Testing: Factory pressure tested and verified to be without leaks.
 - 8) Drain: Hydronic side of assembly with drain connection at low point.
- d. Unit Accessories:
 - 1) Strainer: Y-pattern strainer for installation on entering hydronic piping to unit.
- e. Unit Controls:
 - 1) Enclosure: Metal, similar to enclosure, and suitable for indoor locations.
 - 2) Factory-Installed Controller: Configurable digital control.
 - 3) Factory-Installed Sensors: [**Unit entering refrigerant temperature**][**Unit leaving refrigerant temperature**][**Unit entering-water temperature**][**Unit leaving-water temperature**]<Insert sensor> .
 - 4) Features and Functions: Self-diagnostics, time delay, auto-restart, hydronic pump interlock [, **auto operation mode**][, **manual operation mode**][, **run test switch**][, **leaving-water set-point control**][, **entering- or leaving-water set-point control**][, **automatic water temperature control reset based on outdoor temperature**][, **automatic water temperature control reset based on a remote signal**]<Insert function> .
 - 5) Communication: Network communication with other indoor units and outdoor unit(s).
 - 6) Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 - 7) Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
- f. Unit Electrical:
 - 1) Enclosure: Metal, similar to enclosure, and suitable for indoor locations.

- 2) Field Connection: Single-point connection to power entire unit and integral controls.
- 3) Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
- 4) Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
- 5) Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
- 6) Raceways: Enclose line voltage wiring in [**metal**] raceways to comply with NFPA 70.

8. VRF Indoor Unit - Dedicated Outdoor Air Ventilation Units:

- a. Description: Factory-assembled [**and -tested**] complete unit with components, piping, wiring, and controls required for mating to ductwork, piping, power, and controls field connections.
 - 1) Specially designed for up to 100 percent outdoor air entering unit.
- b. Cabinet:
 - 1) Material: [**Galvanized**][**or**][**painted**] steel.
 - 2) Insulation: Manufacturer's standard internal insulation [, **complying with ASHRAE 62.1,**] to provide thermal resistance and prevent condensation.
 - 3) Duct Connections: Extended collar or flange, or designated exterior cabinet surface, designed for attaching field-installed ductwork.
 - 4) Mounting: Manufacturer-designed provisions for field installation.
 - 5) Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.
- c. DX Coil Assembly:
 - 1) Coil Casing: Aluminum, galvanized, or stainless steel.
 - 2) Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
 - 3) Coil Tubes: Copper, of diameter and thickness required by performance.
 - 4) Expansion Valve: Electronic modulating type with linear or proportional characteristics.
 - 5) Unit Internal Tubing: Copper tubing with brazed joints.
 - 6) Unit Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
 - 7) Field Piping Connections: Manufacturer's standard.
 - 8) Factory Charge: Dehydrated air or nitrogen.
 - 9) Testing: Factory pressure tested and verified to be without leaks.
- d. DX Coil Assembly for Reheat Applications: Provide units with a reheat coil where indicated on Drawings.
 - 1) Coil Casing: Aluminum, galvanized, or stainless steel.
 - 2) Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
 - 3) Coil Tubes: Copper, of diameter and thickness required by performance.
 - 4) Expansion Valve: Electronic modulating type with linear or proportional characteristics.
 - 5) Unit Internal Tubing: Copper tubing with brazed joints.
 - 6) Unit Internal Tubing Insulation: Manufacturer's standard insulation.
 - 7) Field Piping Connections: Manufacturer's standard.

- 8) Factory Charge: Dehydrated air or nitrogen.
 - 9) Testing: Factory pressure tested and verified to be without leaks.
- e. Drain Assembly:
- 1) Pan: Non-ferrous material, with bottom sloped to low point drain connection.
 - 2) Condensate Removal: Unit-mounted pump or other integral lifting mechanism, capable of lifting drain water to an elevation above top of cabinet.
 - 3) Field Piping Connection: Non-ferrous material [**with threaded NPT**] .
- f. Fan and Motor Assembly:
- 1) Fan(s):
 - a) Direct-drive arrangement.
 - b) Single or multiple fans connected to a common motor shaft and driven by a single motor.
 - c) Fabricated from non-ferrous components or ferrous components with corrosion protection finish.
 - d) Wheels statically and dynamically balanced.
 - 2) Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
 - 3) Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
 - 4) Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
 - 5) Vibration Control: Integral isolation to dampen vibration transmission.
- g. Filter Assembly:
- 1) Access: Bottom, side, or rear to accommodate field installation without removing ductwork and to accommodate filter replacement without need for tools.
 - 2) Efficiency: [ASHRAE 52.2, MERV 7][ASHRAE 52.2, MERV 11][ASHRAE 52.2, MERV 13]<Insert efficiency> .
 - 3) Replaceable Media: Extended surface, panel, or cartridge with antimicrobial treatment fiber media.
- h. Unit Accessories:
- 1) Motorized Inlet Damper Kit: Low-leakage damper with spring return electric actuator to fail closed on loss of power. Damper controlled by unit to open when unit is operating and close when unit off.
- i. Unit Controls:
- 1) Enclosure: Metal, similar to enclosure, and suitable for indoor locations.
 - 2) Factory-Installed Controller: Configurable digital control.
 - 3) Factory-Installed Sensors: [Coil entering refrigerant temperature][Coil leaving refrigerant temperature][Unit entering-air temperature][Unit leaving-air temperature][Unit entering-air relative humidity][Unit leaving-air relative humidity]<Insert sensor> .
 - 4) Field-Customizable I/O Capability:
 - a) Analog Inputs: [Two][Three][Four]<Insert number> for use in customizable

- control strategies.
 - b) Digital Inputs: [Two][Three][Four]<Insert number> for use in customizable control strategies.
 - c) Digital Outputs: [Two][Three][Four]<Insert number> for use in customizable control strategies.
 - 5) Features and Functions: Self-diagnostics, time delay, auto-restart [, **external static pressure control**][, **auto operation mode**][, **manual operation mode**][, **filter service notification**][, **power consumption display**][, **drain-assembly, high-water-level safety shutdown and notification**][, **run test switch**]<Insert function> .
 - 6) Communication: Network communication with other indoor units and outdoor unit(s).
 - 7) Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 - 8) Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 - j. Unit Electrical:
 - 1) Enclosure: Metal, similar to enclosure, and suitable for indoor locations.
 - 2) Field Connection: Single-point connection to power entire unit and integral controls.
 - 3) Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
 - 4) Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
 - 5) Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 - 6) Raceways: Enclose line voltage wiring in [**metal**] raceways to comply with NFPA 70.
9. VRF Indoor Unit - Energy Recovery Ventilator:
- a. Description: Factory-assembled [**and -tested**] complete unit with components, wiring, and controls required for mating to ductwork, power, and controls field connections.
 - b. Cabinet:
 - 1) Material: Galvanized steel.
 - 2) Insulation: Manufacturer's standard internal insulation [, **complying with ASHRAE 62.1**] .
 - 3) Duct Connections: Extended collar or flange, or designated exterior cabinet surface, designed for attaching field-installed ductwork.
 - 4) Mounting: Manufacturer-designed provisions for field installation.
 - 5) Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.
 - c. Damper Assemblies:
 - 1) Outdoor Air Intake and Exhaust Air Discharge:
 - a) Low-leakage damper with spring return electric actuator to fail closed on loss of power.
 - b) Damper controlled by unit to open when unit is operating and close when unit off.
 - 2) Energy Recovery Heat-Exchanger Bypass:

- a) Low leakage damper with electric actuator with integral controls to bypass outdoor air around the energy recovery heat exchanger during times of favorable weather, and there is no energy-saving benefit to circulate air across the energy recovery heat exchanger.
- d. Fan and Motor Assemblies: Separate fan and motor assemblies for supply and exhaust airstreams with control for equal airflow.
 - 1) Fan(s):
 - a) Direct-drive arrangement.
 - b) Fabricated from non-ferrous components or ferrous components with corrosion protection finish.
 - c) Wheels statically and dynamically balanced.
 - 2) Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
 - 3) Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
 - 4) Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least **[50]<Insert number>** percent.
 - 5) Vibration Control: Integral isolation to dampen vibration transmission.
- e. Filter Assemblies: Separate filter assemblies for outdoor air and exhaust airstreams entering energy recovery heat exchanger.
 - 1) Access: To accommodate filter replacement without the need for tools.
 - 2) Efficiency: **[ASHRAE 52.2, MERV 7]<Insert efficiency>** .
 - 3) Replaceable Media: Extended surface, panel, or cartridge with antimicrobial treatment fiber media.
- f. Energy Recovery Heat Exchanger:
 - 1) Total (sensible and latent) energy exchange between outdoor air and exhaust airstreams with performance indicated on Drawings.
 - 2) Fixed element with no moving parts.
 - 3) AHRI 1060 certified and bearing the AHRI label.
- g. Unit Accessories:
 - 1) Electric Duct Preheater:
 - a) Heater operation interlocked with energy recovery ventilator unit.
 - b) Heater with integral controls to control outdoor air temperature entering energy recovery ventilator unit to a temperature set-point determined by energy recovery ventilator unit manufacturer.
 - c) Listed and labeled.
- h. Unit Controls:
 - 1) Enclosure: Metal, similar to enclosure, and suitable for indoor locations.
 - 2) Factory-Installed Controller: Configurable digital control.
 - 3) Factory-Installed Sensors:

- a) Unit entering outdoor air temperature.
 - b) Unit leaving supply air temperature.
 - c) Unit entering exhaust air temperature.
 - d) Unit leaving exhaust air temperature.
 - e) Unit entering outdoor air relative humidity.
 - f) Unit leaving supply air relative humidity.
 - g) Unit entering exhaust air relative humidity.
 - h) Unit leaving exhaust air relative humidity.
 - 4) Field-Customizable I/O Capability:
 - a) Analog Inputs: **[Two][Three][Four]<Insert number>** for use in customizable control strategies.
 - b) Digital Inputs: **[Two][Three][Four]<Insert number>** for use in customizable control strategies.
 - c) Digital Outputs: **[Two][Three][Four]<Insert number>** for use in customizable control strategies.
 - 5) Features and Functions: Self-diagnostics, time delay, auto-restart [, **external static pressure control**][, **local auto operation mode**][, **auto operation through remote signal**][, **manual operation mode**][, **filter service notification**][, **power consumption display**][, **run test switch**]**<Insert function>** .
 - 6) Communication: Network communication with other indoor units and outdoor unit(s).
 - 7) Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 - 8) Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 - i. Unit Electrical:
 - 1) Enclosure: Metal, similar to enclosure, and suitable for indoor locations.
 - 2) Field Connection: Single-point connection to power entire unit and integral controls.
 - 3) Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
 - 4) Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
 - 5) Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 - 6) Raceways: Enclose line voltage wiring in [**metal**] raceways to comply with NFPA 70.
10. VRF Indoor Unit - Hydronic Heat Pump:
- a. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.
 - 1) Specially designed for use in systems with either all heating or all cooling demands, but not for use in systems with simultaneous heating and cooling.
 - 2) Systems are to consist of one unit, or multiple unit modules that are designed by variable refrigerant system manufacturer for field interconnection to make a single refrigeration circuit that connects multiple indoor units.
 - 3) All units installed are to be from the same product development generation.
 - b. Cabinet:
 - 1) Galvanized-steel construction.



- 2) Mounting: Manufacturer-designed provisions for field installation.
 - 3) Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.
 - 4) Internal Cabinet Cooling: Unit is to include integral cabinet cooling to maintain inside of cabinet within acceptable operating temperature for internal components.
 - a) If unit is not available with integral cooling, provide a field-installed indoor unit that is dedicated to provide cabinet cooling.
- c. Compressor and Motor Assembly:
- 1) One or more positive-displacement, direct-drive and hermetically sealed scroll compressor(s) with inverter drive and turndown to [15]<Insert number> percent of rated capacity.
 - 2) Protection: Integral protection against the following:
 - a) High and low refrigerant pressure.
 - b) Low oil level.
 - c) High oil temperature.
 - d) Thermal and overload.
 - e) Voltage fluctuations.
 - f) Phase failure and phase reversal.
 - g) Short cycling.
 - 3) Speed Control: Variable to automatically maintain refrigerant suction and condensing pressures while varying refrigerant flow to satisfy system cooling and heating loads.
 - 4) Vibration Control: Integral isolation to dampen vibration transmission.
 - 5) Oil management system to ensure safe and proper lubrication over entire operating range.
 - 6) Crankcase heaters with integral control to maintain safe operating temperature.
 - 7) Fusible plug.
- d. Drain Pan: If required by manufacturer's design, provide unit with non-ferrous drain pan with bottom sloped to a low point drain connection.
- e. Heat-Exchanger Assembly:
- 1) Brazed plate heat exchanger(s) with performance indicated on Drawings.
 - 2) Testing: Factory pressure tested and verified to be without leaks.
 - 3) Drain: Hydronic side of assembly with drain connection at low point.
- f. Unit Accessories:
- 1) Strainer: Y-pattern strainer for installation on entering hydronic piping to unit.
- g. Unit Controls:
- 1) Enclosure: Manufacturer's standard, and suitable for unprotected outdoor locations.
 - 2) Factory-Installed Controller: Configurable digital control.
 - 3) Factory-Installed Sensors:
 - a) Entering-water temperature.
 - b) Leaving-water temperature.
 - c) Refrigerant suction temperature.
 - d) Refrigerant discharge temperature.

- e) Outdoor air temperature.
 - f) Refrigerant high pressure.
 - g) Refrigerant low pressure.
 - h) Oil level.
 - 4) Features and Functions: Self-diagnostics, time delay, auto-restart, fuse protection, not less than 15 steps of capacity control, freeze protection sensor, proof of water flow [, **auto operation mode**][, **manual operation mode**][, **power consumption display**][, **run test switch**][, **automatic control through a remote signal**]<Insert function> .
 - 5) Communication: Network communication with indoor units and other outdoor unit(s).
 - 6) Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 - 7) Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 - h. Unit Electrical:
 - 1) Enclosure: Metal, similar to enclosure, and suitable for unprotected outdoor locations.
 - 2) Field Connection: Single-point connection to power entire unit and integral controls.
 - 3) Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
 - 4) Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
 - 5) Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 - 6) Raceways: Enclose line voltage wiring in [**metal**] raceways to comply with NFPA 70.
 - i. Unit Hardware: Zinc-plated steel, or stainless steel. Coat exposed surfaces with additional corrosion-resistant coating if required to prevent corrosion when exposed to salt spray test for [1000]<Insert number> hours in accordance with ASTM B117.
 - j. Unit Piping:
 - 1) Unit Tubing: Copper tubing with brazed joints.
 - 2) Unit Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
 - 3) Field Piping Connections: Manufacturer's standard.
 - 4) Factory Charge: Dehydrated air or nitrogen.
 - 5) Testing: Factory pressure tested and verified to be without leaks.
11. VRF Indoor Unit - Hydronic Heat Recovery:
- a. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.
 - 1) Specially designed for use in systems with simultaneous heating and cooling.
 - 2) Systems are to consist of one unit, or multiple unit modules that are designed by variable refrigerant system manufacturer for field interconnection to make a single refrigeration circuit that connects multiple indoor units.
 - 3) All units installed are to be from the same product development generation.
 - b. Cabinet:
 - 1) Galvanized-steel construction.

- 2) Mounting: Manufacturer-designed provisions for field installation.
- 3) Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.
- c. Internal Cabinet Cooling: Unit is to include integral cabinet cooling to maintain inside of cabinet within acceptable operating temperature for internal components.
 - 1) If unit is not available with integral cooling, provide a field-installed indoor unit that is dedicated to provide cabinet cooling.
- d. Compressor and Motor Assembly:
 - 1) One or more positive-displacement, direct-drive and hermetically sealed scroll compressor(s) with inverter drive and turndown to [15]<Insert number> percent of rated capacity.
 - 2) Protection: Integral protection against the following:
 - a) High and low refrigerant pressure.
 - b) Low oil level.
 - c) High oil temperature.
 - d) Thermal and overload.
 - e) Voltage fluctuations.
 - f) Phase failure and phase reversal.
 - g) Short cycling.
 - 3) Speed Control: Variable to automatically maintain refrigerant suction and condensing pressures while varying refrigerant flow to satisfy system cooling and heating loads.
 - 4) Vibration Control: Integral isolation to dampen vibration transmission.
 - 5) Oil management system to ensure safe and proper lubrication over entire operating range.
 - 6) Crankcase heaters with integral control to maintain safe operating temperature.
 - 7) Fusible plug.
- e. Drain Pan: If required by manufacturer's design, provide unit with non-ferrous drain pan with bottom sloped to a low point drain connection.
- f. Heat-Exchanger Assembly:
 - 1) Brazed plate heat exchanger(s) with performance indicated on Drawings.
 - 2) Testing: Factory pressure tested and verified to be without leaks.
 - 3) Drain: Hydronic side of assembly with drain connection at low point.
- g. Unit Accessories:
 - 1) Strainer: Y-pattern strainer for installation on entering hydronic piping to unit.
- h. Unit Controls:
 - 1) Enclosure: Manufacturer's standard, and suitable for unprotected outdoor locations.
 - 2) Factory-Installed Controller: Configurable digital control.
 - 3) Factory-Installed Sensors:
 - a) Entering-water temperature.
 - b) Leaving-water temperature.
 - c) Refrigerant suction temperature.

- d) Refrigerant discharge temperature.
 - e) Outdoor air temperature.
 - f) Refrigerant high pressure.
 - g) Refrigerant low pressure.
 - h) Oil level.
 - 4) Features and Functions: Self-diagnostics, time delay, auto-restart, fuse protection, not less than 15 steps of capacity control, freeze protection sensor, proof of water flow [, **auto operation mode**][, **manual operation mode**][, **power consumption display**][, **run test switch**][, **automatic control through a remote signal**]<Insert function> .
 - 5) Communication: Network communication with indoor units and other outdoor unit(s).
 - 6) Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 - 7) Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 - i. Unit Electrical:
 - 1) Enclosure: Metal, similar to enclosure, and suitable for unprotected outdoor locations.
 - 2) Field Connection: Single-point connection to power entire unit and integral controls.
 - 3) Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
 - 4) Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
 - 5) Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 - 6) Raceways: Enclose line voltage wiring in [**metal**] raceways to comply with NFPA 70.
 - j. Unit Hardware: Zinc-plated steel, or stainless steel.
 - k. Unit Piping:
 - 1) Unit Tubing: Copper tubing with brazed joints.
 - 2) Unit Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
 - 3) Field Piping Connections: Manufacturer's standard.
 - 4) Factory Charge: Dehydrated air or nitrogen.
 - 5) Testing: Factory pressure tested and verified to be without leaks.
12. VRF Indoor Unit - Heat Recovery Control Unit (HRCU):
- a. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.
 - 1) Specially designed for use in systems with simultaneous heating and cooling.
 - 2) Systems are to consist of one unit, or multiple unit that are designed by variable refrigerant system manufacturer for field interconnection to make a single refrigeration circuit that connects multiple indoor units.
 - b. Cabinet:
 - 1) Galvanized-steel construction.
 - 2) Insulation: Manufacturer's standard internal insulation to provide thermal resistance and prevent condensation.

- 3) Mounting: Manufacturer-designed provisions for field installation.
- 4) Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.
- c. Drain Pan: If required by manufacturer's design, provide unit with non-ferrous drain pan with bottom sloped to a low point drain connection.
- d. Refrigeration Assemblies and Specialties:
 - 1) Specially designed by manufacturer for type of VRF HVAC system being installed, either two or three pipe.
 - 2) Each refrigerant branch circuit is to have refrigerant control valve(s) to control refrigerant flow.
 - 3) Spares: Each heat recovery control unit is to include at least **[one][two]<Insert number>** branch circuit port(s) for future use.
 - 4) Each system piping connection upstream of heat recovery unit is to be fitted with an isolation valve to allow for service to any heat recovery control unit in the system without interrupting operation of the system.
 - 5) Each branch circuit connection is to be fitted with an isolation valve and capped service port to allow for service to any individual branch circuit without interrupting operation of the system.
 - a) If not available as an integral part of the heat recovery control unit, isolation valves are to be field installed adjacent to the unit pipe connection.
- e. Unit Controls:
 - 1) Enclosure: Manufacturer's standard, and suitable for indoor locations.
 - 2) Factory-Installed Controller: Configurable digital control.
 - 3) Factory-Installed Sensors: **<Insert sensor>** .
 - 4) Features and Functions: Self-diagnostics, fuse protection, **<Insert function>** .
 - 5) Communication: Network communication with indoor units and outdoor unit(s).
 - 6) Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 - 7) Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
- f. Unit Electrical:
 - 1) Enclosure: Metal, similar to enclosure, and suitable for indoor locations.
 - 2) Field Connection: Single-point connection to power entire unit and integral controls.
 - 3) Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
 - 4) Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
 - 5) Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 - 6) Raceways: Enclose line voltage wiring in **[metal]** raceways to comply with NFPA 70.
- g. Unit Piping:
 - 1) Unit Tubing: Copper tubing with brazed joints.
 - 2) Unit Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
 - 3) Field Piping Connections: Manufacturer's standard.

- 4) Factory Charge: Dehydrated air or nitrogen.
- 5) Testing: Factory pressure tested and verified to be without leaks.

F. VRF Outdoor Units:

1. VRF Outdoor Unit - Air-Source Heat Pump:

- a. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.
 - 1) Specially designed for use in systems with either all heating or all cooling demands, but not for use in systems with simultaneous heating and cooling.
 - 2) Systems are to consist of one unit, or multiple unit modules that are designed by variable refrigerant system manufacturer for field interconnection to make a single refrigeration circuit that connects multiple indoor units.
 - 3) All units installed are to be from the same product development generation.
- b. Cabinet:
 - 1) Galvanized steel and coated with a corrosion-resistant finish.
 - a) Coating with documented salt spray test performance of **[1000]<Insert number>** hours in accordance with ASTM B117 surface scratch test (SST) procedure.
 - 2) Mounting: Manufacturer-designed provisions for field installation.
 - 3) Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.
- c. Compressor and Motor Assembly:
 - 1) One or more positive-displacement, direct-drive and hermetically sealed scroll compressor(s) with inverter drive and turndown to **[15]<Insert number>** percent of rated capacity.
 - 2) Protection: Integral protection against the following:
 - a) High refrigerant pressure.
 - b) Low oil level.
 - c) High oil temperature.
 - d) Thermal and overload.
 - e) Voltage fluctuations.
 - f) Phase failure and phase reversal.
 - g) Short cycling.
 - 3) Speed Control: Variable to automatically maintain refrigerant suction and condensing pressures while varying refrigerant flow to satisfy system cooling and heating loads.
 - 4) Vibration Control: Integral isolation to dampen vibration transmission.
 - 5) Oil management system to ensure safe and proper lubrication over entire operating range.
 - 6) Crankcase heaters with integral control to maintain safe operating temperature.
 - 7) Fusible plug.
- d. Condenser Coil Assembly:
 - 1) Plate Fin Coils:

- a) Casing: Aluminum, galvanized, or stainless steel.
 - b) Fins: Aluminum or copper, mechanically bonded to tubes, with arrangement required by performance.
 - c) Tubes: Copper, of diameter and thickness required by performance.
- 2) Aluminum Microchannel Coils:
 - a) Series of flat tubes containing a series of multiple, parallel-flow microchannels layered between refrigerant header manifolds.
 - b) Single- or multiple-pass arrangement.
 - c) Construct fins, tubes, and header manifolds of aluminum alloy.
- 3) Coating: **[None][Corrosion resistant]** .
- 4) Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.
- e. Condenser Fan and Motor Assembly:
 - 1) Fan(s): Propeller type.
 - a) Direct-drive arrangement.
 - b) Fabricated from non-ferrous components or ferrous components with corrosion protection finish to match performance indicated for condenser coil.
 - c) Dynamically **[and statically]** balanced.
 - 2) Fan Guards: Removable safety guards complying with OSHA regulations. If using metal materials, coat with corrosion-resistant coating to match performance indicated for condenser coil.
 - 3) Motor(s): Brushless dc or electronically commutated with permanently lubricated bearings and rated for outdoor duty.
 - 4) Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
 - 5) Speed Settings and Control: Variable speed with a speed range of least **[75]<Insert number>** percent.
 - 6) Vibration Control: Integral isolation to dampen vibration transmission.
- f. Drain Pan: If required by manufacturer's design, provide unit with non-ferrous drain pan with bottom sloped to a low point drain connection.
- g. Unit Controls:
 - 1) Enclosure: Manufacturer's standard, and suitable for unprotected outdoor locations.
 - 2) Factory-Installed Controller: Configurable digital control.
 - 3) Factory-Installed Sensors:
 - a) Refrigerant suction temperature.
 - b) Refrigerant discharge temperature.
 - c) Outdoor air temperature.
 - d) Refrigerant high pressure.
 - e) Refrigerant low pressure.
 - f) Oil level.
- h. Features and Functions: Self-diagnostics, time delay, auto-restart, fuse protection **[, auto operation mode][, manual operation mode][, night setback control][, power consumption display][, run test switch][, equalize run time between multiple same components]<Insert function>** .

- i. Communication: Network communication with indoor units and other outdoor unit(s).
 - j. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 - k. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 - l. Unit Electrical:
 - 1) Enclosure: Metal, similar to enclosure, and suitable for unprotected outdoor locations.
 - 2) Field Connection: Single-point connection to power entire unit and integral controls.
 - 3) Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
 - 4) Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
 - 5) Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 - 6) Raceways: Enclose line voltage wiring in [**metal**] raceways to comply with NFPA 70.
 - m. Unit Hardware: Zinc-plated steel, or stainless steel. Coat exposed surfaces with additional corrosion-resistant coating if required to prevent corrosion when exposed to salt spray test for [1000]<Insert number> hours in accordance with ASTM B117.
 - n. Unit Piping:
 - 1) Unit Tubing: Copper tubing with brazed joints.
 - 2) Unit Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
 - 3) Field Piping Connections: Manufacturer's standard.
 - 4) Factory Charge: Dehydrated air or nitrogen.
 - 5) Testing: Factory pressure tested and verified to be without leaks.
2. VRF Outdoor Unit - Air-Source Heat Recovery:
- a. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.
 - 1) Specially designed for use in systems with simultaneous heating and cooling.
 - 2) Systems shall consist of one unit, or multiple unit modules that are designed by variable refrigerant system manufacturer for field interconnection to make a single refrigeration circuit that connects multiple indoor units.
 - 3) All units installed shall be from the same product development generation.
 - b. Cabinet:
 - 1) Galvanized steel and coated with a corrosion-resistant finish.
 - a) Coating with documented salt spray test performance of [1000]<Insert number> hours in accordance with ASTM B117 surface scratch test (SST) procedure.
 - 2) Mounting: Manufacturer-designed provisions for field installation.
 - 3) Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.
 - c. Compressor and Motor Assembly:

- 1) One or more positive-displacement, direct-drive and hermetically sealed scroll compressor(s) with inverter drive and turndown to [15]<Insert number> percent of rated capacity.
 - 2) Protection: Integral protection against the following:
 - a) High refrigerant pressure.
 - b) Low oil level.
 - c) High oil temperature.
 - d) Thermal and overload.
 - e) Voltage fluctuations.
 - f) Phase failure and phase reversal.
 - g) Short cycling.
 - 3) Speed Control: Variable to automatically maintain refrigerant suction and condensing pressures while varying refrigerant flow to satisfy system cooling and heating loads.
 - 4) Vibration Control: Integral isolation to dampen vibration transmission.
 - 5) Oil management system to ensure safe and proper lubrication over entire operating range.
 - 6) Crankcase heaters with integral control to maintain safe operating temperature.
 - 7) Fusible plug.
- d. Condenser Coil Assembly:
- 1) Plate Fin Coils:
 - a) Casing: Aluminum, galvanized, or stainless steel.
 - b) Fins: Aluminum or copper, mechanically bonded to tubes, with arrangement required by performance.
 - c) Tubes: Copper, of diameter and thickness required by performance.
 - 2) Aluminum Microchannel Coils:
 - a) Series of flat tubes containing a series of multiple, parallel-flow microchannels layered between refrigerant header manifolds.
 - b) Single- or multiple-pass arrangement.
 - c) Construct fins, tubes, and header manifolds of aluminum alloy.
 - 3) Coating: **[None][Corrosion resistant]** .
 - 4) Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.
- e. Condenser Fan and Motor Assembly:
- 1) Fan(s): Propeller type.
 - a) Direct-drive arrangement.
 - b) Fabricated from non-ferrous components or ferrous components with corrosion protection finish to match performance indicated for condenser coil.
 - c) Dynamically **[and statically]** balanced.
 - 2) Fan Guards: Removable safety guards complying with OSHA regulations. If using metal materials, coat with corrosion-resistant coating to match performance indicated for condenser coil.
 - 3) Motor(s): Brushless dc or electronically commutated with permanently lubricated

- bearings and rated for outdoor duty.
 - 4) Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
 - 5) Speed Settings and Control: Variable speed with a speed range of least **[75]<Insert number>** percent.
 - 6) Vibration Control: Integral isolation to dampen vibration transmission.
 - f. Drain Pan: If required by manufacturer's design, provide unit with non-ferrous drain pan with bottom sloped to a low point drain connection.
 - g. Unit Controls:
 - 1) Enclosure: Manufacturer's standard, and suitable for unprotected outdoor locations.
 - 2) Factory-Installed Controller: Configurable digital control.
 - 3) Factory-Installed Sensors:
 - a) Refrigerant suction temperature.
 - b) Refrigerant discharge temperature.
 - c) Outdoor air temperature.
 - d) Refrigerant high pressure.
 - e) Refrigerant low pressure.
 - f) Oil level.
 - 4) Features and Functions: Self-diagnostics, time delay, auto-restart, fuse protection [, **auto operation mode**][, **manual operation mode**][, **night setback control**][, **power consumption display**][, **run test switch**][, **equalize run time between multiple same components**]**<Insert function>** .
 - 5) Communication: Network communication with indoor units and other outdoor unit(s).
 - 6) Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 - 7) Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 - h. Unit Electrical:
 - 1) Enclosure: Metal, similar to enclosure, and suitable for unprotected outdoor locations.
 - 2) Field Connection: Single-point connection to power entire unit and integral controls.
 - 3) Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
 - 4) Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
 - 5) Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 - 6) Raceways: Enclose line voltage wiring in [**metal**] raceways to comply with NFPA 70.
 - i. Unit Hardware: Zinc-plated steel, or stainless steel. Coat exposed surfaces with additional corrosion-resistant coating if required to prevent corrosion when exposed to salt spray test for **[1000]<Insert number>** hours in accordance with ASTM B117.
 - j. Unit Piping:
 - 1) Unit Tubing: Copper tubing with brazed joints.
 - 2) Unit Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
 - 3) Field Piping Connections: Manufacturer's standard.
 - 4) Factory Charge: Dehydrated air or nitrogen.

- 5) Testing: Factory pressure tested and verified to be without leaks.

G. System Controls:

1. General Requirements:

- a. Network: Indoor units [, **HRCUs,**] and outdoor units shall include integral controls and connect through a [**TIA-485A**][or][**manufacturer-selected**]**<Insert network type>** control network.
- b. Network Communication Protocol: [**Manufacturer proprietary**][or][**open**] control communication between interconnected units.
- c. Integration with Building Automation System: ASHRAE 135, BACnet IP and certified by BACnet Testing Lab (BTL), including the following:
 - 1) Ethernet connection via RJ-45 connectors and port with transmission at [**100**]**<Insert value>** Mbps or higher.
 - 2) Integration devices are to be connected to local uninterruptible power supply unit(s) to provide at least [**5 minutes**]**<Insert time>** of battery backup operation after a power loss.
 - 3) Integration is to include [**control**][**monitoring**][**scheduling**][**change of value notifications**]**<Insert requirements>** .
- d. Operator Interface:
 - 1) Operator interface with system and unit controls is to be through the following:
 - a) Operator interfaces integral to controllers.
 - b) Owner-furnished PC connected to central controller(s).
 - c) Web interface through web browser software.
 - d) Integration with Building Automation System.
 - 2) Users interface with controllers for indoor units control to extent privileges are to be enabled. Control features available to users are to include the following:
 - a) On/off control.
 - b) Temperature set-point adjustment.

2. VRF HVAC System Operator Software for PC:

- a. Software offered by VRF HVAC system manufacturer is to provide system operators with ability to monitor and control VRF HVAC system(s) from a single dedicated Owner-furnished PC.
- b. Software is to provide operator with a graphic user interface to allow monitoring and control of multiple central controllers from a single device location through point-and-click mouse exchange.
- c. Plan views are to show building plans with location of indoor units and identification superimposed on plans.
- d. Controls operation mode of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units. Operation modes available through central controller are to match those operation modes of controllers for indoor units.
- e. Schedules operation of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units. Schedules daily, weekly, and annual events.
- f. Changes operating set points of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.
- g. Optimized start feature to start indoor units before scheduled time to reach temperature

- set-point at scheduled time based on operating history.
 - h. Night setback feature to operate indoor units at energy-conserving heating and cooling temperature set-points during unoccupied periods.
 - i. Supports Multiple Languages: **[English][or][French][Spanish]<Insert language>** .
 - j. Supports Imperial and Metric Temperature Units: **[Fahrenheit][or][Celsius][Fahrenheit and Celsius]** .
 - k. Displays service notifications and error codes.
 - l. Monitors and displays up to **[3000]<Insert number>** item error history and **[10000]<Insert number>** item operation history for regular reporting and further archiving.
 - m. Monitors and displays cumulative operating time of indoor units.
 - n. Able to disable and enable operation of individual controllers for indoor units.
 - o. Information displayed on individual controllers shall also be available for display.
 - p. Information Displayed for Outdoor Units:
 - 1) Refrigerant high and low pressures and percent capacity.
- 3. Central Controllers:
 - a. Centralized control for all indoor and outdoor units from a single central controller location.
 - 1) Include multiple interconnected controllers as required.
 - b. Controls operation mode of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units. Operation modes available through central controller are to match those operation modes of controllers for indoor units.
 - c. Schedule operation of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.
 - 1) Sets schedule for daily, weekly, and annual events.
 - 2) Schedule options available through central controller are to at least include the schedule options of controllers for indoor units.
 - d. Changes operating set points of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.
 - e. Optimized start feature to start indoor units before scheduled time to reach temperature set-point at scheduled time based on operating history.
 - f. Night setback feature to operate indoor units at energy-conserving heating and cooling temperature set-points during unoccupied periods.
 - g. Service diagnostics tool.
 - h. Able to disable and enable operation of individual controllers for indoor units.
 - i. Information displayed on individual controllers is to also be available for display through central controller.
 - j. Information Displayed for Outdoor Units:
 - 1) Refrigerant high and low pressures and percent capacity.
 - k. Multiple RJ-45 ports for direct connection to a local PC and an Ethernet network switch.
 - l. Operator interface through a backlit, high-resolution color display touch panel **[and web accessible through standard web browser software]** .
- 4. Wired Controllers for Indoor Units:
 - a. Single controller capable of controlling multiple indoor units as group.
 - b. Auto Timeout Touch Screen LCD: Timeout duration shall be adjustable.
 - c. Multiple Language: **[English][or][French][Spanish]<Insert language>** .
 - d. Temperature Units: **[Fahrenheit][or][Celsius][Fahrenheit and Celsius]** .

- e. On/Off: Turns indoor unit on or off.
 - f. Hold: Hold operation settings until hold is released.
 - g. Operation Mode: Cool, Heat, Auto, Dehumidification, Fan Only, and Setback.
 - h. Temperature Display: 1-degree increments.
 - i. Temperature Set-Point: Separate set points for Cooling, Heating, and Setback modes. Adjustable in 1-degree increments between **<Insert temperature range>**.
 - j. Relative Humidity Display: 1 percent increments.
 - k. Relative Humidity Set-Point: Adjustable in 1 percent increments between **<Insert relative humidity range>**.
 - l. Fan Speed Setting: Select between available options furnished with the unit.
 - m. Airflow Direction Setting: If applicable to unit, select between available options furnished with the unit.
 - n. Seven-day programmable operating schedule with up to **[five][eight]<Insert number>** events per day. Operations are to include On/Off, Operation Mode, and Temperature Set-Point.
 - o. Auto Off Timer: Operates unit for an adjustable time duration and then turns unit off.
 - p. Occupancy detection.
 - q. Service Notification Display: "Filter" **<Insert notifications>**.
 - r. Service Run Tests: Limit use by service personnel to troubleshoot operation.
 - s. Error Code Notification Display: Used by service personnel to troubleshoot abnormal operation and equipment failure.
 - t. User and Service Passwords: Capable of preventing adjustments by unauthorized users.
 - u. Setting stored in nonvolatile memory to ensure that settings are not lost if power is lost. Battery backup for date and time only.
 - v. Low-voltage power required for controller is to be powered through non-polar connections to indoor unit.
5. Wireless Controllers for Indoor Units:
- a. Wireless Communication:
 - 1) Controller communicates to remote-mounted receiver that is wired to indoor unit(s).
 - a) Include receivers with wireless controllers as required to complete installation.
 - b) Low-voltage power required for receivers shall be powered through non-polar connections to indoor unit.
 - 2) One wireless controller is to be capable of communicating with one or multiple receivers to control one or multiple indoor units as a group.
 - b. Controller Battery Life: **[Three]<Insert number>** years.
 - c. Auto Timeout Touch Screen LCD: Timeout duration shall be adjustable.
 - d. Multiple Language: **[English][or][French][Spanish]<Insert language>**.
 - e. Temperature Units: **[Fahrenheit][or][Celsius][Fahrenheit and Celsius]**.
 - f. On/Off: Turns indoor unit on or off.
 - g. Hold: Hold operation settings until hold is released.
 - h. Operation Mode: Cool, Heat, Auto, Dehumidification, Fan Only, and Setback.
 - i. Temperature Display: 1-degree increments.
 - j. Temperature Set-Point: Separate set points for Cooling, Heating, and Setback modes. Adjustable in 1-degree increments between **<Insert temperature range>**.
 - k. Relative Humidity Display: 1 percent increments.
 - l. Relative Humidity Set-Point: Adjustable in 1 percent increments between **<Insert relative humidity range>**.
 - m. Fan Speed Setting: Select between available options furnished with the unit.
 - n. Airflow Direction Setting: If applicable to unit, select between available options furnished

- with the unit.
- o. Seven-day programmable operating schedule with up to **[five][eight]<Insert number>** events per day. Operations shall include On/Off, Operation Mode, and Temperature Set-Point.
- p. Auto Off Timer: Operates unit for an adjustable time duration and then turns unit off.
- q. Occupancy detection.
- r. Service Notification Display: "Filter" **<Insert notifications>** .
- s. Service Run Tests: Limit use by service personnel to troubleshoot operation.
- t. Error Code Notification Display: Used by service personnel to troubleshoot abnormal operation and equipment failure.
- u. User and Service Passwords: Capable of preventing adjustments by unauthorized users.
- v. Setting stored in non-volatile memory to ensure that settings are not lost if power is lost. Battery for date and time only.

H. System Refrigerant and Oil:

1. Refrigerant: As required by VRF HVAC system manufacturer for system to comply with performance requirements indicated.
 - a. Classification: ASHRAE 34, **<Insert classification>** .
 - b. Type: **<Insert refrigerant type>** .
2. Oil: As required by VRF HVAC system manufacturer and to comply with performance requirements indicated.

2.3 VRF SYSTEM CONDENSATE DRAIN PIPING

- A. See Section 232113 "Hydronic Piping" for VRF system condensate drain piping.
- B. Copper Tube:
 1. Drawn-Temper Tubing: Complying with **[ASTM B88, Type L (ASTM B88M, Type B)][ASTM B88, Type M (ASTM B88M, Type C)]** or Type DWV complying with ASTM B306.
 2. Wrought-Copper Fittings: ASME B16.22.
 3. Wrought-Copper Unions: ASME B16.22.
 4. Solder Filler Metals: ASTM B32, lead-free alloys, and water-flushable flux complying with ASTM B813.
- C. CPVC Plastic Pipe: Complying with ASTM F441/F441M, Schedule 40, with socket-type pipe fittings complying with ASTM F438 and solvent cement complying with ASTM F493.
- D. PVC Plastic Pipe: Complying with ASTM D1785, Schedule 40, with socket-type pipe fittings complying with ASTM D2466 and solvent cement in accordance with ASTM D2564, primer complying with ASTM F656.

2.4 SYSTEM HYDRONIC PIPING

- A. Comply with requirements in Section 232113 "Hydronic Piping" for system piping requirements.

2.5 SYSTEM REFRIGERANT PIPING

- A. Comply with requirements in Section 232300 "Refrigerant Piping" for system piping requirements.

B. Refrigerant Piping, Valves, and Fittings:

1. Copper Tube: **[ASTM B280, Type ACR]<Insert material>** .
2. Wrought-Copper Fittings, Brazed Joints: ASME B16.50.
3. Brazing Filler Metals: AWS A5.8/A5.8M.
4. Refrigerant Tubing Kits:
 - a. Furnished by VRF HVAC system manufacturer.
 - b. Factory-rolled and -bundled, soft-copper tubing with tubing termination fittings at each end.
 - c. Standard one-piece length for connecting to indoor units.
 - d. Pre-insulated with flexible elastomeric insulation of thickness to comply with governing energy code and sufficient to eliminate condensation.
 - e. Factory Charge: **[Dehydrated air or nitrogen][or]<Insert charge>** .

C. Divided-Flow Specialty Fittings: Where required by VRF HVAC system manufacturer for proper system operation, VRF HVAC system manufacturer is to furnish specialty fittings with identification and instructions for proper installation by Installer.

D. Refrigerant Isolation Ball Valves: Uni-body full port design, rated for maximum system temperature and pressure, and factory tested under pressure to ensure tight shutoff. Designed for valve operation without removing seal cap.

1. Seals: Compatible with system refrigerant and oil. Seal service life of at least 20 years.
2. Valve Connections: Flare or sweat, depending on size.

2.6 METAL HANGERS AND SUPPORTS

A. See Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for metal hangers and supports.

B. Copper Tube Hangers: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.

1. Hanger Rods: Continuous-thread rod, nuts, and washer made of **[galvanized or copper-coated steel][stainless steel]<Insert material>** .

C. Plastic Pipe Hangers:

1. Description: MSS SP-58, Types 1 through 58, galvanized-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of **[galvanized steel][stainless steel]<Insert material>** .

2.7 METAL STRUT SUPPORT SYSTEMS

A. Strut Support System - Metal, Rod Type:

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

- b. [Anvil; an ASC Engineered Solution]
 - c. [Atkore Unistrut]
 - d. [CADDY; brand of nVent Electrical plc]
 - e. [Carpenter & Paterson, Inc]
 - f. [Cooper B-line; brand of Eaton, Electrical Sector]
 - g. [Empire Industries, Inc.]
 - h. [Flex-Strut Inc.]
 - i. [G-Strut]
 - j. [Haydon Corp.]
 - k. [Wesanco/ZSi-Foster; an Ideal Tridon Group Company]
 - l. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [ABB Electrification Installations Products]
 - b. [Anvil; an ASC Engineered Solution]
 - c. [Atkore Unistrut]
 - d. [CADDY; brand of nVent Electrical plc]
 - e. [Carpenter & Paterson, Inc]
 - f. [Cooper B-line; brand of Eaton, Electrical Sector]
 - g. [Empire Industries, Inc.]
 - h. [Flex-Strut Inc.]
 - i. [G-Strut]
 - j. [Haydon Corp.]
 - k. [Wesanco/ZSi-Foster; an Ideal Tridon Group Company]
 - l. <Insert manufacturer's name>
3. Description: Factory-fabricated pipe-support assembly made of steel channels, vertical metal support rods, accessories, fittings, and other components for supporting multiple parallel pipes.
4. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
5. Struts: Continuous slotted [carbon steel][stainless steel, Type 304][stainless steel, Type 316][extruded-aluminum]<Insert material>[channel with inturned lips][or][angle]<Insert strut type> .
6. Strut Width: Selected for applicable load criteria.
7. Strut Nuts: Formed or stamped nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
8. Hanger Rods: Continuous-thread rod, nuts, and washer made of [galvanized steel][stainless steel]<Insert material> .
9. Metallic Coating: [Plain][Pregalvanized G90 (Z275)][Electroplated zinc][Hot-dip galvanized][Gold (yellow zinc dichromate) galvanized] .
10. Paint Coating: [Green epoxy, acrylic, or urethane]<Insert paint type> .
11. Plastic Coating: [PVC]<Insert plastic type> .
12. Combination Coating: <Insert combination coating> .

2.8 FASTENER SYSTEMS

- A. Powder-Actuated Fasteners: Threaded, zinc-coated steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
- B. Mechanical-Expansion Anchors: Insert-wedge-type anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

1. Indoor Applications: **[Zinc-coated][or][stainless]** steel.
2. Outdoor Applications: Stainless steel.

2.9 ROOFTOP-MOUNTED STRUT SUPPORT SYSTEMS

A. Strut Support System - Rooftop-Mounted Pipe Stand, Compact:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[G-Strut]**
 - b. **[MIRO Industries Inc.]**
 - c. **[PHP Systems/Design]**
 - d. **[RectorSeal HVAC; a CSW Industrials Company]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[G-Strut]**
 - b. **[MIRO Industries Inc.]**
 - c. **[PHP Systems/Design]**
 - d. **[RectorSeal HVAC; a CSW Industrials Company]**
 - e. **<Insert manufacturer's name>**
3. Description: Shop-fabricated assembly made of manufactured corrosion-resistant components to support rooftop-mounted piping.
4. Configuration: Single base unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
5. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.
6. Recycled Content: Provide manufacturer documentation for recycled content, indicating postconsumer and preconsumer recycled content.
7. Hardware: Galvanized steel or polycarbonate.
8. Accessories: Protection pads.

B. Strut Support System - Rooftop-Mounted Pipe Stand, Single Base, Single Pipe, Low Profile:

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

- a. **[G-Strut]**
 - b. **[MIRO Industries Inc.]**
 - c. **[PHP Systems/Design]**
 - d. **<Insert manufacturer's name>**
3. Description: Shop-fabricated assembly made of manufactured corrosion-resistant components to support rooftop-mounted piping.
 4. Configuration: Single base with vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
 5. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.
 6. Recycled Content: Provide manufacturer documentation for recycled content, indicating postconsumer and preconsumer recycled content.
 7. Vertical Members: Two **[galvanized-steel][stainless steel]** , continuous-thread **1/2-inch (12-mm)** rods.
 8. Horizontal Member: Adjustable horizontal, **[galvanized-steel][stainless steel]** pipe support channels.
 9. Pipe Supports: **[Roller][Strut clamps][Clevis hanger][Swivel hanger]** .
 10. Hardware: **[Galvanized][Stainless]** steel.
 11. Accessories: Protection pads.
 12. Height: **[12 inches (300 mm) above roof]<Insert lesser dimension above roof>** .
- C. Strut Support System - Rooftop-Mounted Pipe Stand, Single Base, Single Pipe, High Profile:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[MIRO Industries Inc.]**
 - b. **[PHP Systems/Design]**
 - c. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[MIRO Industries Inc.]**
 - b. **[PHP Systems/Design]**
 - c. **<Insert manufacturer's name>**
 3. Description: Single base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
 4. Base: Single vulcanized rubber or molded polypropylene.
 5. Recycled Content: Provide manufacturer documentation for recycled content, indicating postconsumer and preconsumer recycled content.
 6. Vertical Members: Two **[galvanized-steel][stainless steel]** , continuous-thread **1/2-inch (12-mm)** rods.
 7. Horizontal Member: One adjustable-height, **[galvanized-steel][or][stainless steel]** pipe support slotted channel or plate.
 8. Pipe Supports: **[Roller][Clevis hanger][Swivel hanger]** .
 9. Hardware: **[Galvanized][Stainless]** steel.
 10. Accessories: Protection pads [, **1/2-inch (12-mm) continuous-thread galvanized-steel rod][, 1/2-inch (12-mm) continuous-thread stainless steel rod]** .
 11. Height: **[36 inches (900 mm) above roof]<Insert lesser dimension above roof>** .
- D. Strut Support System - Rooftop-Mounted Pipe Stand, Multiple Pipe, High Profile:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[MIRO Industries Inc.]**
 - b. **[PHP Systems/Design]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[MIRO Industries Inc.]**
 - b. **[PHP Systems/Design]**
 - c. **<Insert manufacturer's name>**
3. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
4. Bases: Two or more **[vulcanized rubber][molded polypropylene]<Insert material>** .
5. Recycled Content: Provide manufacturer documentation for recycled content, indicating postconsumer and preconsumer recycled content.
6. Vertical Members: Two or more **[galvanized-steel][stainless steel]** channels.
7. Horizontal Members: One or more adjustable-height, **[galvanized-steel][stainless steel]** pipe supports.
8. Pipe Supports: **[Roller][Strut clamps][Clevis hanger][Swivel hanger]** .
9. Hardware: **[Galvanized][Stainless]** steel.
10. Accessories: Protection pads [, **1/2-inch (12-mm) continuous-thread rod**] .
11. Height: **[36 inches (900 mm) above roof]<Insert lesser dimension above roof>** .

- E. Strut Support System - Rooftop-Mounted Pipe Stand, Curb-Mounted Type: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.10 EQUIPMENT STANDS, OUTDOOR TYPE

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

1. **[DiversiTech Corp.]**
2. **[MIRO Industries Inc.]**
3. **[RectorSeal HVAC; a CSW Industrials Company]**
4. **<Insert manufacturer's name>**

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

1. **[DiversiTech Corp.]**
2. **[MIRO Industries Inc.]**
3. **[RectorSeal HVAC; a CSW Industrials Company]**
4. **<Insert manufacturer's name>**

- C. Description: Individual foot supports with elevated adjustable channel cross bars and

clamps/fasteners/bolts for ground or roof-supported outdoor equipment components, without roof membrane penetration, in a prefabricated system that can be modularly assembled on-site.

- D. Foot Material: Rubber or polypropylene.
- E. Rails Material: Hot-dip galvanized carbon steel.
- F. Wind/Sliding Load Resistance: Up to **[100 mph (44 m/s)]<Insert value>** minimum.

2.11 MISCELLANEOUS SUPPORT MATERIALS

- A. Grout: ASTM C1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
 - 1. Properties: Nonstaining, noncorrosive, and nongaseous.
 - 2. Design Mix: **5000 psi (34.5 MPa)**, 28-day compressive strength.
- B. Structural Steel: ASTM A36/A36M, carbon steel plates, shapes, and bars; galvanized.
- C. Threaded Rods: Continuously threaded. Zinc-plated steel or galvanized steel for indoor applications and stainless steel for outdoor applications. Mating nuts and washers of similar material as rods.

2.12 PIPING AND TUBING INSULATION

- A. Comply with requirements in Section 230719 "HVAC Piping Insulation" for system piping insulation requirements.
- B. Condensate Drain Piping and Tubing Insulation and Jacket Requirements:
 - 1. Flexible Elastomeric Insulation:
 - a. Closed-cell, sponge- or expanded-rubber materials, complying with ASTM C534, Type I for tubular materials.
 - b. Indoors: **[1/2 inch (13 mm)][3/4 inch (19 mm)][1 inch (25 mm)]<Insert dimension>** thick.
 - c. Outdoors: **[1/2 inch (13 mm)][3/4 inch (19 mm)][1 inch (25 mm)]<Insert dimension>** thick.
 - 2. Field-Applied Jacket:
 - a. Concealed: None required.
 - b. Indoors, Exposed to View: **[None required][PVC, 20 mils (0.5 mm) thick][PVC, color selected by Architect, 20 mils (0.5 mm) thick]<Insert jacket>** .
 - c. Outdoors, Exposed to View: **[None required][Aluminum, smooth, 0.020 inch (0.51 mm) thick]<Insert jacket>** .
- C. Refrigerant Tubing Insulation and Jacket Requirements:
 - 1. Pipe Insulation - Flexible Elastomeric:
 - a. Closed-cell, sponge- or expanded-rubber materials, complying with ASTM C534, Type I for tubular materials.
 - b. Indoors: **[1 inch (25 mm)]<Insert dimension>** thick.
 - c. Outdoors: **[1 inch (25 mm)]<Insert dimension>** thick.

2. Field-Applied Jacket:

- a. Concealed: None required.
- b. Indoors, Exposed to View: **[None required][PVC, 20 mils (0.5 mm) thick][PVC, color selected by Architect, 20 mils (0.5 mm) thick]<Insert jacket>** .
- c. Outdoors, Exposed to View: **[None required][Aluminum, smooth, 0.020 inch (0.51 mm) thick]<Insert jacket>** .

D. Flexible Elastomeric Insulation Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. Verify adhesives and sealants comply with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
2. Verify adhesives and sealants comply with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify formaldehyde emissions do not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
3. Verify adhesives and sealants comply with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify building concentration of formaldehyde does not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde does not exceed 9 mcg/cu. m.

E. PVC Jacket Adhesive: Compatible with PVC jacket.

1. Verify adhesives and sealants comply with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
2. Verify adhesives and sealants comply with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify formaldehyde emissions do not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
3. Verify adhesives and sealants comply with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify building concentration of formaldehyde does not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde does not exceed 9 mcg/cu. m.

F. Metal Jacket Flashing Sealants:

1. Materials are to be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: **Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).**
4. Color: Aluminum.
5. Verify adhesives and sealants comply with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
6. Verify adhesives and sealants comply with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify formaldehyde emissions do not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
7. Verify adhesives and sealants comply with testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify building concentration of formaldehyde does not exceed half of the indoor recommended

exposure limit, or 33 mcg/cu. m, and that of acetaldehyde does not exceed 9 mcg/cu. m.

2.13 SYSTEM CONTROL CABLE

A. Cable Rating: Listed and labeled for application in accordance with NFPA 70.

1. Flame Travel and Smoke Density in Plenums: As determined by testing identical products in accordance with NFPA 262, by a qualified testing agency. Identify products for installation in plenums with appropriate markings of applicable testing agency.
 - a. Flame Travel Distance: **60 inches (1520 mm)** or less.
 - b. Peak Optical Smoke Density: 0.5 or less.
 - c. Average Optical Smoke Density: 0.15 or less.
2. Flame Travel and Smoke Density for Riser Cables in Non-Plenum Building Spaces: As determined by testing identical products in accordance with UL 1666.
3. Flame Travel and Smoke Density for Cables in Non-Riser Applications and Non-Plenum Building Spaces: As determined by testing identical products in accordance with UL 1685.

B. Low-Voltage Control Cabling:

1. Paired Cable: NFPA 70, Type CMG.
 - a. One pair, twisted, 16 AWG, stranded (19x29) or 18 AWG, stranded (19x30) tinned-copper conductors as required by VRF HVAC system manufacturer.
 - b. PVC insulation.
 - c. Braided or foil shielded.
 - d. PVC jacket.
 - e. Flame Resistance: Comply with UL 1685.
2. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.
 - a. One pair, twisted, 16 AWG, stranded (19x29) or 18 AWG, stranded (19x30) tinned-copper conductors as required by VRF HVAC system manufacturer.
 - b. PVC insulation.
 - c. Braided or foil shielded.
 - d. PVC jacket.
 - e. NFPA 262 includes the standard flame-resistance test criteria in common use for cables and conductors.
 - f. Flame Resistance: Comply with NFPA 262.
3. Product Data: For each conductor and cable, indicating lead content of less than 300 ppm.

C. TIA-485A Network Cabling:

1. Standard Cable: NFPA 70, Type CMG.
 - a. Paired, **[one pair][two pairs]**, twisted, 22 AWG, stranded (7x30) tinned-copper conductors.
 - b. PVC insulation.
 - c. Unshielded.
 - d. PVC jacket.
 - e. Flame Resistance: Comply with UL 1685.
2. Plenum-Rated Cable: NFPA 70, Type CMP.



- a. Paired, **[one pair][two pairs]** , 22 AWG, stranded (7x30) tinned-copper conductors.
- b. Fluorinated ethylene propylene insulation.
- c. Unshielded.
- d. Fluorinated ethylene propylene jacket.
- e. NFPA 262 includes the standard flame-resistance test criteria in common use for cables and conductors.
- f. Flame Resistance: NFPA 262.

3. Product Data: For each conductor and cable, indicating lead content of less than 300 ppm.

D. Ethernet Network Cabling: TIA-568.2-D Category **[6][6a]<Insert category>** cable with **[RJ-45]<Insert connector type>** connectors.

1. Description: Four-pair, balanced-twisted pair cable, certified to meet transmission characteristics of category cable indicated.
2. Conductors: 100-ohm, 23 AWG solid copper.
3. Product Data: For each conductor and cable, indicating lead content of less than 300 ppm.
4. Shielding: **[Unshielded twisted pairs (UTP)][Shielded twisted pairs (FTP)]** .
5. Cable Rating: By application.
6. Jacket: **[White][Gray][Blue][Yellow]<Insert color>** thermoplastic.

E. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems" for cable raceways.

2.14 MATERIALS

A. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for steel sheet.

B. Stainless Steel:

1. Manufacturer's standard grade for casing.
2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653/A653M.

D. Aluminum: ASTM B209.

E. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating.

F. Corrosion-Resistant Coating: Coat with a corrosion-resistant coating capable of withstanding a **[3000]<Insert time>** -hour salt-spray test in accordance with ASTM B117.

1. Standards:

- a. ASTM B117 for salt spray.
- b. ASTM D2794 for minimum impact resistance of **100 in-lb (11.3 N-m)**.
- c. ASTM B3359 for cross-hatch adhesion of 5B.

2. Application: **[Immersion][Spray]** .

3. Thickness: **[1 mil (0.025 mm)]<Insert value>** .

4. Gloss: Minimum gloss of 60 on a 60-degree meter.

2.15 SOURCE QUALITY CONTROL

- A. Factory Tests: Test and inspect factory-assembled equipment.
 1. Equipment will be considered defective if it does not pass tests and inspections.
- B. Prepare test and inspection reports for historical record. Submit reports only if requested.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine products before installation. Reject products that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for piping and tubing to verify actual locations of connections before equipment installation.
- D. Examine roughing-in for ductwork to verify actual locations of connections before equipment installation.
- E. Examine roughing-in for wiring and conduit to verify actual locations of connections before equipment installation.
- F. Examine walls, floors, roofs, and outdoor pads for suitable conditions where equipment will be installed.
- G. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
- H. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF VRF HVAC SYSTEMS, GENERAL

- A. Clearance:
 1. Maintain manufacturer's recommended clearances for service and maintenance.
 2. Maintain clearances required by governing code.
- B. Loose Components: Install components, devices, and accessories furnished by manufacturer, with equipment, that are not factory mounted.
 1. Loose components are to be installed by **[manufacturer's service representative][or][system Installer under supervision of manufacturer's service representative]** .
- C. Equipment Restraint Installation: Install equipment with seismic-restraint device. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

3.3 INSTALLATION OF VRF HVAC SYSTEMS

A. Installation of VRF Indoor Units:

1. Install units to be level and plumb while providing a neat and finished appearance.
2. Unless otherwise required by VRF HVAC system manufacturer, support ceiling-mounted units from structure above using threaded rods; minimum rod size of **3/8 inch (10 mm)**.
3. Adjust supports of exposed and recessed units to draw units tight to adjoining surfaces.
4. Protect finished surfaces of ceilings, floors, and walls that come in direct contact with units. Refinish or replaced damaged areas after units are installed.
5. In rooms with ceilings, conceal piping and tubing, controls, and electrical power serving units above ceilings.
6. In rooms without ceiling, arrange piping and tubing, controls, and electrical power serving units to provide a neat and finished appearance.
7. Provide lateral bracing if needed to limit movement of suspended units to not more than **[0.25 inch (13 mm)]<Insert dimension>**.
8. For floor- and wall-mounted units that are exposed, conceal piping and tubing, controls, and electrical power serving units within walls.
9. Floor-mounted units located in **[mechanical]<Insert room type>** rooms.
10. Install floor-mounted units on support structure indicated on Drawings.
11. Install floor-mounted units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
12. Attachment: Install hardware for proper attachment to supported equipment.
13. Grouting: Place grout under equipment supports and make bearing surface smooth.

B. Installation of Duct, Accessories, and Air Outlets:

1. Where installing ductwork adjacent to equipment, allow space for service and maintenance.
2. Comply with requirements for metal ducts specified in Section 233113 "Metal Ducts."
3. Comply with requirements for nonmetal ducts specified in Section 233116 "Nonmetal Ducts."
4. Comply with requirements for air duct accessories specified in Section 233300 "Air Duct Accessories."
5. Comply with requirements for flexible ducts specified in Section 233346 "Flexible Ducts."
6. Comply with requirements for air diffusers specified in Section 233713.13 "Air Diffusers."
7. Comply with requirements for registers and grilles specified in Section 233713.23 "Registers and Grilles."

C. Installation of VRF Outdoor Units:

1. Install units to be level and plumb while providing a neat and finished appearance.
2. Install outdoor units on support structures indicated on Drawings.
3. Pad-Mounted Installations: Install outdoor units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - a. Attachment: Install anchor bolts to elevations required for proper attachment to supported equipment.
 - b. Grouting: Place grout under equipment supports and make bearing surface smooth.
4. Roof-Mounted Installations: Install outdoor units on equipment supports specified in Section 077200 "Roof Accessories." Anchor units to supports with removable, stainless steel fasteners.

3.4 INSTALLATION OF PIPING, GENERAL

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping and tubing systems. Install piping and tubing as indicated unless deviations to layout are approved on coordination drawings.
- B. Install piping and tubing in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping and tubing at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping and tubing above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping and tubing to permit valve servicing.
- F. Install piping and tubing at indicated slopes.
- G. Install piping and tubing free of sags.
- H. Install fittings for changes in direction and branch connections.
- I. Install piping and tubing to allow application of insulation.
- J. Install groups of pipes and tubing parallel to each other, spaced to permit applying insulation with service access between insulated piping and tubing.
- K. Install sleeves for piping and tubing penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230500 "Common Work Results for HVAC."
- L. Install escutcheons for piping and tubing penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230500 "Common Work Results for HVAC."

3.5 INSTALLATION OF VRF SYSTEM CONDENSATE DRAIN PIPING

- A. General Requirements for Drain Piping and Tubing:
 - 1. Install a union in piping at each threaded unit connection.
 - 2. Install an adjustable stainless steel hose clamp with adjustable gear operator on unit hose connections. Tighten clamp to provide a leak-free installation.
 - 3. If required for unit installation, provide a trap assembly in drain piping to prevent air circulated through unit from passing through drain piping. Comply with more stringent of the following:
 - a. Details indicated on Drawings.
 - b. Manufacturer's requirements.
 - c. Governing codes.
 - d. In the absence of requirements, comply with requirements in ASHRAE handbooks.
 - 4. Extend drain piping from units with drain connections to drain receptors as indicated on Drawings. If not indicated on Drawings, terminate drain connection at nearest accessible location that is not exposed to view by occupants.
 - 5. Provide each 90-degree change in direction with a Y- or T-fitting. Install a threaded plug connection in the dormant side of fitting or future use as a service cleanout.

B. Gravity Drains:

1. Slope piping from unit connection toward drain termination at a constant slope of not less than **[one][two]<Insert number>** percent.

C. Pumped Drains:

1. If unit condensate pump or lift mechanism is not included with an integral check valve, install a full-size check valve in each branch pipe near unit connection to prevent backflow into unit.

3.6 INSTALLATION OF SYSTEM HYDRONIC PIPING

- A. Comply with requirements for hydronic pipe and tubing specified in Section 232113 "Hydronic Piping."
- B. Comply with requirements for hydronic specialties specified in Section 232116 "Hydronic Piping Specialties."
- C. Comply with requirements for ball valves specified in Section 230523 "General-Duty Valves for HVAC Piping."
- D. Comply with requirements for butterfly valves specified in Section 230523 "General-Duty Valves for HVAC Piping."
- E. Comply with requirements for check valves specified in Section 230523 "General-Duty Valves for HVAC Piping."
- F. Install continuous-thread hanger rods and **[elastomeric][spring]** hangers of size required to support equipment weight.
 1. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC." Fabricate brackets or supports as required.
 2. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- G. Where installing piping and tubing adjacent to equipment, allow space for service and maintenance.

3.7 INSTALLATION OF SYSTEM REFRIGERANT PIPING

A. Refrigerant Tubing Kits:

1. Unroll and straighten tubing to suit installation. Deviations in straightness of exposed tubing are to be unnoticeable to observer.
2. Support tubing using hangers and supports indicated at intervals not to exceed **[5 ft. (1.5 m)]<Insert dimension>**. Minimum rod size, **1/4 inch (6.4 mm)**.
3. Prepare tubing ends and make mating connections to provide a pressure-tight and leak-free installation.

- B. Install refrigerant piping in accordance with ASHRAE 15 and governing codes.
- C. Select system components with pressure rating equal to or greater than system operating pressure.
- D. Install piping as short and direct as possible, with a minimum number of joints and fittings.

- E. Arrange piping to allow inspection and service of equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Section 083113 "Access Doors and Frames" if valves or equipment requiring maintenance are concealed behind finished surfaces.
- F. Install refrigerant piping and tubing in protective conduit where installed belowground.
- G. Install refrigerant piping and tubing in rigid or flexible conduit in locations where exposed to mechanical damage.
- H. Unless otherwise required by VRF HVAC system manufacturer, slope refrigerant piping and tubing as follows:
 - 1. Install horizontal hot-gas discharge piping and tubing with a uniform slope downward away from compressor.
 - 2. Install horizontal suction lines with a uniform slope downward to compressor.
 - 3. Install traps to entrain oil in vertical runs.
 - 4. Liquid lines may be installed level.
- I. When brazing, remove or protect components that could be damaged by heat.
- J. Before installation, clean piping, tubing, and fittings to cleanliness level required by VRF HVAC system manufacturer.
- K. Joint Construction:
 - 1. Ream ends of tubes and remove burrs.
 - 2. Remove scale, slag, dirt, and debris from inside and outside of tube and fittings before assembly.
 - 3. Construct joints in accordance with AWS's "Brazing Handbook," "Pipe and Tube" Chapter.
 - a. Use Type BCuP (copper-phosphorus) alloy for joining copper fittings with copper tubing.
 - b. Use Type BAg (cadmium-free silver) alloy for joining copper with bronze.

3.8 INSTALLATION OF METAL HANGERS AND SUPPORTS

- A. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.
- B. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
- C. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- D. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- E. Install lateral bracing with pipe hangers and supports to prevent swaying.
- F. Install building attachments within concrete slabs or attach to structural steel.
 - 1. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

- G. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- H. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.
- I. Piping and Tubing Insulation:
1. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields are to span an arc of 180 degrees.
 2. Shield Dimensions for Pipe: Not less than the following:
 - a. NPS 1/4 to NPS 3-1/2 (DN 8 to DN 90): **12 inches (305 mm)** long and **0.048 inch (1.22 mm)** thick.
- J. Horizontal-Piping Hangers and Supports: Install the following types:
1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes **NPS 1/2 to NPS 30 (DN 15 to DN 750)**.
 2. Pipe Hangers (MSS Type 5): For suspension of pipes **NPS 1/2 to NPS 4 (DN 15 to DN 100)**, to allow off-center closure for hanger installation before pipe erection.
 3. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
 4. Multiple horizontal pipes located indoors may use metal framing systems with split clamp attachment for each pipe in lieu of individual clevis hangers.
 5. Pipe stands for horizontal pipes located outdoors.
 6. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
 7. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.
- K. Horizontal Piping Hanger Spacing and Rod Size: Install hangers for drawn-temper copper piping with the following maximum horizontal spacing and minimum rod sizes:
1. Sizes through NPS 3/4 (DN 20): Maximum span, **5 ft. (1.5 m)**; minimum rod size, **1/4 inch (6.4 mm)**.
 2. NPS 1 (DN 25): Maximum span, **6 ft. (1.8 m)**; minimum rod size, **1/4 inch (6.4 mm)**.
 3. NPS 1-1/4 (DN 32): Maximum span, **7 ft. (2.1 m)**; minimum rod size, **3/8 inch (10 mm)**.
 4. NPS 1-1/2 (DN 40): Maximum span, **8 ft. (2.4 m)**; minimum rod size, **3/8 inch (10 mm)**.
 5. NPS 2 (DN 50): Maximum span, **8 ft. (2.4 m)**; minimum rod size, **3/8 inch (10 mm)**.
 6. NPS 2-1/2 (DN 65): Maximum span, **9 ft. (2.7 m)**; minimum rod size, **3/8 inch (10 mm)**.
 7. NPS 3 (DN 80) and Larger: Maximum span, **10 ft. (3 m)**; minimum rod size, **3/8 inch (10 mm)**.
- L. Plastic Pipe Hanger and Support Spacing:
1. Space hangers and supports in accordance with pipe manufacturer's written instructions for service conditions.
 2. Maximum spacing, **5 ft. (1.5 m)**; minimum rod size, **1/4 inch (6.4 mm)**.
- M. Vertical-Piping Clamps: Install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8).
 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): If longer ends are required for riser clamps.
- N. Support vertical runs at roof, at each floor, and at midpoint intervals between floors, not to exceed **[5 ft. (1.5 m)][10 ft. (3 m)]<Insert dimension>** .

- O. Comply with MSS SP-58 for pipe-hanger selections and applications that are not specified.
- P. Use hangers, supports, and attachments with galvanized coatings unless otherwise indicated.
- Q. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- R. Trim excess length of continuous-thread hanger and support rods to **[1 inch (25 mm)]<Insert dimension>** .
- S. Hanger-Rod Attachments: Install the following types:
 - 1. Steel Turnbuckles (MSS Type 13): For adjustment up to **6 inches (150 mm)** for heavy loads.
 - 2. Steel Clevises (MSS Type 14): For **120 to 450 deg F (49 to 232 deg C)** piping installations.
 - 3. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
 - 4. Steel Weldless Eye Nuts (MSS Type 17): For **120 to 450 deg F (49 to 232 deg C)** piping installations.
- T. Building Attachments: Install the following types:
 - 1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 - 2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
 - 3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 - 4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 - 5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 - 6. C-Clamps (MSS Type 23): For structural shapes.
 - 7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
 - 8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
 - 9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
 - 10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
 - 11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
 - 12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): **750 lb (340 kg)**.
 - b. Medium (MSS Type 32): **1500 lb (680 kg)**.
 - 13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
 - 14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
 - 15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

3.9 INSTALLATION OF METAL STRUT SUPPORT SYSTEMS

- A. Metal Strut Support System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.

- B. Comply with MFMA-103 for metal framing system selections and applications that are not specified.

3.10 INSTALLATION OF FASTENER SYSTEMS

A. Fastener System Installation:

1. Install powder-actuated fasteners, for use in lightweight concrete or concrete slabs less than **4 inches (100 mm)** thick, in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners in accordance with powder-actuated tool manufacturer's operating manual.
2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners in accordance with manufacturer's written instructions.
3. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

3.11 INSTALLATION OF ROOFTOP-MOUNTED STRUT SUPPORT SYSTEMS

A. Pipe Stand Installation:

1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 077200 "Roof Accessories" for curbs.

3.12 INSTALLATION OF PIPING AND TUBING INSULATION

- A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated. Installation to maintain a continuous vapor barrier.

B. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are unavailable, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

- D. Where PVC jackets are indicated, install with **1-inch (25-mm)** overlap at longitudinal seams and end joints; for horizontal applications. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

- E. Where metal jackets are indicated, install with **2-inch (50-mm)** overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended in writing by insulation manufacturer. Secure jacket with stainless steel bands **12 inches (300 mm)** o.c. and at end joints.

3.13 ELECTRICAL CONNECTIONS

- A. Comply with requirements indicated on Drawings and in applicable Division 26 Sections.
- B. To extent electrical power is required for system equipment, components, and controls, and is not indicated on Drawings and addressed in the Specifications, the design for such electrical power is to be delegated to VRF HVAC system provider.
 - 1. Delegated design of electrical power to equipment, components and controls, and associated installation is to be included at no additional cost to Owner.
- C. Connect field electrical power source to each separate electrical device requiring field electrical power. Coordinate termination point and connection type with Installer.
- D. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.
- E. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems" for grounding connections.
- F. Install nameplate or acrylic label with self-adhesive back for each electrical connection indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate is to be laminated phenolic layers of black with engraved white letters. Letters at least **1/2 inch (13 mm)** high.
 - 2. Locate nameplate or label where easily visible.
- G. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems" for raceway selection and installation requirements for conduits as supplemented or revised in this Section.
- H. Comply with requirements in Section 260533.16 "Boxes and Covers for Electrical Systems" for box selection and installation requirements for boxes as supplemented or revised in this Section.
- I. Comply with requirements in Section 260533.23 "Surface Raceways for Electrical Systems" for wireways selection and installation requirements for wireways as supplemented or revised in this Section.
 - 1. Provide outlet boxes no smaller than **2 inches (50 mm)** wide, **3 inches (75 mm)** high, and **2-1/2 inches (64 mm)** deep.
 - 2. Provide outlet boxes for cables no smaller than **4 inches (102 mm)** square by **[1-1/2 inches (38 mm)][2-1/8 inches (53 mm)]** deep with extension ring sized to bring edge of ring to within **1/8 inch (3.1 mm)** of the finished wall surface.
 - 3. Flexible metal conduit is prohibited.
- J. Comply with TIA-569-E for pull-box sizing and length of conduit and number of bends between pull points.
- K. Install manufactured conduit sweeps and long-radius elbows if possible.

- L. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

3.14 INSTALLATION OF SOFTWARE

- A. Cybersecurity:
 - 1. Software:
 - a. Coordinate security requirements with **[IT department][CIO]<Insert entity responsible for IT security>**.
 - b. Ensure that latest stable software release is installed and properly operating.
 - c. Disable or change default passwords to password using a combination of uppercase and lower letters, numbers, and symbols at least eight characters in length. Record passwords and turn over to party responsible for system operation and administration.
 - 2. Hardware:
 - a. Coordinate location and access requirements with **[IT department][CIO]<Insert entity responsible for IT security>**.
 - b. Enable highest level of wireless encryption that is compatible with Owner's ICT network.
 - c. Disable dual network connections.

3.15 INSTALLATION OF SYSTEM CONTROL CABLE

- A. Comply with NECA 1.
- B. Installation Method:
 - 1. Install cables in raceways except as follows:
 - a. Within equipment and associated control enclosures.
 - b. In accessible ceiling spaces where open cable installation method may be used.
 - c. In gypsum board partitions where cable may be enclosed within wall cavity.
 - 2. Conceal raceway and cables except in unfinished spaces.
- C. General Requirements for Cabling:
 - 1. Comply with TIA-568.2-D.
 - 2. Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems."
 - 3. Terminate all conductors; no cable is to contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
 - 4. Cables must be continuous from terminal to terminal. Do not splice cable.
 - 5. Cables serving a common system may be grouped in a common raceway. Install control cable in separate raceway from power wiring. Do not group conductors from different systems or different voltages.
 - 6. Secure and support cables at intervals not exceeding **30 inches (760 mm)** and not more than **6 inches (150 mm)** from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
 - 7. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems." Install lacing bars and distribution spools.

8. Do not install bruised, kinked, scored, deformed, or abraded cable. Remove and discard cable if damaged during installation and replace it with new cable.
9. Cold-Weather Installation: Bring cable to room temperature before dereeling. Do not use heat lamps for heating.
10. Pulling Cable: Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems." Monitor cable pull tensions.
11. Support: Do not allow cables to lie on removable ceiling tiles or access panels.
12. Secure: Fasten securely in place with hardware specifically designed and installed so as to not damage cables.
13. Provide strain relief.
14. Keep runs short. Allow extra length for connecting to terminals.
15. Do not bend cables in a radius less than 10 times the cable OD.
16. Use sleeves or grommets to protect cables from vibration at points where they pass around sharp corners and through penetrations.
17. Ground wire is to be copper, and grounding methods shall comply with IEEE C2. Demonstrate ground resistance.

D. Balanced Twisted-Pair Cable Installation:

1. Comply with TIA-568.2-D.
2. Do not untwist balanced twisted-pair cables more than **1/2 inch (13 mm)** at the point of termination to maintain cable geometry.

E. Open-Cable Installation:

1. Suspend copper cable not in a wireway or pathway a minimum of **8 inches (200 mm)** above ceilings by cable supports not more than [**30 inches (760 mm)**]**<Insert dimension>** apart.
2. Do not route cable through or on structural members or in contact with pipes, ducts, or other potentially damaging items. Do not run cables between structural members and corrugated panels.

- F. Separation from EMI Sources: Comply with BICSI TDMM and TIA-569-E recommendations for separating unshielded cable from potential EMI sources including electrical power wiring and equipment.

3.16 FIRESTOPPING

- A. Comply with requirements in Section 078413 "Penetration Firestopping" and Section 078443 "Joint Firestopping."
- B. Comply with TIA-569-E.
- C. Comply with BICSI TDMM, "Firestopping" Chapter.

3.17 GROUNDING

- A. For data communication wiring, comply with TIA-607-E and with BICSI TDMM, "Bonding and Grounding (Earthing)" Chapter.
- B. For low-voltage control cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.18 IDENTIFICATION

- A. Identify system equipment, piping, tubing, and valves. Comply with requirements for identification specified in Section 230553 "Identification for HVAC Piping and Equipment."
- B. Identify system electrical [**and controls**] components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
 - 1. Identify each control cable on each end and at each terminal with a number-coded identification tag. Provide a unique tag for each cable.

3.19 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage VRF HVAC system manufacturer's service representative to advise and assist installers; witness testing; and observe and inspect components, assemblies, and equipment installations, including controls and connections.
 - 1. Field service must be performed by [**an employee**] [**or**] [**a factory-trained and -authorized service representative**] of VRF HVAC system manufacturer whose primary job responsibilities are to provide direct technical support of its products.
 - a. Additional factory-authorized representatives may assist with completion of certain activities only if supervised by manufacturer's employee. A factory-authorized representative must not provide assistance without manufacturer's employee supervision.
 - 2. Manufacturer is to provide on-site visits during the course of construction at installation milestones indicated. System Installer is to coordinate each visit in advance to give manufacturer sufficient notice to plan the visit.
 - a. First Visit: Kick-off meeting.
 - b. Second Visit: At approximately [**25**] [**<Insert number>**] percent completion of system(s).
 - c. Third Visit: At approximately [**50**] [**<Insert number>**] percent completion of system(s).
 - d. Fourth Visit: At approximately [**75**] [**<Insert number>**] percent completion of system(s).
 - e. Fifth Visit: Final inspection before system startup.
 - 3. Kick-off Meeting:
 - a. Meeting is to include system Installer and other related trades with sole purpose of reviewing VRF HVAC system installation requirements and close coordination required to make a successful installation.
 - b. Meeting is to be held at Project site and scheduled at a mutually agreed to time that occurs before the start of any part of system installation.
 - c. Meeting is to cover the following as a minimum requirement:
 - 1) Review of latest issue of Contract Documents, Drawings, and Specifications, relevant to VRF HVAC systems.
 - 2) Manufacturer's installation requirements specific to systems being installed.
 - 3) Review of all relevant VRF HVAC system submittals, including delegated design submittals.
 - 4) Required field activities related installation of VRF HVAC system.
 - 5) Project team communication protocol, contact information, and exchange of responsibilities for each party involved, including manufacturer, supplier, system Installer, and other related trades.

4. Site Visits: Activities for each site visit are to include the following:
 - a. Meet with VRF HVAC system Installer to discuss field activities, issues, and suggested methods to result in a successful installation.
 - b. Offer technical support to Installer and related trades as related to VRF system(s) being installed.
 - c. Review progress of VRF HVAC system(s) installation for strict compliance with manufacturer's requirements.
 - d. Advise and if necessary assist Installer with updating related refrigerant calculations and system documentation.
 - e. Issue a report for each visit, documenting the visit.
 - 1) Report to include name and contact information of individual making the visit.
 - 2) Date(s) and time frames while on-site.
 - 3) Names and contact information of people meeting with while on-site.
 - 4) Clearly identify and list each separate issue that requires resolution. For each issue, provide a unique identification number, relevant importance, specific location or equipment identification, description of issue, recommended corrective action, and follow-up requirements needed. Include a digital photo for clarification if deemed to be beneficial.
5. Final Inspection before Startup:
 - a. Before inspection, Installer to provide written request to manufacturer stating the system is fully installed in accordance with manufacturer's requirements and ready for final inspection.
 - b. All system equipment and operating components are to be inspected. If components are inaccessible for inspection, they are to be made accessible before the final inspection can be completed.
 - c. Manufacturer is to provide a comprehensive inspection of all equipment and each operating component that comprise the complete system(s). Inspection is to follow a detailed checklist specific to each equipment and operating component.
 - d. Inspection reports for indoor units are to include, but not be limited to, the following:
 - 1) Unit designation on Drawings.
 - 2) Manufacturer model number.
 - 3) Serial number.
 - 4) Network address, if applicable.
 - 5) Each equipment setting.
 - 6) Mounting, supports, and restraints properly installed.
 - 7) Proper service clearance provided.
 - 8) Wiring and power connections correct.
 - 9) Line-voltage reading(s) within acceptable range.
 - 10) Wiring and controls connections correct.
 - 11) Low-voltage reading(s) within an acceptable range.
 - 12) Controller type and model controlling unit.
 - 13) Controller location.
 - 14) Temperature settings and readings within an acceptable range.
 - 15) Humidity settings and readings within an acceptable range.
 - 16) Condensate removal acceptable.
 - 17) Fan settings and readings within an acceptable range.
 - 18) Unit airflow direction within an acceptable range.
 - 19) If applicable, fan external static pressure setting.
 - 20) Filter type and condition acceptable.
 - 21) Noise level within an acceptable range.
 - 22) Refrigerant piping properly connected and insulated.

- 23) Condensate drain piping properly connected and insulated.
 - 24) If applicable, ductwork properly connected.
 - 25) If applicable, external interlocks properly connected.
 - 26) Remarks.
- e. Inspection reports for outdoor units are to include, but not be limited to, the following:
- 1) Unit designation on Drawings.
 - 2) Manufacturer model number.
 - 3) Serial number.
 - 4) Network address, if applicable.
 - 5) Each equipment setting.
 - 6) Mounting, supports, and restraints properly installed.
 - 7) Proper service clearance provided.
 - 8) Wiring and power connections correct.
 - 9) Line-voltage reading(s) within acceptable range.
 - 10) Wiring and controls connections correct.
 - 11) Low-voltage reading(s) within an acceptable range.
 - 12) Condensate removal acceptable.
 - 13) Noise level within an acceptable range.
 - 14) Refrigerant piping properly connected and insulated.
 - 15) Condensate drain piping properly connected and insulated.
 - 16) Remarks.
- f. Inspection reports for indoor, dedicated outdoor air ventilation units are to include, but not be limited to, the following:
- 1) Unit designation on Drawings.
 - 2) Manufacturer model number.
 - 3) Serial number.
 - 4) Network address, if applicable.
 - 5) Each equipment setting.
 - 6) Mounting, supports, and restraints properly installed.
 - 7) Proper service clearance provided.
 - 8) Wiring and power connections correct.
 - 9) Line-voltage reading(s) within acceptable range.
 - 10) Wiring and controls connections correct.
 - 11) Low-voltage reading(s) within an acceptable range.
 - 12) Controller type and model controlling unit.
 - 13) Controller location.
 - 14) Temperature settings and readings within an acceptable range.
 - 15) Humidity settings and readings within an acceptable range.
 - 16) Condensate removal acceptable.
 - 17) Fan settings and readings within an acceptable range.
 - 18) Fan external static pressure setting.
 - 19) Filter type and condition acceptable.
 - 20) Noise level within an acceptable range.
 - 21) Refrigerant piping properly connected and insulated.
 - 22) Condensate drain piping properly connected and insulated.
 - 23) Automatic dampers properly installed and operating.
 - 24) Ductwork properly connected.
 - 25) If applicable, external interlocks properly connected.
 - 26) Remarks.
- g. Inspection reports for energy recovery ventilators are to include, but not be limited to, the

following:

- 1) Unit designation on Drawings.
- 2) Manufacturer model number.
- 3) Serial number.
- 4) Network address, if applicable.
- 5) Each equipment setting.
- 6) Mounting, supports, and restraints properly installed.
- 7) Proper service clearance provided.
- 8) Wiring and power connections correct.
- 9) Line-voltage reading(s) within acceptable range.
- 10) Wiring and controls connections correct.
- 11) Low-voltage reading(s) within an acceptable range.
- 12) Controller type and model controlling unit.
- 13) Controller location.
- 14) Temperature settings and readings within an acceptable range.
- 15) Humidity readings.
- 16) Condensate removal acceptable.
- 17) Fan settings and readings within an acceptable range.
- 18) Fan external static pressure setting.
- 19) Filter type and condition acceptable.
- 20) Noise level within an acceptable range.
- 21) Automatic dampers properly installed and operating.
- 22) Ductwork properly connected.
- 23) If applicable, external interlocks properly connected.
- 24) Remarks.

h. Inspection reports for hydronic units are to include, but not be limited to, the following:

- 1) Unit designation on Drawings.
- 2) Manufacturer model number.
- 3) Serial number.
- 4) Network address, if applicable.
- 5) Each equipment setting.
- 6) Mounting, supports, and restraints properly installed.
- 7) Proper service clearance provided.
- 8) Wiring and power connections correct.
- 9) Line-voltage reading(s) within acceptable range.
- 10) Wiring and controls connections correct.
- 11) Low-voltage reading(s) within an acceptable range.
- 12) Controller type and model controlling unit.
- 13) Controller location.
- 14) Temperature settings and readings within an acceptable range.
- 15) Condensate removal acceptable.
- 16) Noise level within an acceptable range.
- 17) Refrigerant piping properly connected and insulated.
- 18) Hydronic piping properly connected and insulated.
- 19) Proof of water flow checked for proper operation.
- 20) Condensate drain piping properly connected and insulated.
- 21) If applicable, external interlocks properly connected.
- 22) Remarks.

i. Installer is to provide manufacturer with the requested documentation and technical support during inspection.

j. Installer is to correct observed deficiencies found by the inspection.

k. Upon completing the on-site inspection, manufacturer is to provide a written report with

complete documentation describing each inspection step, the result, and any corrective action required.

- l. If corrective action is required by Installer that cannot be completed during the same visit, provide additional visits, as required, until deficiencies are resolved and systems are deemed ready for startup.
- m. Final report is to indicate the system(s) inspected are installed in accordance with manufacturer's requirements and are ready for startup.

B. Perform tests and inspections with the assistance of manufacturer's service representative as follows:

- 1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
- 2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
- 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
- 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Refrigerant Tubing Positive Pressure Testing:

- 1. Comply with more stringent of VRF HVAC system manufacturer's requirements and requirements indicated.
- 2. After completion of tubing installation, pressurize tubing systems to a test pressure of not less than [1.2][1.5]<Insert value> times VRF HVAC system operating pressure, but not less than [600 psig (4137 kPa)]<Insert value> , using [dry nitrogen]<Insert test medium> .
- 3. Successful testing is to show test pressure is maintained for a continuous and uninterrupted period of [24]<Insert number> hours. Allowance for pressure changes attributed to changes in ambient temperature are acceptable.
- 4. Prepare test report to record information for each test as follows:
 - a. Name of person starting test, company name, phone number, and e-mail address.
 - b. Name of manufacturer's service representative witnessing test, company name, phone number, and e-mail address.
 - c. Detailed description of extent of tubing tested.
 - d. Date and time at start of test.
 - e. Test pressure at start of test.
 - f. Outdoor temperature at start of test.
 - g. Name of person ending test, company name, phone number, and e-mail address.
 - h. Date and time at end of test.
 - i. Test pressure at end of test.
 - j. Outdoor temperature at end of test.
 - k. Remarks:
- 5. Submit test reports for Project record.

D. Refrigerant Tubing Evacuation Testing:

- 1. Comply with more stringent of VRF HVAC system manufacturer's requirements and requirements indicated.
- 2. After completion of tubing positive-pressure testing, evacuate tubing systems to a pressure of [500]<Insert value> microns.
- 3. Successful testing is to show test pressure is maintained for a continuous and uninterrupted period of [one]<Insert number> hour(s) with no change.
- 4. Prepare test report to record information for each test as follows:

- a. Name of person starting test, company name, phone number, and e-mail address.
 - b. Name of manufacturer's service representative witnessing test, company name, phone number, and e-mail address.
 - c. Detailed description of extent of tubing tested.
 - d. Date and time at start of test.
 - e. Test pressure at start of test.
 - f. Outdoor temperature at start of test.
 - g. Name of person ending test, company name, phone number, and e-mail address.
 - h. Date and time at end of test.
 - i. Test pressure at end of test.
 - j. Outdoor temperature at end of test.
 - k. Remarks:
 5. Submit test reports for Project record.
 6. Upon successful completion of evacuation testing, system is to be charged with refrigerant.
- E. System Refrigerant Charge:
1. Using information collected from the refrigerant tubing evacuation testing, system Installer is to consult variable refrigerant system manufacturer to determine the correct system refrigerant charge.
 2. Installer is to charge system following VRF HVAC system manufacturer's written instructions.
 3. System refrigerant charging is to be witnessed by system manufacturer's representative.
 4. Total refrigerant charge is to be recorded and permanently displayed at the system's outdoor unit.
- F. Products will be considered defective if they do not pass tests and inspections.
- G. Prepare test and inspection reports.
- 3.20 STARTUP SERVICE
- A. Engage a VRF HVAC system manufacturer's service representative to perform system(s) startup service.
1. Service representative is to be **[an employee][or][a factory-trained and -authorized service representative]** of VRF HVAC system manufacturer.
 2. Complete startup service of each separate system.
 3. Complete system startup service in accordance with manufacturer's written instructions.
- B. Startup checks are to include, but not be limited to, the following:
1. Check control communications of equipment and each operating component in system(s).
 2. Check each indoor unit's response to demand for cooling and heating.
 3. Check each indoor unit's response to changes in airflow settings.
 4. Check each indoor unit [, **HRCU**,] and outdoor unit for proper condensate removal.
 5. Check sound levels of each indoor [**and outdoor**] unit.
- C. Installer is to accompany manufacturer's service representative during startup service and provide manufacturer's service representative with requested documentation and technical support during startup service.
1. Installer is to correct deficiencies found during startup service for reverification.
- D. System Operation Report:

1. After completion of startup service, manufacturer is to issue a report for each separate system.
2. Report is to include complete documentation describing each startup check, the result, and any corrective action required.
3. Manufacturer is to electronically record not less than **[two]<Insert number>** hours of continuous operation of each system and submit with report for historical reference.
 - a. All available system operating parameters are to be included in the information submitted.

E. Witness:

1. Invite **[Architect][Owner][and][Commissioning Agent]** to witness startup service procedures.
2. Provide written notice not less than **[20]<Insert number>** business days before start of startup service.

3.21 ADJUSTING

- A. Adjust equipment and components to function smoothly, and lubricate as recommended in writing by manufacturer.
- B. Adjust initial temperature and humidity set points. Adjust initial airflow settings and discharge airflow patterns.
- C. Set field-adjustable switches and circuit-breaker trip ranges in accordance with VRF HVAC system manufacturer's written instructions, and as indicated.
- D. Occupancy Adjustments: When requested within **[12]<Insert number>** months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to **[two]<Insert number>** visits to Project during other-than-normal occupancy hours for this purpose.

3.22 PROTECTION

- A. Protect products from moisture and water damage. Remove and replace products that are wet, moisture damaged, or mold damaged.
- B. Protect equipment from physical damage. Replace equipment with physical damage that cannot be repaired to new condition. Observable surface imperfections are grounds for removal and replacement.
- C. Protect equipment from electrical damage. Replace equipment suffering electrical damage.
- D. Cover and seal openings of equipment to keep inside of equipment clean. Do not remove covers until finish work is complete.

3.23 MAINTENANCE SERVICE

- A. Beginning at Substantial Completion, verify that maintenance service includes **[12]<Insert duration>** months' full maintenance by **[skilled employees of system Installer][manufacturer's authorized service representative]**. Include **[two][four]<Insert number>** service visits for preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper equipment and system operation. Verify that parts and supplies are manufacturer's authorized replacement parts and supplies.

3.24 SOFTWARE SERVICE AGREEMENT

- A. Technical Support: Beginning at Substantial Completion, verify that service agreement includes software support for **[two]<Insert number>** years.
- B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within **[two]<Insert number>** years from date of Substantial Completion. Verify that upgrading software includes operating system and new or revised licenses for using software.
 - 1. Upgrade Notice: No fewer than **[30]<Insert number>** days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.
- C. Written Report: Prepare report after each update, documenting upgrades installed.

3.25 DEMONSTRATION

- A. Engage a VRF HVAC system manufacturer's **[employed training instructor][or][factory-authorized service representative]** to train Owner's maintenance personnel to adjust, operate, and maintain entire system.
- B. Instructor:
 - 1. Instructor is to be factory trained and certified by VRF HVAC system manufacturer with current training on the system(s), equipment, and controls that are installed.
 - 2. Instructor's credentials are to be submitted for review by **[Architect][Commissioning Agent][Owner]** before scheduling training.
 - 3. Instructor(s) **[primary][sole]** job responsibility is to be Owner training.
 - 4. Instructor(s) is to have not less than **[three]<Insert number>** years of training experience with VRF HVAC system manufacturer and past training experience on at least **[three]<Insert number>** projects of comparable size and complexity.
- C. Schedule and Duration:
 - 1. Schedule training with Owner at least **[20]<Insert number>** business days before first training session.
 - 2. Training is to occur before Owner occupancy.
 - 3. Training is to be held at mutually agreed date and time during normal business hours.
 - 4. Each training day is not to exceed **[eight]<Insert number>** hours of training. Daily training schedule is to allow time for **[one]<Insert number>** -hour lunch period and **[15]<Insert number>** -minute break after every **[two]<Insert number>** hours of training.
 - 5. Perform not less than **[eight][16][24]<Insert number>** total hours of training.
- D. Location: Owner is to provide a suitable on-site location to host classroom training.
- E. Training Attendees: Estimate **[three]<Insert number>** people.
- F. Training Attendance: For record purposes, document training attendees at the start of each new training session. Record attendee's name, signature, phone number, and e-mail address.
- G. Training Format: Individual training modules are to include classroom training followed by hands-on field demonstration and training.
- H. Training Materials: Provide training materials in electronic format to each attendee.

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1. Include instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
 2. Video record each classroom training session and submit an electronic copy to Owner before requesting Owner acceptance of training.
- I. Acceptance: Obtain **[Architect][Commissioning Agent][or][Owner]** written acceptance that training is complete and requirements indicated have been satisfied.

END OF SECTION 23 81 00 00



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 81 13 00	23 81 00 00	Variable-Refrigerant-Flow HVAC Systems



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SECTION 23 81 13 11 - PACKAGED TERMINAL AIR-CONDITIONERS, THROUGH-WALL UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Packaged, terminal air conditioners, through-wall units.

B. Related Requirements:

1. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

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

B. Shop Drawings: For packaged, terminal air-conditioners.

1. Include plans, elevations, sections, details for wall penetrations,[**seismic bracing,**] and attachments to other work.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Color Samples: For unit cabinet, discharge grille, and exterior louver, and for each color and texture specified.

D. Sustainable Design Submittals:

1. Ventilation: Product Data for ventilation equipment, indicating compliance with ASHRAE 62.1, Section 5 - "Systems and Equipment."
2. Refrigerant: Product Data for refrigerants, indicating compliance with refrigerant management practices.
3. Product Data: For refrigerants, indicating compliance with refrigerant management practices.
4. Product Data: For energy performance.

1.3 INFORMATIONAL SUBMITTALS

A. Product Test Reports: For packaged, terminal air conditioners, for tests performed by manufacturer and witnessed by a qualified testing agency.

B. Seismic Qualification Certificates: For packaged terminal air conditioners, accessories, and components, from manufacturer.



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

C. Field quality control reports.

D. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For packaged, terminal air conditioners to include in emergency, operation, and maintenance manuals.

1.5 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of packaged, terminal air conditioners that fail in materials or workmanship within specified warranty period.
1. Warranty Period for Sealed Refrigeration System: Manufacturer's standard, but not less than **[five]<Insert number>** years from date of Substantial Completion, including components and labor.
 2. Warranty Period for Nonsealed System Parts: Manufacturer's standard, but not less than **[five]<Insert number>** years from date of Substantial Completion, including only components and excluding labor.
 3. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than **[five]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Packaged terminal air conditioners are to withstand the effects of earthquake motions. See Section 230548 "Vibration and Seismic Controls for HVAC" and Section 018123 "Facility Seismic and Wind Criteria" for building seismic performance criteria.
1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."
 2. Component Importance Factor: **[1.5][1.0]**.
 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 PACKAGED, TERMINAL AIR CONDITIONERS, THROUGH-WALL UNITS

A. Packaged, Terminal Air Conditioners, Through-Wall Units:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Amana; Whirlpool Corporation]**
 - b. **[ClimateMaster, Inc.]**
 - c. **[Comfort-Aire; a division of Heat Controller, Inc.]**
 - d. **[Friedrich Air Conditioning Company]**
 - e. **[GE Appliances; Haier Group]**
 - f. **[Ice Air LLC]**
 - g. **[LG Electronics USA, Inc.; LG Electronics Inc.]**
 - h. **[Suburban Manufacturing Company; a division of AIRXCEL, Inc.]**
 - i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Amana; Whirlpool Corporation]**
 - b. **[ClimateMaster, Inc.]**
 - c. **[Comfort-Aire; a division of Heat Controller, Inc.]**
 - d. **[Friedrich Air Conditioning Company]**
 - e. **[GE Appliances; Haier Group]**
 - f. **[Ice Air LLC]**
 - g. **[LG Electronics USA, Inc.; LG Electronics Inc.]**
 - h. **[Suburban Manufacturing Company; a division of AIRXCEL, Inc.]**
 - i. **<Insert manufacturer's name>**
3. Description: Factory-assembled and -tested, self-contained, packaged, terminal air conditioner with room cabinet, electric refrigeration system, **[heating,]** and temperature controls; fully charged with refrigerant and filled with oil; with **[cord-connected][hardwired]** chassis.
4. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Ventilation Rate Procedures," and Section 7 - "Construction and Startup."
5. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.
6. ASHRAE Thermal Comfort: Applicable requirements in ASHRAE 55.
7. UL listed and ETL performance certified.
8. Chassis:
 - a. Cabinet: **[0.052-inch- (1.3-mm-)]<Insert dimension>** thick **[galvanized][powder-coated]** steel with removable front panel with concealed latches.
 - 1) Mounting: **[Wall with wall sleeve][Floor with subbase].**
 - 2) Top: **[Angled][Flat].**
 - 3) Discharge Grille: **[Punched-louver discharge grille allowing four-way discharge-air pattern][Extruded-aluminum discharge grille][Reversible-polycarbonate discharge grille allowing upward and horizontal airflow],** tamperproof, and carrying a flame test rating in accordance with UL 94.
 - 4) Louvers: **[Extruded aluminum with enamel finish][Stamped aluminum with clear-anodized finish][Stamped steel with enamel finish];**
[white][bronze][brown][beige]<Insert color> color.

- 5) Finish: **[Epoxy coating][Baked enamel]**.
 - 6) Access Door: Hinged door in top of cabinet for access to controls.
 - 7) Cabinet Extension: Matching cabinet in construction and finish, allowing diversion of airflow to adjoining room; with grille.
 - 8) Finish of Interior Surfaces: Surfaces in contact with the airstream are to comply with requirements in ASHRAE 62.1.
 - 9) Electrical Subbase: Enameled steel with four adjustable leveling feet and adjustable end plates[, **with factory-installed and -wired, fused disconnect switch and receptacle sized for unit**].
 - 10) Hydronic Subbase: Enameled steel with six adjustable leveling feet and adjustable end plates with two-row **NPS 5/8 (DN 18)** copper tube, aluminum-plate finned coil for use with hot water or steam, **[normally open][normally closed]** low-voltage electric valve for **[hot water][steam]** and provision for mounting receptacle[, **with factory-installed and -wired, fused disconnect switch and receptacle sized for unit**].
 - 11) Wall Sleeves: **[Galvanized steel with polyester finish][Galvanized steel with powder-coated paint][Molded polymer][Molded fiberglass-reinforced polyester]**.
- b. Refrigeration System: Direct-expansion indoor coil with capillary restrictor and hermetically sealed scroll compressor with vibration isolation and overload protection.
- 1) Indoor and Outdoor Coils: Seamless copper tubes mechanically expanded into aluminum fins[**with capillary tube distributor on indoor coil**].
 - 2) Accumulator.
 - 3) Constant-pressure expansion valve.
 - 4) Reversing valve.
 - 5) Refrigerant: **[R-32][R-454B]<Insert refrigerant type>**.
- c. Indoor Fan: Forward curved, centrifugal; with **[single-][two-]**speed motor and positive-pressure ventilation damper with **[concealed manual][electric]** operator.
- d. Filters: Washable polyurethane in molded plastic frame.
- e. Condensate Drain: Drain pan **[to direct condensate to outdoor coil for re-evaporation][and piping to direct condensate to building waste and vent piping]**.
- 1) Comply with ASHRAE 62.1 for drain pan construction and connections.
- f. Outdoor Fan: **[Forward curved, centrifugal][Propeller][Forward curved, centrifugal or propeller]** type **[with separate][driven by indoor fan]** motor.
- 1) Indoor and Outdoor Fan Motors: Two speed; comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - a) Fan Motors: Permanently lubricated split capacitor.
 - b) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - c) Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
9. Heating:
- a. Electric-Resistance Heating Coil: Nickel-chromium-wire, electric-resistance heating elements with contactor and high-temperature-limit switch.
 - b. Hot-Water Heating Coil: Seamless copper tubes mechanically expanded into aluminum fins with two-way modulating control valve and air vent.

c. Gas Heat:

- 1) General Requirements for Gas-Fired, Noncondensing Furnaces: Factory assembled, piped, wired, and tested; complying with ANSI Z21.86/CSA 2.32, "Vented Gas-Fired Space Heating Appliances," and with NFPA 54.
- 2) Type of Gas: **[Natural][Propane]**.
- 3) Heat Exchanger: **[Aluminized][Stainless]** steel.
- 4) Burner:
 - a) Gas Valve: 100 percent safety, single-stage main gas valve; main shutoff valve; pressure regulator; safety pilot with electronic flame sensor; limit control, transformer; and combination ignition/fan timer control board.
 - b) Ignition: Electric pilot ignition with hot-surface igniter or electric spark ignition.
- 5) Gas-Burner Safety Controls:
 - a) Electronic Flame Sensor: Prevents gas valve from opening until pilot flame is proven; stops gas flow on ignition failure.
 - b) Flame Rollout Switch: Installed on burner box; prevents burner operation.
 - c) Limit Control: Fixed stop at maximum permissible setting; de-energizes burner on excessive bonnet temperature; automatic reset.
- 6) Combustion-Air Inducer: Centrifugal fan prepurges heat exchanger and vents combustion products; thermally protected motor includes sleeve bearings; pressure switch prevents operation if combustion-air inlet or flue outlet is blocked.
- 7) Furnace Controls: Solid-state board for integrating ignition, heat, cooling, and fan speeds; adjustable fan-on and fan-off timing; and terminals for connection to accessories.

10. Controls:

- a. Control Module: Unit-mounted digital panel with touchpad temperature control and with touchpad for heating, cooling, and fan operation. Include the following features:
 - 1) Low-Ambient Lockout Control: Prevents cooling-cycle operation below **40 deg F (5 deg C)** outdoor air temperature.
 - 2) Heat-Pump Ambient Control: Field-adjustable switch changes to heat-pump heating operation above **40 deg F (5 deg C)** and to supplemental heating below **plus 25 deg F (minus 4 deg C)**.
 - 3) Temperature-Limit Control: Prevents occupant from exceeding preset **[setback or]** setup temperature.
 - 4) Building Automation System Interface: Allows remote on-off control with setback temperature control.
 - 5) Reverse-Cycle Defrost: Solid-state sensor monitors frost buildup on **[indoor][outdoor]** coil and reverses unit to melt frost.
- b. Remote Control: Standard unit-mounted controls with remote-mounted, low-voltage, adjustable thermostat with heat anticipator; **[heat-off-cool-auto][heat-off-cool]** switch; and **[on-auto]** fan switch.
- c. Outdoor Air:
 - 1) Motorized intake damper. Open intake when unit indoor-air fan runs.
 - 2) Manual intake damper.

B. Capacities and Characteristics:

1. Airflow: **<Insert cfm (L/s)>**.
2. Outdoor-Air Intake Rate: **<Insert cfm (L/s)>**.
3. Cooling Capacity:
 - a. Total: **<Insert Btu/h (kW)>**.
 - b. Sensible: **<Insert Btu/h (kW)>**.
 - c. Energy-Efficiency Ratio: **<Insert number>**.
 - d. Indoor Coil Entering-Air Dry Bulb Temperature: **<Insert deg F (deg C)>**.
 - e. Indoor Coil Entering-Air Wet Bulb Temperature: **<Insert deg F (deg C)>**.
 - f. Indoor Coil Leaving-Air Dry Bulb Temperature: **<Insert deg F (deg C)>**.
 - g. Indoor Coil Leaving-Air Wet Bulb Temperature: **<Insert deg F (deg C)>**.
 - h. Outdoor Coil Entering-Air Temperature: **<Insert deg F (deg C)>**.
4. Heat-Pump Capacity:
 - a. Total: **<Insert Btu/h (kW)>**.
 - b. Outdoor Temperature: **<Insert deg F (deg C)>**.
5. Electric Heat Capacity: **<Insert Btu/h (kW)>**.
6. Hydronic Heat Capacity:
 - a. Total: **<Insert Btu/h (kW)>**.
 - b. Entering-Air Temperature: **<Insert deg F (deg C)>**.
 - c. Leaving-Air Temperature: **<Insert deg F (deg C)>**.
 - d. Water Flow: **<Insert gpm (L/s)>**.
 - e. Entering-Water Temperature: **<Insert deg F (deg C)>**.
 - f. Leaving-Water Temperature: **<Insert deg F (deg C)>**.
7. Gas Heat Capacity:
 - a. Input: **<Insert Btu/h (kW)>**.
 - b. Output: **<Insert Btu/h (kW)>**.
 - c. AFUE: **[80]<Insert number>** percent.
8. Sound:
 - a. Indoor: **<Insert decibels>**.
 - b. Outdoor: **<Insert decibels>**.
9. Electrical Characteristics:
 - a. Volts: **<Insert value>**.
 - b. Phase: **[Single][Three]**.
 - c. Hertz: 60.
 - d. Full-Load Amperes: **<Insert value>**.
 - e. Minimum Circuit Ampacity: **<Insert value>**.
 - f. Maximum Overcurrent Protection: **<Insert amperage>**.

C. Source Quality Control

1. Sound-Power Level Ratings: Factory test to comply with AHRI 300, "Sound Rating and Sound Transmission Loss of Packaged Terminal Equipment."
2. Unit Performance Ratings: Factory test to comply with AHRI 310/380/CSA C744, "Packaged Terminal Air-Conditioners and Heat Pumps."

PART 3 - EXECUTION

3.1 INSTALLATION OF PACKAGED, TERMINAL AIR CONDITIONERS, THROUGH-WALL UNITS

- A. Install units level and plumb, maintaining manufacturer's recommended clearances and tolerances.
- B. Install wall sleeves in finished wall assembly; seal and weatherproof. Joint-sealant materials and applications are specified in Section 079200 "Joint Sealants."
- C. Install and anchor wall sleeves to withstand, without damage to equipment and structure, seismic forces required by building code.

3.2 PIPING CONNECTIONS

- A. Comply with requirements for piping specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Comply with requirements for piping specified in Section 231123 "Facility Natural-Gas Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- C. Install piping adjacent to machine to allow service and maintenance.

3.3 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
 - 1. Inspect for and remove shipping bolts, blocks, and tie-down straps.
 - 2. After installing packaged, terminal air conditioners and after electrical circuitry has been energized, test for compliance with requirements.
 - 3. Unit is level on base and is flashed in exterior wall.
 - 4. Unit casing has no visible damage.
 - 5. Compressor, air-cooled condenser coil, and fans have no visible damage.
 - 6. Labels are clearly visible.
 - 7. Controls are connected and operable.
 - 8. Shipping bolts, blocks, and tie-down straps are removed.
 - 9. Filters are installed and clean.
 - 10. Drain pan and drain line are installed correctly.
 - 11. Electrical wiring installation complies with manufacturer's submittal and installation requirements in electrical Sections.
 - 12. Installation: Perform startup checks in accordance with manufacturer's written instructions, including the following:
 - a. Lubricate bearings on fan.
 - b. Check fan-wheel rotation for correct direction without vibration and binding.



13. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
14. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. After operational test, change filters.

E. Packaged, terminal air conditioners will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.4 ADJUSTING

A. Adjust initial temperature set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

3.5 DEMONSTRATION

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

END OF SECTION 23 81 13 11



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 81 13 11	23 81 00 00	Variable-Refrigerant-Flow HVAC Systems



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SECTION 23 81 13 12 - PACKAGED TERMINAL AIR-CONDITIONERS, FREESTANDING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Packaged terminal air conditioners, freestanding units.

B. Related Requirements:

1. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

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

B. Shop Drawings: For packaged, terminal air conditioners.

1. Include plans, elevations, sections, details for wall penetrations, [**seismic bracing,**] and attachments to other work.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Color Samples: For unit cabinet, discharge grille, and exterior louver, and for each color and texture specified.

D. Sustainable Design Submittals:

1. Ventilation: Product Data for ventilation equipment, indicating compliance with ASHRAE 62.1, Section 5 - "Systems and Equipment."
2. Refrigerant: Product Data for refrigerants, indicating compliance with refrigerant management practices.
3. Product Data: For refrigerants, indicating compliance with refrigerant management practices.
4. Product Data: For energy performance.

1.3 INFORMATIONAL SUBMITTALS

A. Product Test Reports: For packaged, terminal air conditioners, for tests performed by manufacturer and witnessed by a qualified testing agency.

B. Seismic Qualification Certificates: For packaged terminal air conditioners, accessories, and components, from manufacturer.



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

C. Field quality control reports.

D. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For packaged, terminal air conditioners to include in emergency, operation, and maintenance manuals.

1.5 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of packaged, terminal air conditioners that fail in materials or workmanship within specified warranty period.
1. Warranty Period for Sealed Refrigeration System: Manufacturer's standard, but not less than **[five]<Insert number>** years from date of Substantial Completion, including components and labor.
 2. Warranty Period for Nonsealed System Parts: Manufacturer's standard, but not less than **[five]<Insert number>** years from date of Substantial Completion, including only components and excluding labor.
 3. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than **[five]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Packaged terminal air conditioners are to withstand the effects of earthquake motions. See Section 230548 "Vibration and Seismic Controls for HVAC" and Section 018123 "Facility Seismic and Wind Criteria" for building seismic performance criteria.
1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."
 2. Component Importance Factor: **[1.5][1.0]**.
 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 PACKAGED TERMINAL AIR CONDITIONERS, FREESTANDING UNITS

A. Packaged Terminal Air Conditioners, Freestanding Units:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ClimateMaster, Inc.]**
 - b. **[Friedrich Air Conditioning Company]**
 - c. **[GE Appliances; Haier Group]**
 - d. **[Ice Air LLC]**
 - e. **[Rupp Air Management Systems]**
 - f. **[Suburban Manufacturing Company; a division of AIRXCEL, Inc.]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ClimateMaster, Inc.]**
 - b. **[Friedrich Air Conditioning Company]**
 - c. **[GE Appliances; Haier Group]**
 - d. **[Ice Air LLC]**
 - e. **[Rupp Air Management Systems]**
 - f. **[Suburban Manufacturing Company; a division of AIRXCEL, Inc.]**
 - g. **<Insert manufacturer's name>**
3. Description: Factory-assembled and -tested, self-contained, packaged, terminal air conditioner with room cabinet, electric refrigeration system, **[heating,]** and temperature controls; fully charged with refrigerant and filled with oil; with **[cord-connected][hardwired]** chassis.
4. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Ventilation Rate Procedures," and Section 7 - "Construction and Startup."
5. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.
6. ASHRAE Thermal Comfort: Applicable requirements in ASHRAE 55.
7. UL listed and ETL performance certified.
8. Chassis:
 - a. Cabinet: **[0.052-inch- (1.32-mm-)]<Insert dimension> thick [galvanized][powder-coated]** steel with removable front panel with concealed latches.
 - 1) Mounting: **[Floor with subbase][Horizontal][Vertical]**.
 - 2) Top: **[Angled][Flat]**.
 - 3) Discharge Grille: **[Punched-louver discharge grille allowing four-way discharge-air pattern][Extruded-aluminum discharge grille][Reversible-polycarbonate discharge grille allowing upward and horizontal airflow]**, tamperproof, and carrying a flame test rating in accordance with UL 94.
 - 4) Louvers: **[Extruded aluminum with enamel finish][Stamped aluminum with clear-anodized finish][Stamped steel with enamel finish]; [white][bronze][brown][beige]<Insert color> color.**
 - 5) Finish: **[Epoxy coating][Baked enamel]**.
 - 6) Access Door: Hinged door in top of cabinet for access to controls.
 - 7) Cabinet Extension: Matching cabinet in construction and finish, allowing diversion of airflow to adjoining room; with grille.

- 8) Finish of Interior Surfaces: Surfaces in contact with the airstream are to comply with requirements in ASHRAE 62.1.
 - 9) Electrical Subbase: Enameled steel with four adjustable leveling feet and adjustable end plates[, **with factory-installed and -wired, fused disconnect switch and receptacle sized for unit**].
 - 10) Hydronic Subbase: Enameled steel with six adjustable leveling feet and adjustable end plates with two-row **NPS 5/8 (DN 18)** copper tube, aluminum-plate finned coil for use with hot water or steam, [**normally open**][**normally closed**] low-voltage electric valve for [**hot water**][**steam**] and provision for mounting receptacle[, **with factory-installed and -wired, fused disconnect switch and receptacle sized for unit**].
 - 11) Wall Sleeves: [**Galvanized steel with polyester finish**][**Galvanized steel with powder coated paint**][**Molded polymer**][**Molded fiberglass-reinforced polyester**].
- b. Refrigeration System: Direct-expansion indoor coil with capillary restrictor and hermetically sealed scroll compressor with vibration isolation and overload protection.
 - 1) Indoor and Outdoor Coils: Seamless copper tubes mechanically expanded into aluminum fins[**with capillary tube distributor on indoor coil**].
 - 2) Accumulator.
 - 3) Constant-pressure expansion valve.
 - 4) Reversing valve.
 - 5) Refrigerant: [**R-32**][**R-454B**]**<Insert refrigerant type>**.
 - c. Indoor Fan: Forward curved, centrifugal; with [**single-**][**two-**]speed motor and positive-pressure ventilation damper with [**concealed manual**][**electric**] operator.
 - d. Filters: Washable polyurethane in molded plastic frame.
 - e. Condensate Drain: Drain pan [**to direct condensate to outdoor coil for re-evaporation**][**and piping to direct condensate to building waste and vent piping**].
 - 1) Comply with ASHRAE 62.1 for drain pan construction and connections.
 - f. Outdoor Fan: [**Forward curved, centrifugal**][**Propeller**][**Forward curved, centrifugal or propeller**] type [**with separate**][**driven by indoor fan**] motor.
 - 1) Indoor and Outdoor Fan Motors: Two speed; comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - a) Fan Motors: Permanently lubricated split capacitor.
 - b) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - c) Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
9. Heating:
 - a. Electric-Resistance Heating Coil: Nickel-chromium-wire, electric-resistance heating elements with contactor and high-temperature-limit switch.
 - b. Hot-Water Heating Coil: Seamless copper tubes mechanically expanded into aluminum fins with two-way modulating control valve and air vent
 - c. Gas Heat:
 - 1) General Requirements for Gas-Fired, Noncondensing Furnaces: Factory assembled, piped, wired, and tested; complying with ANSI Z21.86/CSA 2.32,

- "Vented Gas-Fired Space Heating Appliances," and with NFPA 54.
- 2) Type of Gas: **[Natural][Propane]**.
 - 3) Heat Exchanger: **[Aluminized][Stainless]** steel.
 - 4) Burner:
 - a) Gas Valve: 100 percent safety, **[two-stage][modulating]** main gas valve; main shutoff valve; pressure regulator; safety pilot with electronic flame sensor; limit control; transformer; and combination ignition/fan timer control board.
 - b) Ignition: Electric pilot ignition with hot-surface igniter or electric spark ignition.
 - 5) Gas-Burner Safety Controls:
 - a) Electronic Flame Sensor: Prevents gas valve from opening until pilot flame is proven; stops gas flow on ignition failure.
 - b) Flame Rollout Switch: Installed on burner box; prevents burner operation.
 - c) Limit Control: Fixed stop at maximum permissible setting; de-energizes burner on excessive bonnet temperature; automatic reset.
 - 6) Combustion-Air Inducer: Centrifugal fan prepurges heat exchanger and vents combustion products; thermally protected motor includes sleeve bearings; pressure switch prevents operation if combustion-air inlet or flue outlet is blocked.
 - 7) Furnace Controls: Solid-state board for integrating ignition, heat, cooling, and fan speeds; adjustable fan-on and fan-off timing; and terminals for connection to accessories.

10. Controls:

- a. Control Module: Unit-mounted digital panel with touchpad temperature control and with touchpad for heating, cooling, and fan operation. Include the following features:
 - 1) Low-Ambient Lockout Control: Prevents cooling-cycle operation below **40 deg F (5 deg C)** outdoor air temperature.
 - 2) Heat-Pump Ambient Control: Field-adjustable switch changes to heat-pump heating operation above **40 deg F (5 deg C)** and to supplemental heating below **plus 25 deg F (minus 4 deg C)**.
 - 3) Temperature-Limit Control: Prevents occupant from exceeding preset **[setback or]** setup temperature.
 - 4) Building Automation System Interface: Allows remote on-off control with setback temperature control.
 - 5) Reverse-Cycle Defrost: Solid-state sensor monitors frost buildup on **[indoor][outdoor]** coil and reverses unit to melt frost.
- b. Remote Control: Standard unit-mounted controls with remote-mounted, low-voltage, adjustable thermostat with heat anticipator; **[heat-off-cool-auto][heat-off-cool]** switch; and **[on-auto]** fan switch.
- c. Outdoor Air:
 - 1) Motorized intake damper. Open intake when unit indoor-air fan runs.
 - 2) Manual intake damper.

B. Capacities and Characteristics:

1. Airflow: **<Insert cfm (L/s)>**.
2. Outdoor-Air Intake Rate: **<Insert cfm (L/s)>**.
3. Cooling Capacity:

- a. Total: **<Insert Btu/h (kW)>**.
 - b. Sensible: **<Insert Btu/h (kW)>**.
 - c. Energy-Efficiency Ratio: **<Insert number>**.
 - d. Indoor Coil Entering-Air Dry Bulb Temperature: **<Insert deg F (deg C)>**.
 - e. Indoor Coil Entering-Air Wet Bulb Temperature: **<Insert deg F (deg C)>**.
 - f. Indoor Coil Leaving-Air Dry Bulb Temperature: **<Insert deg F (deg C)>**.
 - g. Indoor Coil Leaving-Air Wet Bulb Temperature: **<Insert deg F (deg C)>**.
 - h. Outdoor Coil Entering-Air Temperature: **<Insert deg F (deg C)>**.
4. Heat-Pump Capacity:
 - a. Total: **<Insert Btu/h (kW)>**.
 - b. Outdoor Temperature: **<Insert deg F (deg C)>**.
5. Electric Heat Capacity: **<Insert Btu/h (kW)>**.
6. Hydronic Heat Capacity:
 - a. Total: **<Insert Btu/h (kW)>**.
 - b. Entering-Air Temperature: **<Insert deg F (deg C)>**.
 - c. Leaving-Air Temperature: **<Insert deg F (deg C)>**.
 - d. Water Flow: **<Insert gpm (L/s)>**.
 - e. Entering-Water Temperature: **<Insert deg F (deg C)>**.
 - f. Leaving-Water Temperature: **<Insert deg F (deg C)>**.
7. Gas Heat Capacity:
 - a. Input: **<Insert Btu/h (kW)>**.
 - b. Output: **<Insert Btu/h (kW)>**.
 - c. AFUE: **[80]<Insert number>** percent.
8. Sound:
 - a. Indoor: **<Insert decibels>**.
 - b. Outdoor: **<Insert decibels>**.
9. Electrical Characteristics:
 - a. Volts: **<Insert value>**.
 - b. Phase: **[Single][Three]**.
 - c. Hertz: 60.
 - d. Full-Load Amperes: **<Insert value>**.
 - e. Minimum Circuit Ampacity: **<Insert value>**.
 - f. Maximum Overcurrent Protection: **<Insert amperage>**.
- C. Source Quality Control:
 1. Sound-Power Level Ratings: Factory test to comply with AHRI 300, "Sound Rating and Sound Transmission Loss of Packaged Terminal Equipment."
 2. Unit Performance Ratings: Factory test to comply with AHRI 310/380/CSA C744, "Packaged Terminal Air-Conditioners and Heat Pumps."

PART 3 - EXECUTION

3.1 INSTALLATION OF PACKAGED TERMINAL AIR CONDITIONERS, FREESTANDING UNITS

- A. Install units level and plumb, maintaining manufacturer's recommended clearances and tolerances.
- B. Install exterior louver in finished wall assembly; seal and weatherproof. Joint-sealant materials and applications are specified in Section 079200 "Joint Sealants."
- C. Install and anchor exterior louver to withstand, without damage to equipment and structure, seismic forces required by building code.

3.2 PIPING CONNECTIONS

- A. Comply with requirements for piping specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Comply with requirements for piping specified in Section 231123 "Facility Natural-Gas Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- C. Install piping adjacent to machine to allow service and maintenance.

3.3 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
 - 1. Inspect for and remove shipping bolts, blocks, and tie-down straps.
 - 2. After installing packaged, terminal air conditioners and after electrical circuitry has been energized, test for compliance with requirements.
 - 3. Unit is level on base and is flashed in exterior wall.
 - 4. Unit casing has no visible damage.
 - 5. Compressor, air-cooled condenser coil, and fans have no visible damage.
 - 6. Labels are clearly visible.
 - 7. Controls are connected and operable.
 - 8. Shipping bolts, blocks, and tie-down straps are removed.
 - 9. Filters are installed and clean.
 - 10. Drain pan and drain line are installed correctly.
 - 11. Electrical wiring installation complies with manufacturer's submittal and installation requirements in electrical Sections.
 - 12. Installation: Perform startup checks in accordance with manufacturer's written instructions, including the following:
 - a. Lubricate bearings on fan.
 - b. Check fan-wheel rotation for correct direction without vibration and binding.



13. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
14. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

- D. After performance test, change filters.
- E. Packaged, terminal air conditioners will be considered defective if they do not pass tests and inspections.
- F. Prepare test and inspection reports.

3.4 ADJUSTING

- A. Adjust initial temperature set points.
- B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

3.5 DEMONSTRATION

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

END OF SECTION 23 81 13 12



SECTION 23 81 13 13 - PACKAGED TERMINAL AIR-CONDITIONERS, OUTDOOR, WALL-MOUNTED UNITS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: Packaged, terminal air-conditioners, outdoor, wall-mounted units.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Sustainable Design Submittals:
 - 1. Product Data: For ventilation equipment, indicating compliance with ASHRAE 62.1, Section 5 - "Systems and Equipment."
 - 2. Ventilation: Product Data for ventilation equipment, indicating compliance with ASHRAE 62.1, Section 5 - "Systems and Equipment."
- C. Shop Drawings: For packaged, terminal air conditioners.
 - 1. Include plans, elevations, sections, details for wall penetrations,[**seismic bracing**,] and attachments to other work.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.
- D. Color Samples: For unit cabinet, discharge grille, and exterior louver, and for each color and texture specified.

1.3 INFORMATIONAL SUBMITTALS

- A. Product Test Reports: For packaged, terminal air conditioners, for tests performed by manufacturer and witnessed by a qualified testing agency.
- B. Field quality-control reports.
- C. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For packaged, terminal air conditioners to include in emergency, operation, and maintenance manuals.

1.5 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of packaged, terminal air conditioners that fail in materials or workmanship within specified warranty period.
1. Warranty Period for Sealed Refrigeration System: Manufacturer's standard, but not less than **[five]<Insert number>** years from date of Substantial Completion, including components and labor.
 2. Warranty Period for Nonsealed System Parts: Manufacturer's standard, but not less than **[five]<Insert number>** years from date of Substantial Completion, including only components and excluding labor.
 3. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than **[five]<Insert number>** years from date of Substantial Completion.
 4. Warranty Period for Energy Recovery Ventilator: : Manufacturer's standard, but not less than **[five]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PACKAGED TERMINAL AIR-CONDITIONERS, OUTDOOR, WALL-MOUNTED UNITS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Bard Manufacturing Company]**
 2. **[Compu-Aire, Inc]**
 3. **[Liebert; Vertiv Holdings Co.]**
 4. **[Marvair]**
 5. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Bard Manufacturing Company]**
 2. **[Compu-Aire, Inc]**
 3. **[Liebert; Vertiv Holdings Co.]**
 4. **[Marvair]**
 5. **<Insert manufacturer's name>**
- C. Description: Factory-assembled and -tested, self-contained, packaged, terminal air conditioner with room cabinet, electric refrigeration system, **[heating,]** and temperature controls; fully charged with refrigerant and filled with oil; with hardwired chassis and circuit breaker.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- E. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Ventilation Rate Procedures," and Section 7 - "Construction and Startup."
- F. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

- G. ASHRAE Thermal Comfort: Applicable requirements in ASHRAE 55.
- H. ASHRAE ERV Testing: Applicable requirements in ASHRAE 84.
- I. AHRI Rating: Applicable requirements in AHRI 1060.
- J. UL listed and ETL performance certified.

2.2 CHASSIS

- A. Cabinet: Sloped top, **[0.052-inch- (1.32-mm-)]<Insert dimension> thick [steel][aluminum]** with removable front panel with concealed latches.
 - 1. Mounting: On exterior wall.
 - 2. Discharge Grille: **[Extruded-aluminum discharge grille][Supply-air acoustical plenum]**.
 - 3. Return Grille: **[Extruded-aluminum grille][Return-air acoustical plenum]**.
 - 4. Louvers: **[Extruded aluminum with enamel finish][Stamped aluminum with clear-anodized finish]; [medium bronze][dark bronze] color.**
 - 5. Finish: **[Epoxy coating][Baked enamel]**.
 - 6. Access Door: Hinged door in top of cabinet for access to controls.
 - 7. Cabinet Extension: Matching cabinet in construction and finish, allowing diversion of airflow to adjoining room; with grille.
 - 8. Insulation: Cooling and heating sections fully insulated with **1-inch (25-mm)-thick fiberglass insulation.**
 - 9. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
 - 10. Wall Sleeves: **[Galvanized steel with polyester finish][Molded polymer][Molded fiberglass-reinforced polyester]**.
- B. Refrigeration System: Direct-expansion indoor coil with capillary restrictor and hermetically sealed, **soft-start** scroll compressor with **[crankcase heater,]** liquid line filter dryer, externally equalized expansion valve, high-pressure switch, **[low-pressure switch,][low-pressure bypass timer,][fan cycle, control, common alarm,][fan cycle, variable speed control, common alarm,][fan cycle, control, lockout relay, common alarm,][fan cycle, variable speed control, lockout relay, common alarm,]** vibration isolation, and overload protection.
 - 1. Indoor and Outdoor Coils: Seamless copper tubes mechanically expanded into aluminum fins **with capillary tube distributor on indoor coil**.
 - 2. Accumulator.
 - 3. Constant-pressure expansion valve.
 - 4. Reversing valve.
 - 5. Charge: **[R-407C][R-410A]**.
- C. Indoor Fan: Forward curved, centrifugal; with **[single][twin][constant-][variable-]** speed motor(s) and positive-pressure ventilation damper with **[concealed manual][electric]** operator.
- D. Filters: **[Washable polyurethane in molded plastic frame][2-inch (25-mm), pleated, disposable MERV 6]**, serviceable from front of the unit.
- E. Condensate Drain: Coated galvanized-steel drain pan **[to direct condensate to outdoor coil for re-evaporation][and piping to direct condensate to building waste and vent piping]**.
 - 1. Comply with ASHRAE 62.1 for drain pan construction and connections.



- F. Outdoor Fan: **[High-ambient][Forward curved, centrifugal][Propeller][Forward curved, centrifugal, or propeller]** type **[with separate][driven by indoor fan]** motor.
1. Indoor and Outdoor Fan Motors: Two speed; comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - a. Fan Motors: Permanently lubricated split capacitor.
 - b. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - c. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
- G. Energy Recovery Wheel:
1. Casing: Steel with standard factory-painted finish.
 2. Casing seals on periphery of rotor and on duct divider.
 3. Support vertical rotors on grease-lubricated ball bearings having extended grease fittings **[or permanently lubricated bearings]**. Support horizontal rotors on tapered roller bearing.
 4. Rotor: Polymer segmented wheel strengthened with radial spokes impregnated with nonmigrating, water-selective, molecular-sieve desiccant coating.
 5. Drive: Fractional horsepower motor, gear reducer, and self-adjusting multilink belt around outside of rotor.
 - a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
 - b. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 6. Controls: Starting relay, factory mounted and wired, and manual motor starter for field wiring.

2.3 HEATING

- A. Electric-Resistance Heating Coil: Nickel-chromium-wire, electric-resistance heating elements with contactor and high-temperature-limit switch.
- B. Gas Heat:
1. General Requirements for Gas-Fired, Noncondensing Furnaces: Factory assembled, piped, wired, and tested; complying with ANSI Z21.86/CSA 2.32, "Vented Gas-Fired Space Heating Appliances," and with NFPA 54.
 2. Type of Gas: **[Natural][Propane]**.
 3. Heat Exchanger: **[Stainless]** steel.
 4. Burner:
 - a. Gas Valve: 100 percent safety, **[two-stage][modulating]** main gas valve; main shutoff valve; pressure regulator; safety pilot with electronic flame sensor; limit control; transformer; and combination ignition/fan timer control board.
 - b. Ignition: Electric pilot ignition with hot-surface igniter or electric spark ignition.
 - c. Field conversion kit for high altitude.

5. Gas-Burner Safety Controls:
 - a. Electronic Flame Sensor: Prevents gas valve from opening until pilot flame is proven; stops gas flow on ignition failure.
 - b. Flame Rollout Switch: Installed on burner box; prevents burner operation.
 - c. Limit Control: Fixed stop at maximum permissible setting; de-energizes burner on excessive bonnet temperature; automatic reset.
6. Combustion-Air Inducer: Centrifugal fan prepurges heat exchanger and vents combustion products; thermally protected motor includes sleeve bearings; pressure switch prevents operation if combustion-air inlet or flue outlet is blocked.
7. Furnace Controls: Solid-state board for integrating ignition, heat, cooling, and fan speeds; adjustable fan-on and fan-off timing; and terminals for connection to accessories.

2.4 CONTROLS

- A. Control Module: Unit-mounted digital panel with touchpad temperature control and with touchpad for heating, cooling, and fan operation. Include the following features:
 1. Low-Ambient Lockout Control: Prevents cooling-cycle operation below **40 deg F (5 deg C)** outdoor air temperature.
 2. Heat-Pump Ambient Control: Field-adjustable switch changes to heat-pump heating operation above **40 deg F (5 deg C)** and to supplemental heating below **plus 25 deg F (minus 4 deg C)**.
 3. Temperature-Limit Control: Prevents occupant from exceeding preset[**setback or**] setup temperature.
 4. Building Automation System Interface: Allows remote on-off control with setback temperature control.
 5. Reverse-Cycle Defrost: Solid-state sensor monitors frost buildup on **[indoor][outdoor]** coil and reverses unit to melt frost.
- B. Remote Control: Standard unit-mounted controls with remote-mounted, low-voltage, adjustable thermostat with heat anticipator; **[heat-off-cool-auto][heat-off-cool]** switch; and **[on-auto]** fan switch.
- C. Outdoor Air:
 1. Motorized intake damper. Open intake when unit indoor-air fan runs.
 2. Manual intake damper.
- D. Economizer Operation: Motorized intake-air damper controlled by an enthalpy sensor and a mixed-air sensor to provide natural cooling when the outdoor air temperature is favorable.
- E. Dual Unit Control (DUC): Hinged cover with two-stage heat/cool thermostat with individual heat/cool setpoints, adjustable interstage differentials and bimetallic elements. The control shall feature a solid-state timer with 1-2-4-8 day sequence, unit lead selector, Unit 1 and 2 power-on LEDs, Unit 1 or 2 lead unit LEDs, 48-hour program save on loss of power, industry standard connections, and 24-volt power from each unit. The DUC shall provide auto sequencing and displays on status and operating status parameters.
- F. Three-Phase Power Rotation Monitor: Three-phase monitoring to protect compressor from reverse rotation and to protect the unit from phase failure. Monitor manually reset.
- G. Ventilation:

1. Extra Ventilation: Section internally mounted, allowing up to 50% outside air and exhaust air through the action of adjustable dampers.
2. Energy Recovery Ventilator: **[One][Two]** rotary washable desiccant wheel(s), insulated cassette frame with seals, three-speed drive motor and belt, and intake and exhaust blowers.

H. Dehumidification Circuit: Supply-air stream, independent heat exchanger using a separate humidistat, hot gas three-way valve, separate desuperheating condenser circuit, and back drain orifice inserted between the reheat coil and suction line.

2.5 CAPACITIES AND CHARACTERISTICS

A. Airflow: **<Insert cfm (L/s)>**.

B. Outdoor-Air Intake Rate: **<Insert cfm (L/s)>**.

C. Cooling Capacity:

1. Total: **<Insert Btu/h (kW)>**.
2. Sensible: **<Insert Btu/h (kW)>**.
3. Energy-Efficiency Ratio: **<Insert number>**.
4. Indoor Coil Entering-Air Dry Bulb Temperature: **<Insert deg F (deg C)>**.
5. Indoor Coil Entering-Air Wet Bulb Temperature: **<Insert deg F (deg C)>**.
6. Indoor Coil Leaving-Air Dry Bulb Temperature: **<Insert deg F (deg C)>**.
7. Indoor Coil Leaving-Air Wet Bulb Temperature: **<Insert deg F (deg C)>**.
8. Outdoor Coil Entering-Air Temperature: **<Insert deg F (deg C)>**.

D. Heat-Pump Capacity:

1. Total: **<Insert Btu/h (kW)>**.
2. Outdoor Temperature: **<Insert deg F (deg C)>**.

E. Electric Heat Capacity: **<Insert Btu/h (kW)>**.

F. Hydronic Heat Capacity:

1. Total: **<Insert Btu/h (kW)>**.
2. Entering-Air Temperature: **<Insert deg F (deg C)>**.
3. Leaving-Air Temperature: **<Insert deg F (deg C)>**.
4. Water Flow: **<Insert gpm (L/s)>**.
5. Entering-Water Temperature: **<Insert deg F (deg C)>**.
6. Leaving-Water Temperature: **<Insert deg F (deg C)>**.

G. Gas Heat Capacity:

1. Input: **<Insert Btu/h (kW)>**.
2. Output: **<Insert Btu/h (kW)>**.
3. AFUE: **[80]<Insert number>** percent.

H. Exhaust Air:

1. Airflow: **<Insert cfm (L/s)>**.
2. Face Velocity: **<Insert fpm (m/s)>**.

3. Summer:
 - a. Entering-Air Temperature, Dry Bulb: **<Insert deg F (deg C)>**.
 - b. Entering-Air Temperature, Wet Bulb: **<Insert deg F (deg C)>**.
 - c. Leaving-Air Temperature, Dry Bulb: **<Insert deg F (deg C)>**.
 - d. Leaving-Air Temperature, Wet Bulb: **<Insert deg F (deg C)>**.
 4. Winter:
 - a. Entering-Air Temperature, Dry Bulb: **<Insert deg F (deg C)>**.
 - b. Entering-Air Temperature, Wet Bulb: **<Insert deg F (deg C)>**.
 - c. Leaving-Air Temperature, Dry Bulb: **<Insert deg F (deg C)>**.
 - d. Leaving-Air Temperature, Wet Bulb: **<Insert deg F (deg C)>**.
 5. Air-Pressure Drop: **<Insert inches wg (Pa)>**.
- I. Supply Air:
1. Airflow: **<Insert cfm (L/s)>**.
 2. Face Velocity: **<Insert fpm (m/s)>**.
 3. Summer:
 - a. Entering-Air Temperature, Dry Bulb: **<Insert deg F (deg C)>**.
 - b. Entering-Air Temperature, Wet Bulb: **<Insert deg F (deg C)>**.
 - c. Leaving-Air Temperature, Dry Bulb: **<Insert deg F (deg C)>**.
 - d. Leaving-Air Temperature, Wet Bulb: **<Insert deg F (deg C)>**.
 4. Winter:
 - a. Entering-Air Temperature, Dry Bulb: **<Insert deg F (deg C)>**.
 - b. Entering-Air Temperature, Wet Bulb: **<Insert deg F (deg C)>**.
 - c. Leaving-Air Temperature, Dry Bulb: **<Insert deg F (deg C)>**.
 - d. Leaving-Air Temperature, Wet Bulb: **<Insert deg F (deg C)>**.
 5. Air-Pressure Drop: **<Insert inches wg (Pa)>**.
- J. Wheel Drive:
1. Motor Size: **<Insert horsepower>**.
 2. Motor Electrical Characteristics:
 - a. Volts: **[120][208][230]<Insert value>**.
 - b. Phase: **[Single][Three]**.
 - c. Hertz: 60.
- K. Effectiveness: **<Insert percent>**.
- L. Sound:
1. Indoor: **<Insert bels>**.
 2. Outdoor: **<Insert bels>**.
- M. Electrical Characteristics:



1. Volts: **<Insert value>**.
2. Phase: **[Single][Three]**.
3. Hertz: 60.
4. Full-Load Amperes: **<Insert value>**.
5. Minimum Circuit Ampacity: **<Insert value>**.
6. Maximum Overcurrent Protection: **<Insert amperage>**.

2.6 SOURCE QUALITY CONTROL

- A. Sound-Power Level Ratings: Factory test to comply with AHRI 300, "Sound Rating and Sound Transmission Loss of Packaged Terminal Equipment."
- B. Unit Performance Ratings: Factory test to comply with AHRI 310/380/CSA C744, "Packaged Terminal Air-Conditioners and Heat Pumps."

PART 3 - EXECUTION

3.1 INSTALLATION OF PACKAGED TERMINAL AIR-CONDITIONERS, OUTDOOR, WALL-MOUNTED UNITS

- A. Install units level and plumb, maintaining manufacturer's recommended clearances and tolerances.
- B. Install wall sleeves in finished wall assembly; seal and weatherproof. Joint-sealant materials and applications are specified in Section 079200 "Joint Sealants."
- C. Install and anchor wall sleeves to withstand, without damage to equipment and structure, seismic forces required by building code.

3.2 CONNECTIONS

- A. Comply with requirements for piping specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Comply with requirements for piping specified in Section 231123 "Facility Natural-Gas Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- C. Install piping adjacent to machine to allow service and maintenance.

3.3 FIELD QUALITY CONTROL

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

1. Inspect for and remove shipping bolts, blocks, and tie-down straps.
2. After installing packaged, terminal air conditioners and after electrical circuitry has been energized, test for compliance with requirements.
3. Unit is level on base and is flashed in exterior wall.
4. Unit casing has no visible damage.
5. Compressor, air-cooled condenser coil, and fans have no visible damage.
6. Labels are clearly visible.
7. Controls are connected and operable.
8. Shipping bolts, blocks, and tie-down straps are removed.
9. Filters are installed and clean.
10. Drain pan and drain line are installed correctly.
11. Electrical wiring installation complies with manufacturer's submittal and installation requirements in electrical Sections.
12. Installation: Perform startup checks according to manufacturer's written instructions, including the following:
 - a. Lubricate bearings on fan.
 - b. Check fan-wheel rotation for correct direction without vibration and binding.
13. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
14. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. After performance test, change filters.

E. Packaged, terminal air conditioners will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.4 ADJUSTING

A. Adjust initial temperature set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

3.5 DEMONSTRATION

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

END OF SECTION 23 81 13 13



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23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 81 13 13	23 81 00 00	Variable-Refrigerant-Flow HVAC Systems
23 81 16 00	23 81 00 00	Variable-Refrigerant-Flow HVAC Systems



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SECTION 23 81 23 00 - SMALL CAPACITY COMPUTER-ROOM AIR-CONDITIONERS FLOOR-MOUNTED UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Small capacity (6 tons (21 kw) and smaller), computer-room air-conditioners, floor-mounted units.

1.2 DEFINITIONS

- A. COP: Coefficient of performance.
- B. EER: Energy efficiency ratio.
- C. SCR: Silicon controlled rectifier.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include material descriptions, dimensions of individual components and profiles, and finishes for computer-room air-conditioning units.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Sustainable Design Submittals:

1. Product Data: For energy performance.
2. Refrigerant: Product Data for refrigerants, indicating compliance with refrigerant management practices.
3. Product Data: For refrigerants, indicating compliance with refrigerant management practices.
4. Product data showing compliance with ASHRAE 62.1.

C. Shop Drawings: For computer-room air conditioners.

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

D. Color Samples: For unit cabinet, discharge grille, and exterior louver and for each color and texture specified.



1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans, elevations, and other details, drawn to scale, using input from installers of the items involved.
- B. Seismic Qualification Data: Certificates, for computer-room air conditioners, accessories, and components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Field quality-control reports.
- D. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For computer-room air conditioners to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fan Belts: **[One]<Insert number>** set(s) for each belt-driven fan.
 - 2. Filters: **[One]<Insert number>** set(s) of filters for each unit.

1.7 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of computer-room air conditioners that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Compressors: Manufacturer's standard, but not less than **[five][10]<Insert number>** years from date of Substantial Completion.
 - 2. Warranty Period for Humidifiers: Manufacturer's standard, but not less than **[three]<Insert number>** years from date of Substantial Completion.
 - 3. Warranty Period for Control Boards: Manufacturer's standard, but not less than **[three]<Insert number>** years from date of Substantial Completion.



PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Computer-room air conditioners shall withstand the effects of earthquake motions determined according to **[ASCE/SEI 7]<Insert requirement>**.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified **[and the unit will be fully operational after the seismic event]**."
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. ASHRAE Compliance:
 - 1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
 - 2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Ventilation Rate Procedures," and Section 7 - "Construction and Startup."
- D. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.
- E. ASME Compliance: Fabricate and label water-cooled condenser shell to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

2.2 SMALL CAPACITY (6 TONS (21 KW) AND SMALLER), COMPUTER-ROOM AIR-CONDITIONERS, FLOOR-MOUNTED UNITS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[APC by Schneider Electric]**
 - 2. **[Compu-Aire, Inc]**
 - 3. **[Data Aire Inc]**
 - 4. **[Liebert; Vertiv Holdings Co.]**
 - 5. **[Stulz-ATS]**
 - 6. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[APC by Schneider Electric]**
 - 2. **[Compu-Aire, Inc]**
 - 3. **[Data Aire Inc]**
 - 4. **[Liebert; Vertiv Holdings Co.]**
 - 5. **[Stulz-ATS]**
 - 6. **<Insert manufacturer's name>**
- C. Description: Self-contained, factory assembled, prewired, and prepiped; consisting of cabinet, fan,

Small Capacity Computer-Room Air-Conditioners Floor-

Mounted Units

filters, and controls; for vertical floor mounting in upflow or downflow configuration.

- D. Cabinet and Frame: Welded tubular-steel frame with removable steel panels with baked-enamel finish, insulated with **1-inch- (25-mm-)** thick duct liner.
 - 1. Floor Stand: Welded tubular steel, **<Insert required height>** high, with adjustable legs and vibration isolation pads[**with turning vanes mounted within the stand**].
 - 2. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
 - 3. Unit with **[two][three][four]**-way, powder-coated insulated air distribution plenum.
- E. Supply-Air Fan: Forward curved, centrifugal, and with adjustable V-belt drive.
- F. Refrigeration System:
 - 1. Compressor: **[Digital]** Scroll, **[variable capacity]**,with oil strainer, internal motor overload protection, resilient suspension system, and crankcase heater.
 - 2. Refrigeration Circuit:
 - a. Low-pressure switch.
 - b. Manually reset, high-pressure switch.
 - c. Thermal-expansion valve with external equalizer.
 - d. Sight glass with moisture indicator.
 - e. Service shutoff valves.
 - f. Charging valves.
 - g. Hot-gas bypass.
 - h. Refrigerant charge.
 - 3. Refrigerant: **[R-407C][or][R-410A]<Insert type>**.
 - 4. Refrigerant Evaporator Coil: Direct-expansion coil of seamless copper tubes expanded into aluminum fins, with two circuits, each with solenoid valve.
 - 5. Refrigerant line sets.
 - 6. Refrigerant line-sweat-adapter kit to permit field brazing of refrigerant lines.
 - a. Mount stainless-steel drain pan **[complying with ASHRAE 62.1][and][having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir]** under coil assembly.
 - 7. Integral, Water-Cooled Refrigerant Condenser: Brazed-plate type with liquid-line stop valve and head-pressure-actuated, two-way regulating valve.
 - a. Cooling Medium: **[Water][Glycol solution]**.
 - 8. Remote Air-Cooled Refrigerant Condenser:
 - a. Integral, copper-tube aluminum-fin coil.
 - b. Condenser with surge protection device (SPD) and locking disconnect in the enclosed electrical panel section.
 - 9. Fan:
 - a. Direct-drive, **[single][variable]**-speed propeller type.
 - b. Belt-drive, single propeller type.

- c. Direct-drive, **[single][variable]**-speed centrifugal type.
 - d. Belt-drive, single-speed centrifugal type.
- 10. Split system shall have suction- and liquid-line compatible fittings and refrigerant piping for field interconnection.
- G. Hydronic Cooling Coil: Seamless copper tubes expanded into aluminum fins with modulating **[two][three]**-way control valve and flow switch.
 - 1. Cooling Medium: **[Water][Glycol solution]**.
 - 2. Mount stainless-steel drain pan **[complying with ASHRAE 62.1][and][having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir]** under coil assembly.
- H. Hot-Water Reheat: Copper-tube, aluminum-fin coil with two-way, modulating control valve, and cleanable Y-strainer.
- I. Remote Air-Cooled, Glycol-Solution Cooler:
 - 1. Corrosion-resistant cabinet.
 - 2. Copper-tube, aluminum-fin coil.
 - 3. Head-pressure-actuated, three-way, water-regulating valve.
 - 4. Motorized ball valve.
 - 5. Direct-drive propeller fan with fan guards.
 - 6. Single-phase motors with internal overload protection.
 - 7. Disconnect Switch: Non-automatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.
- J. Glycol-Solution Pump Package:
 - 1. Weatherproof and vented enclosure of enameled, galvanized steel on structural base frame containing **[one][two]** centrifugal pump(s) with mechanical seal(s) **[and lead/lag control]**.
 - 2. Piping: Interconnecting piping, from suction to discharge, with shutoff valves, flow switches, unions, and pressurized expansion tank with air purge vent and system-charging connection.
 - 3. Glycol: Inhibited ethylene glycol and water solution mixed 50:50, suitable for operating temperature of **minus 40 deg F (minus 40 deg C)**.
 - 4. Disconnect Switch: Non-automatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.
- K. Electric-Resistance Reheat Coil:
 - 1. Finned-tube electric elements with contactor and high-temperature-limit switches.
 - 2. SCR to proportionally control the reheat elements providing precise temperature control.
- L. Pre-Filter: **[2-inch- (50-mm-)][4-inch- (100-mm-)]** thick, disposable, pleated, glass-fiber media.
- M. Filter: **[2-inch- (50-mm-)][4-inch- (100-mm-)]** thick, disposable, pleated, glass-fiber media.
 - 1. Initial Resistance: **<Insert number> inches wg (Pa)**.
 - 2. Recommended Final Resistance: **<Insert number> inches wg (Pa)**.
 - 3. Pre-Filter Minimum Efficiency Reporting Value and Average Arrestance:
 - a. MERV Rating: **[MERV 1][MERV 2][MERV 3][MERV 4]<Insert value>** and corresponding average arrestance according to ASHRAE 52.2.



4. Pre-Filter Minimum Efficiency Reporting Value:
 - a. **[MERV 6]**<Insert value> according to ASHRAE 52.2.
5. Filter Minimum Efficiency Reporting Value:
 - a. MERV Rating: **[MERV 6]****[MERV 13]**<Insert value> according to ASHRAE 52.2.
- N. Infrared Humidifier: High-intensity quartz lamps mounted above stainless-steel evaporator pan, serviceable without disconnecting water, drain, or electrical connections; prepiped and located in bypass airstream; with flush-cycle timer and solenoid drain valve.
- O. Electrode Steam Humidifier: Self-contained, microprocessor-controlled unit with disposable, polypropylene-plastic cylinders and having field-adjustable steel electrodes and stainless-steel steam dispersion tube.
 1. Plumbing Components and Valve Bodies: Plastic, linked by flexible rubber hosing, with water fill with air gap and solenoid valve incorporating built-in strainer, pressure-reducing and flow-regulating orifice, and drain with integral air gap.
 2. Control: Fully modulating to provide gradual modulation from zero to 100 percent capacity with field-adjustable maximum capacity; with high-water probe.
 3. Drain Cycle: Field-adjustable drain duration and drain interval.
- P. Ultrasonic Steam Humidifier: Self-contained, microprocessor-controlled unit with nebulizing modules, piezoelectric transducer, printed circuit control board, and fitted nebula distribution device cover.
 1. Plumbing Components and Valve Bodies: Plastic, linked by flexible rubber hosing, with water fill with air gap and solenoid valve incorporating built-in strainer, high and low water floats, heat sink dissipater, and drain with integral air gap.
 2. Control: **[On/off]****[Proportional to provide gradual modulation from zero to 100 percent capacity with field-adjustable maximum capacity]**.
 3. Drain Cycle: Field-adjustable drain duration and drain interval. If the humidifier is idle for 72 hours an automatic drain cycle shall occur.
 4. Boost fan.
 5. Vertical mounting rack.
- Q. Disconnect Switch:
 1. **[Locking]****[Non-locking]** disconnect with handle accessible with the door closed.
 2. Non-locking, non-automatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.
- R. Control System:
 1. Microprocessor **[unit]****[remote]**-mounted panel.
 2. Fan contactor.
 3. Compressor contactor.
 4. Compressor start capacitor.
 5. Control transformer with circuit breaker.
 6. Solid-state temperature-**[and humidity-]**control modules.
 7. Humidity contactor.
 8. Time-delay relay.
 9. Heating contactor.
 10. Smoke sensor.

11. High-temperature thermostat.
12. Solid-state, wall-mounted control panel with start-stop switch[, **adjustable humidity set point**][**remote temperature sensors**][**remote humidity sensors**] and adjustable temperature set point.
13. Remote panel to monitor and change temperature and humidity set points and sensitivities of the unit and unit alarms.

S. Fan Motors:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load does not require motor to operate in service factor range above 1.0.
3. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
4. **<Insert unique motor characteristics>**.

2.3 CAPACITIES AND CHARACTERISTICS

A. Unit Configuration: [Draw][Blow] through.

B. Supply-Air Fan:

1. Number of Fans: **[One][Two]<Insert number>**.
2. Airflow: **<Insert cfm (L/s)>**.
3. Minimum Static Pressure: **<Insert inches wg (kPa)>**.
4. Motor Size: **<Insert number> hp**.

C. Refrigeration System:

1. Unit Energy Efficiency: **[COP][EER]**.
2. Refrigerant Compressor:
 - a. Total Unit Cooling Capacity: **<Insert Btu/h (kW)>**.
 - b. Sensible Unit Cooling Capacity: **<Insert Btu/h (kW)>**.
 - c. Number of Compressors: **[One][Two]<Insert number>**.
 - d. Motor Size: **<Insert number> hp**.
3. Refrigerant Evaporator Coil:
 - a. Cooling Capacity: **<Insert Btu/h (kW)>**.
 - b. Entering-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
 - c. Entering-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
 - d. Leaving-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
 - e. Leaving-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
4. Water-Cooled Refrigerant Condenser:
 - a. Cooling Capacity: **<Insert Btu/h (kW)>**.
 - b. Condenser-Water Flow: **<Insert gpm (L/s)>**.
 - c. Cooling Medium: **[Water][Glycol solution]**.
 - d. Entering-Water Temperature: **<Insert deg F (deg C)>**.
 - e. Fluid Pressure Drop: **<Insert feet of head (kPa)>**.

5. Air-Cooled Refrigerant Condenser:

- a. Cooling Capacity: **<Insert Btu/h (kW)>**.
- b. Entering-Air Temperature: **<Insert deg F (deg C)>**.
- c. Number of Condenser Fan Motors: **<Insert number>**.
- d. Condenser Fan Motors: **<Insert number>** hp.

D. Hydronic Cooling Coil:

1. Cooling Coil Capacity: **<Insert Btu/h (kW)>**.
2. Entering-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
3. Entering-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
4. Leaving-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
5. Leaving-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
6. Fluid Flow: **<Insert gpm (L/s)>**.
7. Entering-Fluid Temperature: **<Insert deg F (deg C)>**.
8. Fluid Pressure Drop: **<Insert feet of head (kPa)>**.
9. Cooling Medium: **[Water][Glycol solution]**.

E. Remote, Air-Cooled, Glycol-Solution Cooler:

1. Cooling Coil Capacity: **<Insert Btu/h (kW)>**.
2. Entering-Air Temperature: **<Insert deg F (deg C)>**.
3. Leaving-Air Temperature: **<Insert deg F (deg C)>**.
4. Glycol Flow: **<Insert gpm (L/s)>**.
5. Entering-Glycol Temperature: **<Insert deg F (deg C)>**.
6. Number of Fans: **<Insert number>**.
7. Fan Motors: **<Insert number>** hp.
8. Number of Pumps: **<Insert number>**.
9. Pump Motors: **<Insert number>** hp.

F. Hydronic Reheating Coil:

1. Total: **<Insert Btu/h (kW)>**.
2. Entering-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
3. Leaving-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
4. Water Flow: **<Insert gpm (L/s)>**.
5. Entering-Water Temperature: **<Insert deg F (deg C)>**.
6. Leaving-Water Temperature: **<Insert deg F (deg C)>**.
7. Fluid Pressure Drop: **<Insert feet of head (kPa)>**.

G. Electric-Resistance Reheating Coil:

1. Total Capacity: **<Insert kilowatts>**.
2. Stages of Heating: **[1][2]<Insert number>**.

H. Humidifier:

1. Total: **<Insert lb/h (kg/h)>**.
2. Input: **<Insert Btu/h (kW)>**.

I. Electrical Characteristics:

1. Volts: [120][208][240][277][480]<Insert value>.
2. Phase: [Single][Three].
3. Hertz: 60.
4. Full-Load Amperes: <Insert value>.
5. Minimum Circuit Ampacity: <Insert value>.
6. Maximum Overcurrent Protection: <Insert amperage>.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for hydronic piping systems to verify actual locations of piping connections before equipment installation.
- C. Examine walls, floors, and roofs for suitable conditions where computer-room air conditioners will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Layout and install computer-room air conditioners and suspension system coordinated with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.
- B. Install computer-room air conditioners coordinated with computer-room access flooring Installer.
- C. Install computer-room air conditioners level and plumb, maintaining manufacturer's recommended clearances. **[Install according to AHRI Guideline B.]**
- D. Computer-Room Air-Conditioner Mounting: Install using **[elastomeric pads][elastomeric mounts][restrained spring isolators]<Insert device>**. Comply with requirements for vibration isolation devices specified in **[Section 230548 "Vibration and Seismic Controls for HVAC."][Section 230548.13 "Vibration Controls for HVAC."]**
 1. Minimum Deflection: **[1/4 inch (6 mm)][1 inch (25 mm)]<Insert dimension>**.
- E. Suspended Computer-Room Air Conditioners: Install using continuous-thread hanger rods and **[elastomeric hangers][spring hangers][spring hangers with vertical-limit stop]** of size required to support weight of computer-room air conditioner.
 1. Comply with requirements for vibration isolation devices specified in **[Section 230548 "Vibration and Seismic Controls for HVAC."][Section 230548.13 "Vibration Controls for HVAC."]** Fabricate brackets or supports as required.
 2. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- F. Air-Cooled Refrigerant Condenser Mounting: Install using **[elastomeric pads][elastomeric**



mounts][restrained spring isolators]<Insert device> on concrete base. Comply with requirements for vibration isolation devices specified in **[Section 230548 "Vibration and Seismic Controls for HVAC."][Section 230548.13 "Vibration Controls for HVAC."]**

1. Minimum Deflection: **[1/4 inch (6 mm)][1 inch (25 mm)]<Insert dimension>**.

- G. Remote, Air-Cooled, Glycol-Solution Cooler Mounting: Install using **[elastomeric pads][elastomeric mounts][restrained spring isolators]<Insert device>** on concrete base. Comply with requirements for vibration isolation devices specified in **[Section 230548 "Vibration and Seismic Controls for HVAC."][Section 230548.13 "Vibration Controls for HVAC."]**

1. Minimum Deflection: **[1/4 inch (6 mm)][1 inch (25 mm)]<Insert dimension>**.

- H. Glycol-Solution Pump Package Mounting: Install using **[elastomeric pads][elastomeric mounts]<Insert device>**. Comply with requirements for vibration isolation devices specified in **[Section 230548 "Vibration and Seismic Controls for HVAC."][Section 230548.13 "Vibration Controls for HVAC."]**

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other heating, ventilating, and air-conditioning Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to computer-room air conditioners, allow space for service and maintenance.
- C. Water and Drainage Connections: Comply with applicable requirements in Section 221116 "Domestic Water Piping." Provide adequate connections for water-cooled units, condensate drain, and humidifier flushing system.
- D. Hot-Water Heating Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Provide shutoff valves in inlet and outlet piping to heating coils.
- E. Condenser-Water Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Provide shutoff valves in water inlet and outlet piping on water-cooled units.
- F. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Provide shutoff valves and piping.

3.4 FIELD QUALITY CONTROL

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

1. Inspect for and remove shipping bolts, blocks, and tie-down straps.
2. After installing computer-room air conditioners and after electrical circuitry has been energized, test for compliance with requirements.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Computer-room air conditioners will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

F. After startup service and performance test, change filters and flush humidifier.

3.5 ADJUSTING

A. Adjust initial temperature[**and humidity**] set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Occupancy Adjustments: When requested within [12]<Insert number> months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to [two]<Insert number> visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

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

END OF SECTION 23 81 23 00



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SECTION 23 81 23 00A - COMPUTER-ROOM AIR-CONDITIONERS, CONSOLE UNITS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Computer-room air-conditioners, console units.

1.2 DEFINITIONS

- A. COP: Coefficient of performance.
- B. EER: Energy efficiency ratio.
- C. SCR: Silicon controlled rectifier.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include material descriptions, dimensions of individual components and profiles, and finishes for computer-room air-conditioning units.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Sustainable Design Submittals:
 - 1. Product Data: For energy performance.
 - 2. Refrigerant: Product Data for refrigerants, indicating compliance with refrigerant management practices.
 - 3. Product Data: For refrigerants, indicating compliance with refrigerant management practices.
 - 4. Product data showing compliance with ASHRAE 62.1.
- C. Shop Drawings: For computer-room air conditioners.
 - 1. Include plans, elevations, sections, and attachment details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.
- D. Color Samples: For unit cabinet, discharge grille, and exterior louver and for each color and texture specified.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans, elevations, and other details, drawn to scale, using input from installers



of the items involved.

- B. Seismic Qualification Certificates: For computer-room air conditioners, accessories, and components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Field quality-control reports.
- D. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For computer-room air conditioners to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fan Belts: **[One]<Insert number>** set(s) for each belt-driven fan.
 - 2. Filters: **[One]<Insert number>** set(s) of filters for each unit.

1.7 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of computer-room air conditioners that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Compressors: Manufacturer's standard, but not less than **[five][10]<Insert number>** years from date of Substantial Completion.
 - 2. Warranty Period for Humidifiers: Manufacturer's standard, but not less than **[three]<Insert number>** years from date of Substantial Completion.
 - 3. Warranty Period for Control Boards: Manufacturer's standard, but not less than **[three]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Computer-room air-conditioners, console units shall withstand the effects of earthquake motions determined according to **[ASCE/SEI 7]<Insert requirement>**.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts when

subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."

- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. ASHRAE Compliance:
 - 1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
 - 2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Ventilation Rate Procedures," and Section 7 - "Construction and Startup."
- D. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.
- E. ASME Compliance: Fabricate and label water-cooled condenser shell to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

2.2 COMPUTER-ROOM AIR-CONDITIONERS, CONSOLE UNITS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Compu-Aire, Inc]**
 - 2. **[Data Aire Inc]**
 - 3. **[Liebert; Vertiv Holdings Co.]**
 - 4. **[Stulz-ATS]**
 - 5. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Compu-Aire, Inc]**
 - 2. **[Data Aire Inc]**
 - 3. **[Liebert; Vertiv Holdings Co.]**
 - 4. **[Stulz-ATS]**
 - 5. **<Insert manufacturer's name>**
- C. Description: Split system consisting of evaporator section for floor or wall mounting and remote condensing section.
- D. Evaporator Cabinet: Furniture-grade steel with baked-enamel finish; with front access and containing direct-drive centrifugal fans and two-speed motor.
 - 1. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- E. Condenser Cabinet: Steel with baked-enamel finish and containing compressor and condenser.
- F. Refrigeration System:
 - 1. Compressor: Scroll, with oil strainer, internal motor overload protection, resilient suspension

2. system, and crankcase heater.
Refrigeration Circuit:
 - a. Filter/dryer.
 - b. Manual-reset high-pressure switch.
 - c. Thermal-expansion valve with external equalizer.
 - d. Sight glass with moisture indicator.
 - e. Service shutoff valves.
 - f. Charging valves.
 - g. Hot-gas bypass.
 - h. Refrigerant charge.
3. Refrigerant: **[R-407C][or][R-410A]<Insert type>**.
4. Refrigerant Evaporator Coil: Direct-expansion coil of seamless copper tubes expanded into aluminum fins.
5. Refrigerant line sets precharged in lengths of **[15 feet (4.5 m)][30 feet (9.0 m)]**.
6. Refrigerant line sweat adapter kit to permit field brazing of refrigerant lines.
 - a. Mount stainless-steel drain pan **[complying with ASHRAE 62.1][and][having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir]** under coil assembly.
7. Integral, Water-Cooled Refrigerant Condenser: **[Coaxial, counter-flow, tube-in-tube][Brazed-plate]** type with liquid-line stop valve and head-pressure-actuated, water-regulating valve.
8. Remote, Air-Cooled Refrigerant Condenser: Integral, copper-tube aluminum-fin coil with direct-drive, **[propeller][centrifugal]** fan.
9. Split system shall have suction- and liquid-line compatible fittings and refrigerant piping for field interconnection.
- G. Hydronic Cooling Coil: Seamless copper tubes expanded into aluminum fins with modulating control valve.
 1. Cooling Medium: **[Water][Glycol solution]**.
 2. Mount stainless-steel drain pan **[complying with ASHRAE 62.1][and][having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir]** under coil assembly.
- H. Remote, Air-Cooled, Glycol-Solution Cooler:
 1. Corrosion-resistant cabinet.
 2. Copper-tube aluminum-fin coil.
 3. Direct-drive propeller fan with fan guards.
 4. Single-phase motor with internal overload protection.
 5. Disconnect Switch: Non-automatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.
- I. Glycol-Solution Pump Package:
 1. Weatherproof and vented enclosure of enameled, galvanized steel on structural base frame containing **[one][two]** centrifugal pump(s) with mechanical seal(s) **[and lead/lag control]**.
 2. Piping: Interconnecting piping, to and from remote, air-cooled, glycol-solution cooler, with shutoff valves, flow switches, unions, and pressurized expansion tank with air purge vent and system-charging connection.
 3. Glycol: Inhibited ethylene glycol and water solution mixed 50:50, suitable for operating temperature of **minus 40 deg F (minus 40 deg C)**.

4. Disconnect Switch: Non-automatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.
- J. Electric-Resistance Reheat Coil:
1. Finned-tube electric elements with contactor and high-temperature-limit switches.
 2. SCR to proportionally control the reheat elements providing precise temperature control.
- K. Filter, Cleanable: Polypropylene monofilament over expanded aluminum with aluminum frame.
- L. Filter, Disposable: **1-inch- (25-mm-)** thick, disposable, glass-fiber media.
1. Initial Resistance: **<Insert number> inches wg (Pa).**
 2. Recommended Final Resistance: **<Insert number> inches wg (Pa).**
 3. Pre-Filter Minimum Efficiency Reporting Value and Average Arrestance:
 - a. MERV Rating: **[MERV 1][MERV 2][MERV 3][MERV 4]<Insert value>** and corresponding average arrestance according to ASHRAE 52.2.
 4. Pre-Filter Minimum Efficiency Reporting Value:
 - a. **[MERV 6]<Insert value>** according to ASHRAE 52.2.
 5. Filter Minimum Efficiency Reporting Value:
 - a. MERV Rating: **[MERV 6][MERV 13]<Insert value>** according to ASHRAE 52.2.
- M. Electrode Steam Humidifier: Self-contained, microprocessor-controlled unit with disposable, polypropylene-plastic cylinders and having field-adjustable steel electrodes and stainless-steel steam dispersion tube.
1. Plumbing Components and Valve Bodies: Plastic, linked by flexible rubber hosing, with water fill with air gap and solenoid valve incorporating built-in strainer, pressure-reducing and flow-regulating orifice, and drain with integral air gap.
 2. Control: Fully modulating to provide gradual modulation from zero to 100 percent capacity with field-adjustable maximum capacity; with high-water probe.
 3. Drain Cycle: Field-adjustable drain duration and drain interval.
- N. Disconnect Switch: Non-automatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.
- O. Epoxy-coated, step-down transformer suitable for mounting on the outdoor condensing unit to provide it with 277-V ac input power.
- P. Control System:
1. Microprocessor, wall-mounted panel interfacing with the unit controls.
 2. Contactors.
 3. Control transformer with circuit breaker.
 4. Solid-state, temperature-[**and humidity**]-control modules.
 5. Solid-state, unit-mounted control panel with start-stop switch[, **adjustable humidity set point,**] and adjustable temperature set point.
 6. Remote panel to monitor and change temperature and humidity set points and sensitivities of the unit and unit alarms.

Q. Fan Motors:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load does not require motor to operate in service factor range above 1.0.
3. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
4. **<Insert unique motor characteristics>.**

2.3 CAPACITIES AND CHARACTERISTICS

A. Unit Configuration: **[Draw][Blow]** through.

B. Supply-Air Fan:

1. Airflow: **<Insert cfm (L/s)>.**
2. Minimum Static Pressure: **<Insert inches wg (kPa)>.**
3. Motor Size: **<Insert number> hp.**

C. Refrigeration System:

1. Unit Energy Efficiency: **[COP][EER].**
2. Refrigerant Compressor:
 - a. Total Unit Cooling Capacity: **<Insert Btu/h (kW)>.**
 - b. Sensible Unit Cooling Capacity: **<Insert Btu/h (kW)>.**
 - c. Number of Compressors: **[One][Two]<Insert number>.**
 - d. Motor Size: **<Insert number> hp.**
3. Refrigerant Evaporator Coil:
 - a. Cooling Capacity: **<Insert Btu/h (kW)>.**
 - b. Entering-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>.**
 - c. Entering-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>.**
 - d. Leaving-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>.**
 - e. Leaving-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>.**
4. Water-Cooled Refrigerant Condenser:
 - a. Cooling Capacity: **<Insert Btu/h (kW)>.**
 - b. Condenser Water Flow: **<Insert gpm (L/s)>.**
 - c. Cooling Medium: **[Water][Glycol solution].**
 - d. Entering-Water Temperature: **<Insert deg F (deg C)>.**
 - e. Fluid Pressure Drop: **<Insert feet of head (kPa)>.**
5. Air-Cooled Refrigerant Condenser:
 - a. Cooling Capacity: **<Insert Btu/h (kW)>.**
 - b. Entering-Air Temperature: **<Insert deg F (deg C)>.**
 - c. Number of Condenser Fan Motors: **<Insert number>.**
 - d. Condenser Fan Motors: **<Insert number> hp.**

D. Hydronic Cooling Coil:

1. Cooling Coil Capacity: **<Insert Btu/h (kW)>**.
2. Entering-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
3. Entering-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
4. Leaving-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
5. Leaving-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
6. Fluid Flow: **<Insert gpm (L/s)>**.
7. Entering-Fluid Temperature: **<Insert deg F (deg C)>**.
8. Fluid Pressure Drop: **<Insert feet of head (kPa)>**.
9. Cooling Medium: **[Water][Glycol solution]**.

E. Remote, Air-Cooled, Glycol-Solution Cooler:

1. Cooling Coil Capacity: **<Insert Btu/h (kW)>**.
2. Entering-Air Temperature: **<Insert deg F (deg C)>**.
3. Leaving-Air Temperature: **<Insert deg F (deg C)>**.
4. Glycol Flow: **<Insert gpm (L/s)>**.
5. Entering-Glycol Temperature: **<Insert deg F (deg C)>**.
6. Number of Fans: **<Insert number>**.
7. Fan Motors: **<Insert number>** hp.
8. Number of Pumps: **<Insert number>**.
9. Pump Motors: **<Insert number>** hp.

F. Electric-Resistance Reheating Coil:

1. Total Capacity: **<Insert kilowatts>**.
2. Stages of Heating: **[1][2]<Insert number>**.

G. Humidifier:

1. Total: **<Insert lb/h (kg/h)>**.
2. Input: **<Insert Btu/h (kW)>**.

H. Electrical Characteristics:

1. Volts: **[120][208][240][277][480]<Insert value>**.
2. Phase: **[Single][Three]**.
3. Hertz: 60.
4. Full-Load Amperes: **<Insert value>**.
5. Minimum Circuit Ampacity: **<Insert value>**.
6. Maximum Overcurrent Protection: **<Insert amperage>**.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for hydronic piping systems to verify actual locations of piping connections before equipment installation.
- C. Examine walls, floors, and roofs for suitable conditions where computer-room air conditioners will be

installed.

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

3.2 INSTALLATION OF COMPUTER-ROOM AIR-CONDITIONERS, CONSOLE UNITS

- A. Layout and install computer-room air conditioners and suspension system coordinated with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.
- B. Install computer-room air conditioners coordinated with computer-room access flooring Installer.
- C. Install computer-room air conditioners level and plumb, maintaining manufacturer's recommended clearances. **[Install according to AHRI Guideline B.]**
- D. Computer-Room Air-Conditioner Mounting: Install using **[elastomeric pads][elastomeric mounts][restrained spring isolators]<Insert device>**. Comply with requirements for vibration isolation devices specified in **[Section 230548 "Vibration and Seismic Controls for HVAC."][Section 230548.13 "Vibration Controls for HVAC."]**
 - 1. Minimum Deflection: **[1/4 inch (6 mm)][1 inch (25 mm)]<Insert dimension>**.
- E. Air-Cooled Refrigerant Condenser Mounting: Install using **[elastomeric pads][elastomeric mounts][restrained spring isolators]<Insert device>** on concrete base. Comply with requirements for vibration isolation devices specified in **[Section 230548 "Vibration and Seismic Controls for HVAC."][Section 230548.13 "Vibration Controls for HVAC."]**
 - 1. Minimum Deflection: **[1/4 inch (6 mm)][1 inch (25 mm)]<Insert dimension>**.
- F. Remote, Air-Cooled, Glycol-Solution Cooler Mounting: Install using **[elastomeric pads][elastomeric mounts][restrained spring isolators]<Insert device>** on concrete base. Comply with requirements for vibration isolation devices specified in **[Section 230548 "Vibration and Seismic Controls for HVAC."][Section 230548.13 "Vibration Controls for HVAC."]**
 - 1. Minimum Deflection: **[1/4 inch (6 mm)][1 inch (25 mm)]<Insert dimension>**.
- G. Glycol-Solution Pump Package Mounting: Install using **[elastomeric pads][elastomeric mounts]<Insert device>**. Comply with requirements for vibration isolation devices specified in **[Section 230548 "Vibration and Seismic Controls for HVAC."][Section 230548.13 "Vibration Controls for HVAC."]**

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other heating, ventilating, and air-conditioning Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to computer-room air conditioners, allow space for service and maintenance.
- C. Water and Drainage Connections: Comply with applicable requirements in Section 221116 "Domestic Water Piping." Provide adequate connections for water-cooled units, condensate drain, and humidifier flushing system.

- D. Condenser-Water Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Provide shutoff valves in water inlet and outlet piping on water/glycol-cooled units.
- E. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Provide shutoff valves and piping.

3.4 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
 - 1. Inspect for and remove shipping bolts, blocks, and tie-down straps.
 - 2. After installing computer-room air conditioners and after electrical circuitry has been energized, test for compliance with requirements.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Computer-room air conditioners will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.
- F. After startup service and performance test, change filters and flush humidifier.

3.5 ADJUSTING

- A. Adjust initial temperature[**and humidity**] set points.
- B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- C. Occupancy Adjustments: When requested within [12]<Insert number> months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to [two]<Insert number> visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

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

END OF SECTION 23 81 23 00A



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SECTION 23 81 23 00B - COMPUTER-ROOM, RACK-COOLING EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Computer-room, rack-cooling equipment.
2. Central refrigeration unit.
3. Horizontally mounted rack-cooling module.
4. Overhead-mounted rack-cooling module.
5. Rear-mounted rack-cooling module.
6. Top-mounted rack-cooling module.
7. Fan module.
8. Refrigerant.
9. Motors.

1.2 DEFINITIONS

- A. COP: Coefficient of performance.
- B. EER: Energy efficiency ratio.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include material descriptions, dimensions of individual components and profiles, and finishes for computer-room, rack-cooling equipment.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Sustainable Design Submittals:

1. Product Data: For ventilation equipment, indicating compliance with ASHRAE 62.1, Section 5 - "Systems and Equipment."
2. Ventilation: Product Data for ventilation equipment, indicating compliance with ASHRAE 62.1, Section 5 - "Systems and Equipment."
3. Refrigerant: Product Data for refrigerants, indicating compliance with refrigerant management practices.
4. Product Data: For refrigerants, indicating compliance with refrigerant management practices.

C. Shop Drawings: For central refrigeration units and rack-cooling units.

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.



- D. Color Samples: For unit cabinets and discharge grille and for each color and texture specified.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans, elevations, and other details, drawn to scale, using input from installers of the items involved.
- B. Seismic Qualification Certificates: For computer-room rack-cooling equipment, accessories, and components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Field quality-control reports.
- D. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For computer-room, rack-cooling equipment to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fan: **[One]<Insert number>**.
 - 2. Pump: **[One]<Insert number>**.

1.7 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of computer-room, rack-cooling equipment that fails in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Compressors: Manufacturer's standard, but not less than **[five][10]<Insert number>** years from date of Substantial Completion.
 - 2. Warranty Period for Control Boards: Manufacturer's standard, but not less than **[three]<Insert number>** years from date of Substantial Completion.



PART 2 - PRODUCTS

2.1 COMPUTER-ROOM, RACK-COOLING EQUIPMENT

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

1. **[APC by Schneider Electric]**
2. **[Liebert; Vertiv Holdings Co.]**
3. **<Insert manufacturer's name>**

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

1. **[APC by Schneider Electric]**
2. **[Liebert; Vertiv Holdings Co.]**
3. **<Insert manufacturer's name>**

2.2 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Computer-room, rack-cooling equipment shall withstand the effects of earthquake motions determined according to **[ASCE/SEI 7]<Insert requirement>**.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified **[and the unit will be fully operational after the seismic event].**"

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

- C. ASHRAE Compliance:

1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Ventilation Rate Procedures," and Section 7 - "Construction and Startup."

- D. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

- E. ASME Compliance: Fabricate and label water-cooled condenser shell to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

2.3 CENTRAL REFRIGERATION UNIT

- A. Description: Packaged, factory assembled, wired, and piped; consisting of cabinet, refrigeration system, heat exchanger, and controls.

- B. Cabinet and Frame: Powder-painted cabinet, hinged doors, and welded tubular steel frame.

- C. Pumps: **[One][Two]**, factory piped and wired.

- D. Heat Exchanger: Brazed plate, Type 316 stainless-steel plates.
- E. Chilled-Water Valve: Modulating, two-way valve, responding to room dew point temperature changes to optimize the supply water temperature to avoid condensation.
- F. Compressor: Scroll type with a suction gas-cooled motor, vibration isolators, thermal overloads, manual reset high-pressure switch, and pump down low-pressure switch.
- G. Control System:
 - 1. Unit-mounted microprocessor panel interfacing with the unit controls consisting of contactors, control transformer with circuit breaker, solid-state temperature-[**and humidity**]-control modules and start-stop switch, [**adjustable humidity set point**], and adjustable temperature set point.
 - 2. Remote panel to monitor and change temperature and humidity set points and sensitivities of the unit and unit alarms.
- H. Capacities and Characteristics:
 - 1. Refrigeration System:
 - a. Unit Energy Efficiency: [**COP**][**EER**].
 - b. Refrigerant Compressor:
 - 1) Total Unit Cooling Capacity: <Insert Btu/h (kW)>.
 - c. Sensible Unit Cooling Capacity: <Insert Btu/h (kW)>.
 - d. Number of Compressors: [**One**][**Two**]<Insert number>.
 - e. Motor Size: <Insert number> hp.
 - f. Refrigerant Heat Exchanger:
 - 1) Cooling Capacity: <Insert Btu/h (kW)>.
 - 2) Entering-Primary Refrigerant Temperature: <Insert deg F (deg C)>.
 - 3) Leaving-Primary Refrigerant Temperature: <Insert deg F (deg C)>.
 - 4) Entering-Secondary Refrigerant Temperature: <Insert deg F (deg C)>.
 - 5) Leaving-Secondary Refrigerant Temperature: <Insert deg F (deg C)>.
 - g. Water-Cooled Heat Exchanger:
 - 1) Cooling Capacity: <Insert Btu/h (kW)>.
 - 2) Primary Water Flow: <Insert gpm (L/s)>.
 - 3) Cooling Medium: [**Water**][**Glycol solution**].
 - 4) Entering-Water Temperature: <Insert deg F (deg C)>.
 - 5) Leaving-Water Temperature: <Insert deg F (deg C)>.
 - 6) Fluid Pressure Drop: <Insert feet of head (kPa)>.
 - 2. Electrical Characteristics:
 - a. Volts: [**120**][**208**][**240**][**277**][**480**]<Insert value>.
 - b. Phase: [**Single**][**Three**].
 - c. Hertz: 60.
 - d. Full-Load Amperes: <Insert value>.
 - e. Minimum Circuit Ampacity: <Insert value>.
 - f. Maximum Overcurrent Protection: <Insert amperage>.

2.4 HORIZONTALLY MOUNTED RACK-COOLING MODULE

- A. Description: Packaged, factory assembled, prewired, and prepiped; consisting of cabinet cooling coil and controls.
- B. Cabinet and Frame: Powder-painted cabinet, hinged doors, and welded tubular steel frame.
- C. Cooling Coil: Aluminum microchannel with drip pan.
- D. Electrical Components:
 - 1. Each module shall be equipped with two sets of two **10-foot (3-m)** power cords with automatic switching, primary and secondary, attached with IEC connectors to the rear of the unit.
 - 2. Each cord shall have a NEMA 5-15P (IEC 320-C14) plug at the end.
 - 3. CE-listed version of the unit shall have permanently attached power cords.
- E. Refrigerant Piping: ACR copper tubing with brazed joints. Factory-installed piping shall be leak tested and pressure tested prior to shipment from the factory. Factory-supplied pipe connections for field piping.
- F. Discharge Diffusers: Mounted on the unit front, discharging to one or both sides.
- G. Control System:
 - 1. Factory-installed control boards and condensate detection for the drip pan.
 - 2. Module with connection points (dry contacts) in the electrical box for connection of outgoing alarm cables for condensate detection, fan failure, and remote shutdown.
- H. Capacities and Characteristics:
 - 1. Supply-Air Fan:
 - a. Number of Fans: **[Six]<Insert number>** axial fans with finger guards.
 - b. Airflow: **<Insert cfm (L/s)>**.
 - c. Minimum Static Pressure: **<Insert inches wg (kPa)>**.
 - d. Refrigerant Heat Exchanger:
 - 1) Cooling Capacity: **<Insert Btu/h (kW)>**.
 - 2) Entering-Primary Refrigerant Temperature: **<Insert deg F (deg C)>**.
 - 3) Entering-Secondary Refrigerant Temperature: **<Insert deg F (deg C)>**.
 - 4) Leaving-Primary Refrigerant Temperature: **<Insert deg F (deg C)>**.
 - 5) Leaving-Secondary Refrigerant Temperature: **<Insert deg F (deg C)>**.
 - 2. Electrical Characteristics:
 - a. Motor Size: **<Insert number>** hp.
 - b. Volts: **[120][208][240][277][480]<Insert value>**.
 - c. Phase: **[Single][Three]**.
 - d. Hertz: 60.
 - e. Full-Load Amperes: **<Insert value>**.
 - f. Minimum Circuit Ampacity: **<Insert value>**.
 - g. Maximum Overcurrent Protection: **<Insert amperage>**.

2.5 OVERHEAD-MOUNTED RACK-COOLING MODULE

- A. Description: Packaged, factory assembled, prewired, and prepiped; consisting of cabinet cooling coil and controls.
- B. Cabinet and Frame: Powder-painted cabinet, hinged doors, and welded tubular steel frame.
- C. Cooling Coil: Aluminum microchannel with drip pan.
- D. Electrical Components:
 - 1. 20-A, 120-V ac receptacle.
 - 2. Lighting fixture mounting capable.
- E. Refrigerant Piping: ACR copper tubing with brazed joints. Factory-installed piping shall be leak tested and pressure tested prior to shipment from the factory. Factory-supplied pipe connections for field piping.
- F. Capacities and Characteristics:
 - 1. Supply-Air Fan:
 - a. Number of Fans: **[Six]<Insert number>** axial fans with finger guards.
 - b. Airflow: **<Insert cfm (L/s)>**.
 - c. Minimum Static Pressure: **<Insert inches wg (kPa)>**.
 - d. Refrigerant Heat Exchanger:
 - 1) Cooling Capacity: **<Insert Btu/h (kW)>**.
 - 2) Entering-Primary Refrigerant Temperature: **<Insert deg F (deg C)>**.
 - 3) Entering-Secondary Refrigerant Temperature: **<Insert deg F (deg C)>**.
 - 4) Leaving-Primary Refrigerant Temperature: **<Insert deg F (deg C)>**.
 - 5) Leaving-Secondary Refrigerant Temperature: **<Insert deg F (deg C)>**.
 - 2. Electrical Characteristics:
 - a. Motor Size: **<Insert number>** hp.
 - b. Volts: **[120][208][240][277][480]<Insert value>**.
 - c. Phase: **[Single][Three]**.
 - d. Hertz: 60.
 - e. Full-Load Amperes: **<Insert value>**.
 - f. Minimum Circuit Ampacity: **<Insert value>**.
 - g. Maximum Overcurrent Protection: **<Insert amperage>**.

2.6 REAR-MOUNTED RACK-COOLING MODULE

- A. Description: Packaged, factory assembled, prewired, consisting of cabinet, refrigeration coils and controls.
- B. Cabinet and Frame: Powder-painted cabinet, hinged doors, and welded tubular steel frame with self-locking door latch.
- C. Cooling Coils: Two aluminum microchannels with drip pan.

- D. Dual power cords with 20-A, 120-V ac receptacle.
- E. Refrigerant Piping: ACR copper tubing with brazed joints. Factory-installed piping shall be leak tested and pressure tested prior to shipment from the factory. Factory-supplied pipe connections for field piping.
- F. Rack Mounting Kit: Black painted steel.
- G. Capacities and Characteristics:
 - 1. Supply-Air Fan:
 - a. Number of Fans: **[Six]<Insert number>** axial fans with finger guards.
 - b. Airflow: **<Insert cfm (L/s)>**.
 - c. Minimum Static Pressure: **<Insert inches wg (kPa)>**.
 - d. Refrigerant Heat Exchanger:
 - 1) Cooling Capacity: **<Insert Btu/h (kW)>**.
 - 2) Entering-Primary Refrigerant Temperature: **<Insert deg F (deg C)>**.
 - 3) Entering-Secondary Refrigerant Temperature: **<Insert deg F (deg C)>**.
 - 4) Leaving-Primary Refrigerant Temperature: **<Insert deg F (deg C)>**.
 - 5) Leaving-Secondary Refrigerant Temperature: **<Insert deg F (deg C)>**.
 - 2. Electrical Characteristics:
 - a. Motor Size: **<Insert number>** hp.
 - b. Volts: **[120][208][240][277][480]<Insert value>**.
 - c. Phase: **[Single][Three]**.
 - d. Hertz: 60.
 - e. Full-Load Amperes: **<Insert value>**.
 - f. Minimum Circuit Ampacity: **<Insert value>**.
 - g. Maximum Overcurrent Protection: **<Insert amperage>**.

2.7 TOP-MOUNTED RACK-COOLING MODULE

- A. Description: Packaged, factory assembled, prewired, and prepiped; consisting of cabinet cooling coil and controls.
- B. Cabinet and Frame: Powder-painted cabinet, hinged doors, and welded tubular steel frame.
- C. Cooling Coil: Aluminum microchannel with drip pan.
- D. Electrical Components:
 - 1. Each module shall be equipped with two sets of two **10-foot (3-m)** power cords with automatic switching, primary and secondary, attached with IEC connectors to the rear of the unit.
 - 2. Each cord shall have a NEMA 5-15P (IEC 320-C14) plug at the end.
 - 3. CE-listed version of the unit shall have permanently attached power cords.
- E. Refrigerant Piping: ACR copper tubing with brazed joints. Factory-installed piping shall be leak tested and pressure tested prior to shipment from the factory. Factory-supplied pipe connections for field piping.
- F. Discharge Diffusers: Mounted on the unit front, discharging to one or both sides.

G. Capacities and Characteristics:

1. Supply-Air Fan:

- a. Number of Fans: **[Six]<Insert number>** axial fans with finger guards.
- b. Airflow: **<Insert cfm (L/s)>**.
- c. Minimum Static Pressure: **<Insert inches wg (kPa)>**.
- d. Refrigerant Heat Exchanger:
 - 1) Cooling Capacity: **<Insert Btu/h (kW)>**.
 - 2) Entering-Primary Refrigerant Temperature: **<Insert deg F (deg C)>**.
 - 3) Entering-Secondary Refrigerant Temperature: **<Insert deg F (deg C)>**.
 - 4) Leaving-Primary Refrigerant Temperature: **<Insert deg F (deg C)>**.
 - 5) Leaving-Secondary Refrigerant Temperature: **<Insert deg F (deg C)>**.

2. Electrical Characteristics:

- a. Motor Size: **<Insert number>** hp.
- b. Volts: **[120][208][240][277][480]<Insert value>**.
- c. Phase: **[Single][Three]**.
- d. Hertz: 60.
- e. Full-Load Amperes: **<Insert value>**.
- f. Minimum Circuit Ampacity: **<Insert value>**.
- g. Maximum Overcurrent Protection: **<Insert amperage>**.

2.8 FAN MODULE

- A. Description: Packaged, factory assembled, prewired, consisting of cabinet, fans and controls.
- B. Cabinet and Frame: Powder-painted cabinet, hinged doors, and welded tubular steel frame.
- C. Dual power cords with 20-A, 120-V ac receptacle.
- D. Capacities and Characteristics:

1. Supply-Air Fan:

- a. Number of Fans: **[Six]<Insert number>** axial fans with finger guards.
- b. Airflow: **<Insert cfm (L/s)>**.
- c. Minimum Static Pressure: **<Insert inches wg (kPa)>**.

2. Electrical Characteristics:

- a. Motor Size: **<Insert number>** hp.
- b. Volts: **[120][208][240][277][480]<Insert value>**.
- c. Phase: **[Single][Three]**.
- d. Hertz: 60.
- e. Full-Load Amperes: **<Insert value>**.
- f. Minimum Circuit Ampacity: **<Insert value>**.
- g. Maximum Overcurrent Protection: **<Insert amperage>**.

2.9 REFRIGERANT

- A. Refrigerant Type: **[R-134A]<Insert type>**.

2.10 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load does not require motor to operate in service factor range above 1.0.
 2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
 3. **<Insert unique motor characteristics>**.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for refrigeration piping systems to verify actual locations of piping connections before equipment installation.
- C. Examine walls, floors, and roofs for suitable conditions where units will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF COMPUTER-ROOM, RACK-COOLING EQUIPMENT

- A. Layout and install computer-room rack-cooling equipment and suspension system coordinated with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.
- B. Install computer-room, rack-cooling equipment level and plumb, maintaining manufacturer's recommended clearances. **[Install according to AHRI Guideline B.]**
- C. Suspended Units: Install using continuous-thread hanger rods and **[elastomeric hangers][spring hangers][spring hangers with vertical-limit stop]** of size required to support weight of computer-room, rack-cooling equipment.
1. Comply with requirements for vibration isolation devices specified in **[Section 230548 "Vibration and Seismic Controls for HVAC."][Section 230548.13 "Vibration Controls for HVAC."]** Fabricate brackets or supports as required.
 2. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other heating, ventilating, and air-conditioning Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to computer-room rack-cooling equipment, allow space for service and maintenance.
- C. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Provide shutoff valves and piping.

3.4 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
 - 1. Inspect for and remove shipping bolts, blocks, and tie-down straps.
 - 2. After installing computer-room rack-cooling equipment and after electrical circuitry has been energized, test for compliance with requirements.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Computer-room, rack-cooling equipment will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

3.5 ADJUSTING

- A. Adjust initial temperature[**and humidity**] set points.
- B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- C. Occupancy Adjustments: When requested within **[12]<Insert number>** months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to **[two]<Insert number>** visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain computer-room, rack-cooling equipment.



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

END OF SECTION 23 81 23 00B



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23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 81 23 00	23 81 00 00	Variable-Refrigerant-Flow HVAC Systems



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SECTION 23 81 23 12 - LARGE CAPACITY (7 TONS (25 KW) AND LARGER), COMPUTER-ROOM AIR-CONDITIONERS, FLOOR-MOUNTED UNITS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: Large capacity (7 tons (25 kW) and larger), computer-room air-conditioners, floor-mounted units.

1.2 DEFINITIONS

- A. COP: Coefficient of performance.
- B. EER: Energy efficiency ratio.
- C. SCR: Silicon controlled rectifier.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include material descriptions, dimensions of individual components and profiles, and finishes for computer-room air-conditioning units.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Sustainable Design Submittals:
 - 1. Product Data: For energy performance.
 - 2. Refrigerant: Product Data for refrigerants, indicating compliance with refrigerant management practices.
 - 3. Product Data: For refrigerants, indicating compliance with refrigerant management practices.
 - 4. Product data showing compliance with ASHRAE 62.1.
- C. Shop Drawings: For computer-room air conditioners.
 - 1. Include plans, elevations, sections, and attachment details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.
- D. Color Samples: For unit cabinet, discharge grille, and exterior louver and for each color and texture specified.



1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans, elevations, and other details, drawn to scale, using input from installers of the items involved.
- B. Seismic Qualification Data: Certificates, for computer-room air conditioners, accessories, and components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Field quality-control reports.
- D. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For computer-room air conditioners to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fan Belts: **[One]<Insert number>** set(s) for each belt-driven fan.
 - 2. Filters: **[One]<Insert number>** set(s) of filters for each unit.

1.7 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of computer-room air conditioners that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Compressors: Manufacturer's standard, but not less than **[five][10]<Insert number>** years from date of Substantial Completion.
 - 2. Warranty Period for Humidifiers: Manufacturer's standard, but not less than **[three]<Insert number>** years from date of Substantial Completion.
 - 3. Warranty Period for Control Boards: Manufacturer's standard, but not less than **[three]<Insert number>** years from date of Substantial Completion.



PART 2 - PRODUCTS

2.1 LARGE CAPACITY (7 TONS (25 KW) AND LARGER), COMPUTER-ROOM AIR-CONDITIONERS, FLOOR-MOUNTED UNITS

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

1. **[APC by Schneider Electric]**
2. **[Compu-Aire, Inc]**
3. **[Data Aire Inc]**
4. **[HUNTAIR; A Nortek Air Solutions Company]**
5. **[Liebert; Vertiv Holdings Co.]**
6. **[Stulz-ATS]**
7. **<Insert manufacturer's name>**

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

1. **[APC by Schneider Electric]**
2. **[Compu-Aire, Inc]**
3. **[Data Aire Inc]**
4. **[HUNTAIR; A Nortek Air Solutions Company]**
5. **[Liebert; Vertiv Holdings Co.]**
6. **[Stulz-ATS]**
7. **<Insert manufacturer's name>**

2.2 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Computer-room air conditioners shall withstand the effects of earthquake motions determined according to **[ASCE/SEI 7]<Insert requirement>**.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified **[and the unit will be fully operational after the seismic event].**"

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

- C. ASHRAE Compliance:

1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Ventilation Rate Procedures," and Section 7 - "Construction and Startup."

- D. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

- E. ASME Compliance: Fabricate and label water-cooled condenser shell to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

Large Capacity (7 Tons (25 kW) and Larger), Computer-Room Air-Conditioners, Floor-Mounted Units



2.3 MANUFACTURED UNITS

- A. Description: Self-contained, factory assembled, prewired, and prepiped; consisting of cabinet, fan, filters, and controls; for vertical floor mounting in upflow or downflow configuration.
- B. Cabinet and Frame: Welded tubular-steel frame with removable [single][double]-thick steel panels and insulated with [1-inch- (25-mm-)][1-1/2-inch- (38-mm-)] thick duct liner.
 - 1. Floor Stand: Welded tubular steel, [4 inches (100 mm)][6 inches (150 mm)]<Insert dimension> high, with adjustable legs and vibration isolation pads[with turning vanes mounted within the stand].
 - 2. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
 - 3. Unit with [two][three][four]-way, powder-coated insulated air distribution plenum.
- C. Supply-Air Fan:
 - 1. Forward curved, double width, double inlet, centrifugal, with adjustable V-belt drive.
 - 2. Plenum, single inlet, direct drive, electronically commutated, and variable speed.
- D. Refrigeration System:
 - 1. Compressor: [Semihermetic][Scroll][Digital scroll], [variable capacity]with oil strainer, internal motor overload protection, resilient suspension system, and crankcase heater.
 - 2. Refrigeration Circuit:
 - a. Two independent circuits with hot-gas mufflers.
 - b. Low-pressure switch.
 - c. Manually reset, high-pressure switch.
 - d. Thermal-expansion valve with external equalizer.
 - e. Sight glass with moisture indicator.
 - f. Service shutoff valves.
 - g. Charging valves.
 - h. Hot-gas bypass.
 - i. Refrigerant charge.
 - 3. Refrigerant: [R-407C][or][R-410A]<Insert type>.
 - 4. Refrigerant Evaporator Coil: Direct-expansion coil of seamless copper tubes expanded into aluminum fins, with two circuits, each with solenoid valve.
 - a. Mount stainless-steel drain pan[complying with ASHRAE 62.1][and][having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir] under coil assembly.
 - 5. Integral, Water-Cooled Refrigerant Condenser: Braze-plate type with liquid-line stop valve and head-pressure-actuated, two-way regulating valve.
 - a. Cooling Medium: [Water][Glycol solution].
 - 6. Remote Air-Cooled Refrigerant Condenser:
 - a. Integral, copper-tube aluminum-fin coil.
 - b. Condenser with surge protection device (SPD) and locking disconnect in the enclosed

electrical panel section.

7. Fan:
 - a. Direct-drive, **[single][variable]**-speed propeller type.
 - b. Belt-drive, single-speed propeller type.
 - c. Direct-drive, **[single][variable]**-speed centrifugal type.
 - d. Belt-drive, single-speed centrifugal type.
8. Split system shall have suction- and liquid-line compatible fittings and refrigerant piping for field interconnection.
- E. Hydronic Cooling Coil: Seamless **[copper][copper nickel]** tubes expanded into aluminum fins **[having polymeric coating]**, modulating **[two][three]**-way control valve, and flow switch.
 1. Cooling Medium: **[Water][Glycol solution]**.
 2. Mount stainless-steel drain pan **[complying with ASHRAE 62.1][and][having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir]** under coil assembly.
- F. Hot-Gas Reheat: Copper-tube, aluminum-fin coil with three-way solenoid valve and refrigerant check valve.
- G. Hot-Water Reheat: Copper-tube, aluminum-fin coil with two-way, modulating control valve and cleanable Y-strainer.
- H. Remote Air-Cooled, Glycol-Solution Cooler:
 1. Corrosion-resistant cabinet.
 2. Copper-tube aluminum-fin coil.
 3. Head-pressure-actuated, three-way, water-regulating valve.
 4. Motorized ball valve.
 5. Direct-drive propeller fan with fan guards.
 6. Single-phase motors with internal overload protection.
 7. Disconnect Switch: Non-automatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.
- I. Glycol-Solution Pump Package:
 1. Weatherproof and vented enclosure of enameled, galvanized steel on structural base frame containing **[one][two]** centrifugal pump(s) with mechanical seal(s) **[and lead/lag control]**.
 2. Piping: Interconnecting piping, from suction to discharge, with shutoff valves, flow switches, unions, and pressurized expansion tank with air purge vent and system-charging connection.
 3. Glycol: Inhibited ethylene glycol and water solution mixed 50:50, suitable for operating temperature of **minus 40 deg F (minus 40 deg C)**.
 4. Disconnect Switch: Non-automatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.
- J. Electric-Resistance Reheat Coil:
 1. Finned-tube electric elements with contactor and high-temperature-limit switches.
 2. SCR to proportionally control the reheat elements providing precise temperature control.
- K. Pre-Filter: **[2-inch- (50-mm-)][4-inch- (100-mm-)]** thick, disposable, pleated, glass-fiber media.

- L. Final Filter: [2-inch- (50-mm-)][4-inch- (100-mm-)] thick, disposable, pleated, glass-fiber media.
1. Initial Resistance: <Insert number> inches wg (Pa).
 2. Recommended Final Resistance: <Insert number> inches wg (Pa).
 3. Pre-Filter Minimum Efficiency Reporting Value and Average Arrestance:
 - a. MERV Rating: [MERV 1][MERV 2][MERV 3][MERV 4]<Insert value> and corresponding average arrestance according to ASHRAE 52.2.
 4. Pre-Filter Minimum Efficiency Reporting Value:
 - a. [MERV 6]<Insert value> according to ASHRAE 52.2.
 5. Filter Minimum Efficiency Reporting Value:
 - a. MERV Rating: [MERV 6][MERV 13]<Insert value> according to ASHRAE 52.2.
- M. Electrode Steam Humidifier: Self-contained, microprocessor-controlled unit with disposable, polypropylene-plastic cylinders and having field-adjustable steel electrodes and stainless-steel steam dispersion tube.
1. Plumbing Components and Valve Bodies: Plastic, linked by flexible rubber hosing, with water fill with air gap and solenoid valve incorporating built-in strainer, pressure-reducing and flow-regulating orifice, and drain with integral air gap.
 2. Control: Fully modulating to provide gradual modulation from zero to 100 percent capacity with field-adjustable maximum capacity; with high-water probe.
 3. Drain Cycle: Field-adjustable drain duration and drain interval.
- N. Ultrasonic Steam Humidifier: Self-contained, microprocessor-controlled unit with nebulizing modules, piezoelectric transducer, printed circuit control board and fitted nebula distribution device cover.
1. Plumbing Components and Valve Bodies: Plastic, linked by flexible rubber hosing, with water fill with air gap and solenoid valve incorporating built-in strainer, high and low water floats, heat sink dissipater, and drain with integral air gap.
 2. Control: [On/off][Proportional to provide gradual modulation from zero to 100 percent capacity with field-adjustable maximum capacity].
 3. Drain Cycle: Field-adjustable drain duration and drain interval. If the humidifier is idle for 72 hours, an automatic drain cycle shall occur.
 4. Boost fan.
 5. Vertical mounting rack.
- O. Disconnect Switch:
1. [Locking][Non-locking] disconnect with handle accessible with the door closed.
 2. Non-locking, non-automatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.
- P. Control System:
1. Microprocessor [unit][remote]-mounted panel.
 2. Fan contactor.
 3. Compressor contactor.
 4. Compressor start capacitor.

5. Control transformer with circuit breaker.
6. Solid-state temperature-[**and humidity**]-control modules.
7. Humidity contactor.
8. Time-delay relay.
9. Heating contactor.
10. Smoke sensor.
11. High-temperature thermostat.
12. Solid-state, wall-mounted control panel with start-stop switch[, **adjustable humidity set point**],[**remote temperature sensors**][**remote humidity sensors**] and adjustable temperature set point.
13. Remote panel to monitor and change temperature and humidity set points and sensitivities of the unit and unit alarms.
14. Sequential load activation, periodic hot-water-reheat coil flushing, and self-diagnostics.

Q. Fan Motors:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load does not require motor to operate in service factor range above 1.0.
3. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
4. Type: [**Open dripproof**][**Totally enclosed fan cooled**].

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

2.4 CAPACITIES AND CHARACTERISTICS

A. Unit Configuration: [**Draw**][**Blow**] through.

B. Supply-Air Fan:

1. Number of Fans: [**One**][**Two**]**<Insert number>**.
2. Airflow: **<Insert cfm (L/s)>**.
3. Minimum Static Pressure: **<Insert inches wg (kPa)>**.
4. Motor Size: **<Insert number>** hp.

C. Refrigeration System:

1. Unit Energy Efficiency: [**COP**][**EER**].
2. Refrigerant Compressor:
 - a. Total Unit Cooling Capacity: **<Insert Btu/h (kW)>**.
 - b. Sensible Unit Cooling Capacity: **<Insert Btu/h (kW)>**.
 - c. Number of Compressors: [**One**][**Two**]**<Insert number>**.
 - d. Motor Size: **<Insert number>** hp.
3. Refrigerant Evaporator Coil:
 - a. Cooling Capacity: **<Insert Btu/h (kW)>**.
 - b. Entering-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
 - c. Entering-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
 - d. Leaving-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
 - e. Leaving-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.

Large Capacity (7 Tons (25 kW) and Larger), Computer-Room Air-Conditioners, Floor-Mounted Units

4. Water-Cooled Refrigerant Condenser:
 - a. Cooling Capacity: **<Insert Btu/h (kW)>**.
 - b. Condenser Water Flow: **<Insert gpm (L/s)>**.
 - c. Cooling Medium: **[Water][Glycol solution]**.
 - d. Entering-Water Temperature: **<Insert deg F (deg C)>**.
 - e. Fluid Pressure Drop: **<Insert feet of head (kPa)>**.
5. Air-Cooled Refrigerant Condenser:
 - a. Cooling Capacity: **<Insert Btu/h (kW)>**.
 - b. Entering-Air Temperature: **<Insert deg F (deg C)>**.
 - c. Number of Condenser Fan Motors: **<Insert number>**.
 - d. Condenser Fan Motors: **<Insert number> hp**.

D. Hydronic Cooling Coil:

1. Cooling Coil Capacity: **<Insert Btu/h (kW)>**.
2. Entering-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
3. Entering-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
4. Leaving-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
5. Leaving-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
6. Fluid Flow: **<Insert gpm (L/s)>**.
7. Entering-Fluid Temperature: **<Insert deg F (deg C)>**.
8. Fluid Pressure Drop: **<Insert feet of head (kPa)>**.
9. Cooling Medium: **[Water][Glycol solution]**.

E. Remote, Air-Cooled, Glycol-Solution Cooler:

1. Cooling Coil Capacity: **<Insert Btu/h (kW)>**.
2. Entering-Air Temperature: **<Insert deg F (deg C)>**.
3. Leaving-Air Temperature: **<Insert deg F (deg C)>**.
4. Glycol Flow: **<Insert gpm (L/s)>**.
5. Entering-Glycol Temperature: **<Insert deg F (deg C)>**.
6. Number of Fans: **<Insert number>**.
7. Fan Motors: **<Insert number> hp**.
8. Number of Pumps: **<Insert number>**.
9. Pump Motors: **<Insert number> hp**.

F. Hydronic Reheating Coil:

1. Total: **<Insert Btu/h (kW)>**.
2. Entering-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
3. Leaving-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
4. Water Flow: **<Insert gpm (L/s)>**.
5. Entering-Water Temperature: **<Insert deg F (deg C)>**.
6. Leaving-Water Temperature: **<Insert deg F (deg C)>**.
7. Fluid Pressure Drop: **<Insert feet of head (kPa)>**.

G. Electric-Resistance Reheating Coil:

1. Total Capacity: **<Insert kilowatts>**.
2. Stages of Heating: **[1][2]<Insert number>**.

H. Humidifier:

1. Total: <Insert lb/h (kg/h)>.
2. Input: <Insert Btu/h (kW)>.

I. Electrical Characteristics:

1. Volts: [120][208][240][277][480]<Insert value>.
2. Phase: [Single][Three].
3. Hertz: 60.
4. Full-Load Amperes: <Insert value>.
5. Minimum Circuit Ampacity: <Insert value>.
6. Maximum Overcurrent Protection: <Insert amperage>.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for hydronic piping systems to verify actual locations of piping connections before equipment installation.
- C. Examine walls, floors, and roofs for suitable conditions where computer-room air conditioners will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Layout and install computer-room air conditioners and suspension system coordinated with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.
- B. Install computer-room air conditioners coordinated with computer-room access flooring Installer.
- C. Install computer-room air conditioners level and plumb, maintaining manufacturer's recommended clearances. [Install according to AHRI Guideline B.]
- D. Computer-Room Air-Conditioner Mounting: Install using [elastomeric pads][elastomeric mounts][restrained spring isolators]<Insert device>. Comply with requirements for vibration isolation devices specified in [Section 230548 "Vibration and Seismic Controls for HVAC."][Section 230548.13 "Vibration Controls for HVAC."]
 1. Minimum Deflection: [1/4 inch (6 mm)][1 inch (25 mm)]<Insert dimension>.
- E. Suspended Computer-Room Air Conditioners: Install using continuous-thread hanger rods and [elastomeric hangers][spring hangers][spring hangers with vertical-limit stop] of size required to support weight of computer-room air conditioner.



1. Comply with requirements for vibration isolation devices specified in [Section 230548 "Vibration and Seismic Controls for HVAC."][Section 230548.13 "Vibration Controls for HVAC."]
Fabricate brackets or supports as required.
2. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

F. Air-Cooled Refrigerant Condenser Mounting: Install using [elastomeric pads][elastomeric mounts][restrained spring isolators]<Insert device> on concrete base. Comply with requirements for vibration isolation devices specified in [Section 230548 "Vibration and Seismic Controls for HVAC."][Section 230548.13 "Vibration Controls for HVAC."]

1. Minimum Deflection: [1/4 inch (6 mm)][1 inch (25 mm)]<Insert dimension>.

G. Remote, Air-Cooled, Glycol-Solution Cooler Mounting: Install using [elastomeric pads][elastomeric mounts][restrained spring isolators]<Insert device> on concrete base. Comply with requirements for vibration isolation devices specified in [Section 230548 "Vibration and Seismic Controls for HVAC."][Section 230548.13 "Vibration Controls for HVAC."]

1. Minimum Deflection: [1/4 inch (6 mm)][1 inch (25 mm)]<Insert dimension>.

H. Glycol-Solution Pump Package Mounting: Install using [elastomeric pads][elastomeric mounts]<Insert device>. Comply with requirements for vibration isolation devices specified in [Section 230548 "Vibration and Seismic Controls for HVAC."][Section 230548.13 "Vibration Controls for HVAC."]

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other heating, ventilating, and air-conditioning Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to computer-room air conditioners, allow space for service and maintenance.
- C. Water and Drainage Connections: Comply with applicable requirements in Section 221116 "Domestic Water Piping." Provide adequate connections for water-cooled units, condensate drain, and humidifier flushing system.
- D. Hot-Water Heating Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Provide shutoff valves in inlet and outlet piping to heating coils.
- E. Condenser-Water Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Provide shutoff valves in water inlet and outlet piping on water-cooled units.
- F. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Provide shutoff valves and piping.

3.4 FIELD QUALITY CONTROL

- A. Testing Agency: [Owner will engage][Engage] a qualified testing agency to perform tests and

inspections.

- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
 - 1. Inspect for and remove shipping bolts, blocks, and tie-down straps.
 - 2. After installing computer-room air conditioners and after electrical circuitry has been energized, test for compliance with requirements.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Computer-room air conditioners will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.
- F. After startup service and performance test, change filters and flush humidifier.

3.5 ADJUSTING

- A. Adjust initial temperature[**and humidity**] set points.
- B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- C. Occupancy Adjustments: When requested within [12]<Insert number> months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to [two]<Insert number> visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

- A. [Engage a factory-authorized service representative to train][Train] Owner's maintenance personnel to adjust, operate, and maintain computer-room air conditioners.

END OF SECTION 23 81 23 12



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23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 81 23 12	23 81 23 00	Small Capacity Computer-Room Air-Conditioners Floor-Mounted Units
23 81 23 12	23 81 23 13	Computer-Room Air-Conditioners, Ceiling-Mounted Units
23 81 23 12	23 81 23 00a	Computer-Room Air-Conditioners, Console Units
23 81 23 12	23 81 23 00b	Computer-Room, Rack-Cooling Equipment
23 81 23 12	23 81 00 00	Variable-Refrigerant-Flow HVAC Systems



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SECTION 23 81 23 13 - COMPUTER-ROOM AIR-CONDITIONERS, CEILING-MOUNTED UNITS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: Computer-room air conditioners, ceiling-mounted units.

1.2 DEFINITIONS

- A. COP: Coefficient of performance.
- B. EER: Energy efficiency ratio.
- C. SCR: Silicon-controlled rectifier.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include material descriptions, dimensions of individual components and profiles, and finishes for computer-room air-conditioning units.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Sustainable Design Submittals:
 - 1. Refrigerant: Product Data for refrigerants, indicating compliance with refrigerant management practices.
 - 2. Product Data: For refrigerants, indicating compliance with refrigerant management practices.
 - 3. Product data showing compliance with ASHRAE 62.1.
- C. Shop Drawings: For computer-room air conditioners.
 - 1. Include plans, elevations, sections, and attachment details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.
- D. Color Samples: For unit cabinet, discharge grille, and exterior louver and for each color and texture specified.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans, elevations, and other details, drawn to scale, using input from installers of the items involved.
- B. Seismic Qualification Certificates: For computer-room air conditioners, accessories, and components,



from manufacturer.

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

C. Field quality-control reports.

D. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For computer-room air conditioners to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fan Belts: **[One]<Insert number>** set(s) for each belt-driven fan.
2. Filters: **[One]<Insert number>** set(s) of filters for each unit.

1.7 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of computer-room air conditioners that fail in materials or workmanship within specified warranty period.
1. Warranty Period for Compressors: Manufacturer's standard, but not less than **[five][10]<Insert number>** years from date of Substantial Completion.
 2. Warranty Period for Humidifiers: Manufacturer's standard, but not less than **[three]<Insert number>** years from date of Substantial Completion.
 3. Warranty Period for Control Boards: Manufacturer's standard, but not less than **[three]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 COMPUTER-ROOM AIR-CONDITIONERS, CEILING-MOUNTED UNITS

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

1. **[APC by Schneider Electric]**
2. **[Compu-Aire, Inc]**
3. **[Data Aire Inc]**

4. [Liebert; Vertiv Holdings Co.]
5. [Stulz-ATS]
6. <Insert manufacturer's name>

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

1. [APC by Schneider Electric]
2. [Compu-Aire, Inc]
3. [Data Aire Inc]
4. [Liebert; Vertiv Holdings Co.]
5. [Stulz-ATS]
6. <Insert manufacturer's name>

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Computer-room air-conditioners, ceiling-mounted units shall withstand the effects of earthquake motions determined according to [ASCE/SEI 7]<Insert requirement>.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."

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

C. ASHRAE Compliance:

1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Ventilation Rate Procedures," and Section 7 - "Construction and Startup."

D. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

E. ASME Compliance: Fabricate and label water-cooled condenser shell to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

2.3 MANUFACTURED UNITS

A. Description: Self-contained, factory assembled, prewired, and prepiped; consisting of cabinet, fan, filters, and controls.

1. Mounting Configuration:
 - a. Exposed in the space.
 - b. Fit T-bar in lay-in ceiling opening.
 - c. Concealed above a hard ceiling.

B. Cabinet: Galvanized steel serviceable from one side, with baked-enamel finish, insulated with 1/2-inch- (13-mm-) thick duct liner, and mounting bracket attached to the unit.

1. Integral factory-supplied supply and return grille to fit ceiling grid kit of **24 by 48 inches (610 by 1220 mm)**, with filter.
2. Unit with supply and return collars for ducting in the field.
3. Unit with **24-by-48-inch (610-by-1220-mm)** air distribution plenum, with integral MERV 8 filter and three-way air distribution.
4. Unit with two-speed, centrifugal direct-drive fan.
5. Unit with single-speed, centrifugal belt-driven fan.
6. Unit with high static blower assembly consisting of field-attached blower box with double-inlet, centrifugal belt-driven fan; with single-speed motor mounted on an adjustable base, and providing up to **2 inches wc (500 Pa)** of external pressure.
7. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Supply-Air Fan:

1. Forward curved, double width, double inlet, centrifugal, with adjustable V-belt drive.
2. Plug/plenum, single inlet, direct drive, electronically commutated, and variable speed.

D. Refrigeration System:

1. Compressor: Scroll, with oil strainer, internal motor overload protection, resilient suspension system, and crankcase heater.
2. Refrigeration Circuit Components:
 - a. Low-pressure switch.
 - b. Manually reset, high-pressure switch.
 - c. Thermal-expansion valve with external equalizer.
 - d. Sight glass with moisture indicator.
 - e. Service shutoff valves.
 - f. Charging valves.
 - g. Hot-gas bypass.
 - h. Refrigerant charge.
3. Refrigerant: **[R-407C][or][R-410A]<Insert type>**.
4. Refrigerant Evaporator Coil: Direct-expansion coil of seamless copper tubes expanded into aluminum fins.
5. Refrigerant line sets precharged in lengths of **[15 feet (4.6 m)][30 feet (9.0 m)]** and of sufficient length to serve the unit from its condensing unit.
6. Refrigerant line-sweat-adapter kit to permit field brazing of refrigerant lines.
 - a. Mount stainless-steel drain pan **[complying with ASHRAE 62.1][and][having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir]** under coil assembly.
7. Integral, Water-Cooled Refrigerant Condenser: **[Coaxial, counterflow, tube-in-tube][Brazed-plate]** type with liquid-line stop valve and head-pressure-actuated, water-regulating valve.
 - a. Cooling Medium: **[Water][Glycol solution]**.
8. Remote, Air-Cooled Refrigerant Condenser: Integral, copper-tube aluminum-fin coil with direct-drive, **[propeller][centrifugal]** fan.
9. Split system shall have suction- and liquid-line compatible fittings and refrigerant piping for field interconnection.

E. Hydronic Cooling Coil: Seamless copper tubes expanded into aluminum fins with two-way control valve.

1. Cooling Medium: **[Water][Glycol solution]**.
 2. Mount stainless-steel drain pan **[complying with ASHRAE 62.1][and][having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir]** under coil assembly.
- F. Hot-Water Reheat: Copper-tube, aluminum-fin coil with two-way, modulating control valve and cleanable Y-strainer.
- G. Remote, Air-Cooled, Glycol-Solution Cooler:
1. Corrosion-resistant cabinet.
 2. Copper-tube aluminum-fin coil.
 3. Direct-drive propeller fan with fan guards.
 4. Single-phase motors with internal overload protection.
- H. Glycol-Solution Pump Package:
1. Weatherproof and vented enclosure of enameled, galvanized steel on structural base frame containing centrifugal pump with mechanical seal.
 2. Piping: Interconnecting piping, to and from remote, air-cooled glycol-solution cooler, with shutoff valves, flow switches, unions, and pressurized expansion tank with air purge vent and system-charging connection.
 3. Glycol: Inhibited ethylene glycol and water solution mixed 50:50, suitable for operating temperature of **minus 40 deg F (minus 40 deg C)**.
- I. Electric-Resistance Reheat Coil:
1. Finned-tube electric elements with contactor.
 2. Dehumidification relay.
 3. High-temperature-limit switches.
 4. SCR to proportionally control the reheat elements providing precise temperature control.
- J. Filter: **1-inch- (25-mm-)** thick, disposable, glass-fiber media.
1. Initial Resistance: **<Insert number> inches wg (Pa)**.
 2. Recommended Final Resistance: **<Insert number> inches wg (Pa)**.
 3. Pre-Filter Minimum Efficiency Reporting Value and Average Arrestance:
 - a. MERV Rating: **[MERV 1][MERV 2][MERV 3][MERV 4]<Insert value>** and corresponding average arrestance according to ASHRAE 52.2.
 4. Pre-Filter Minimum Efficiency Reporting Value:
 - a. **[MERV 6]<Insert value>** according to ASHRAE 52.2.
 5. Filter Minimum Efficiency Reporting Value:
 - a. MERV Rating: **[MERV 6][MERV 13]<Insert value>** according to ASHRAE 52.2.
- K. Electrode Steam Humidifier: Self-contained, microprocessor-controlled unit with disposable, polypropylene-plastic cylinders, and having field-adjustable steel electrodes and stainless-steel steam dispersion tube.
1. Plumbing Components and Valve Bodies: Plastic, linked by flexible rubber hosing, with water fill with air gap and solenoid valve incorporating built-in strainer, pressure-reducing and flow-regulating orifice, and drain with integral air gap.



2. Control: Fully modulating to provide gradual modulation from zero to 100 percent capacity with field-adjustable maximum capacity; with high-water probe.
 3. Drain Cycle: Field-adjustable drain duration and drain interval.
- L. Disconnect Switch: Non-automatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.
- M. Single point power kit permitting single electrical feed to the evaporator and condensing unit of a close-coupled system.
- N. Epoxy-coated, step-down transformer suitable for mounting on the outdoor condensing unit to provide it with 277-V input power.
- O. Control System:
1. Microprocessor **[unit][remote]**-mounted panel.
 2. Fan contactor.
 3. Compressor contactor.
 4. Compressor start capacitor.
 5. Control transformer with circuit breaker.
 6. Solid-state temperature-**[and humidity-]**control modules.
 7. Humidity contactor.
 8. Time-delay relay.
 9. Heating contactor.
 10. Smoke sensor.
 11. Filter clog switch.
 12. Alarm contacts.
 13. High-temperature thermostat.
 14. Solid-state, wall-mounted control panel with start-stop switch[, **adjustable humidity set point,][remote temperature sensors][remote humidity sensors]** and adjustable temperature set point.
 15. Remote panel to monitor and change temperature and humidity set points and sensitivities of the unit and unit alarms.
- P. Fan Motors:
1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load does not require motor to operate in service factor range above 1.0.
 - b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
 - c. **<Insert unique motor characteristics>**.

2.4 CAPACITIES AND CHARACTERISTICS

- A. Supply-Air Fan:
1. Airflow: **<Insert cfm (L/s)>**.
 2. Minimum Static Pressure: **<Insert inches wg (kPa)>**.
 3. Motor Size: **<Insert number>** hp.
- B. Refrigeration System:

1. Unit Energy Efficiency: **[COP][EER]**.
2. Refrigerant Compressor:
 - a. Total Unit Cooling Capacity: **<Insert Btu/h (kW)>**.
 - b. Sensible Unit Cooling Capacity: **<Insert Btu/h (kW)>**.
 - c. Number of Compressors: **[One][Two]<Insert number>**.
 - d. Motor Size: **<Insert number> hp**.
3. Refrigerant Evaporator Coil:
 - a. Cooling Capacity: **<Insert Btu/h (kW)>**.
 - b. Entering-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
 - c. Entering-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
 - d. Leaving-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
 - e. Leaving-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
4. Water-Cooled Refrigerant Condenser:
 - a. Cooling Capacity: **<Insert Btu/h (kW)>**.
 - b. Condenser Water Flow: **<Insert gpm (L/s)>**.
 - c. Cooling Medium: **[Water][Glycol solution]**.
 - d. Entering-Water Temperature: **<Insert deg F (deg C)>**.
 - e. Fluid Pressure Drop: **<Insert feet of head (kPa)>**.
5. Air-Cooled Refrigerant Condenser:
 - a. Cooling Capacity: **<Insert Btu/h (kW)>**.
 - b. Entering-Air Temperature: **<Insert deg F (deg C)>**.
 - c. Number of Condenser Fan Motors: **<Insert number>**.
 - d. Condenser Fan Motors: **<Insert number> hp**.
- C. Hydronic Cooling Coil:
 1. Cooling Coil Capacity: **<Insert Btu/h (kW)>**.
 2. Entering-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
 3. Entering-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
 4. Leaving-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
 5. Leaving-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
 6. Fluid Flow: **<Insert gpm (L/s)>**.
 7. Entering-Fluid Temperature: **<Insert deg F (deg C)>**.
 8. Fluid Pressure Drop: **<Insert feet of head (kPa)>**.
 9. Cooling Medium: **[Water][Glycol solution]**.
- D. Remote, Air-Cooled, Glycol-Solution Cooler:
 1. Cooling Coil Capacity: **<Insert Btu/h (kW)>**.
 2. Entering-Air Temperature: **<Insert deg F (deg C)>**.
 3. Leaving-Air Temperature: **<Insert deg F (deg C)>**.
 4. Glycol Flow: **<Insert gpm (L/s)>**.
 5. Entering-Glycol Temperature: **<Insert deg F (deg C)>**.
 6. Number of Fans: **<Insert number>**.
 7. Fan Motors: **<Insert number> hp**.
 8. Number of Pumps: **<Insert number>**.
 9. Pump Motors: **<Insert number> hp**.
- E. Hydronic Reheating Coil:



1. Total: **<Insert Btu/h (kW)>**.
2. Entering-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
3. Leaving-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
4. Water Flow: **<Insert gpm (L/s)>**.
5. Entering-Water Temperature: **<Insert deg F (deg C)>**.
6. Leaving-Water Temperature: **<Insert deg F (deg C)>**.
7. Fluid Pressure Drop: **<Insert feet of head (kPa)>**.

F. Electric-Resistance Reheating Coil:

1. Total Capacity: **<Insert kilowatts>**.
2. Stages of Heating: **[1][2]<Insert number>**.

G. Humidifier:

1. Total: **<Insert lb/h (kg/h)>**.
2. Input: **<Insert Btu/h (kW)>**.

H. Electrical Characteristics:

1. Volts: **[120][208][240][277][480]<Insert value>**.
2. Phase: **[Single][Three]**.
3. Hertz: 60.
4. Full-Load Amperes: **<Insert value>**.
5. Minimum Circuit Ampacity: **<Insert value>**.
6. Maximum Overcurrent Protection: **<Insert amperage>**.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for hydronic piping systems to verify actual locations of piping connections before equipment installation.
- C. Examine walls, floors, and roofs for suitable conditions where computer-room air conditioners will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF COMPUTER-ROOM AIR-CONDITIONERS, CEILING-MOUNTED UNITS

- A. Layout and install computer-room air conditioners and suspension system coordinated with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.
- B. Install computer-room air conditioners coordinated with computer-room access flooring Installer.
- C. Install computer-room air conditioners level and plumb, maintaining manufacturer's recommended

clearances. **[Install according to AHRI Guideline B.]**

- D. Suspended Computer-Room Air Conditioners: Install using continuous-thread hanger rods and **[elastomeric hangers][spring hangers][spring hangers with vertical-limit stop]** of size required to support weight of computer-room air conditioner.
 - 1. Comply with requirements for vibration isolation devices specified in **[Section 230548 "Vibration and Seismic Controls for HVAC."][Section 230548.13 "Vibration Controls for HVAC."]** Fabricate brackets or supports as required.
 - 2. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- E. Air-Cooled Refrigerant Condenser Mounting: Install using **[elastomeric pads][elastomeric mounts][restrained spring isolators]<Insert device>** on concrete base. Comply with requirements for vibration isolation devices specified in **[Section 230548 "Vibration and Seismic Controls for HVAC."][Section 230548.13 "Vibration Controls for HVAC."]**
 - 1. Minimum Deflection: **[1/4 inch (6 mm)][1 inch (25 mm)]<Insert dimension>**.
- F. Remote, Air-Cooled, Glycol-Solution Cooler Mounting: Install using **[elastomeric pads][elastomeric mounts][restrained spring isolators]<Insert device>** on concrete base. Comply with requirements for vibration isolation devices specified in **[Section 230548 "Vibration and Seismic Controls for HVAC."][Section 230548.13 "Vibration Controls for HVAC."]**
 - 1. Minimum Deflection: **[1/4 inch (6 mm)][1 inch (25 mm)]<Insert dimension>**.
- G. Glycol-Solution Pump Package Mounting: Install using **[elastomeric pads][elastomeric mounts]<Insert device>**. Comply with requirements for vibration isolation devices specified in **[Section 230548 "Vibration and Seismic Controls for HVAC."][Section 230548.13 "Vibration Controls for HVAC."]**

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other heating, ventilating, and air-conditioning Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to computer-room air conditioners, allow space for service and maintenance.
- C. Water and Drainage Connections: Comply with applicable requirements in Section 221116 "Domestic Water Piping." Provide adequate connections for water-cooled units, condensate drain, and humidifier flushing system.
- D. Hot-Water Heating Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Provide shutoff valves in inlet and outlet piping to heating coils.
- E. Condenser-Water Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Provide shutoff valves in water inlet and outlet piping on water-cooled units.
- F. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Provide shutoff valves and piping.

3.4 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections **[with the assistance of a factory-authorized service representative]**:
 - 1. Inspect for and remove shipping bolts, blocks, and tie-down straps.
 - 2. After installing computer-room air conditioners and after electrical circuitry has been energized, test for compliance with requirements.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Computer-room air conditioners will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.
- F. After startup service and performance test, change filters and flush humidifier.

3.5 ADJUSTING

- A. Adjust initial temperature **[and humidity]** set points.
- B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- C. Occupancy Adjustments: When requested within **[12]<Insert number>** months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to **[two]<Insert number>** visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

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

END OF SECTION 23 81 23 13



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 81 23 13	23 81 23 00	Small Capacity Computer-Room Air-Conditioners Floor-Mounted Units
23 81 23 13	23 81 23 00a	Computer-Room Air-Conditioners, Console Units
23 81 23 13	23 81 23 00b	Computer-Room, Rack-Cooling Equipment
23 81 23 13	23 81 00 00	Variable-Refrigerant-Flow HVAC Systems



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SECTION 23 81 26 00 - SPLIT-SYSTEM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Split-system air-conditioners.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product:
 - 1. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Include detail of equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Wiring Diagrams: For power, signal, and control wiring.
- C. Samples for Initial Selection: For units with factory-applied color finishes.
- D. Sustainable Design Submittals:
 - 1. Refrigerant: Product Data for refrigerants, indicating compliance with refrigerant management practices.
 - 2. Product Data: For refrigerants, indicating compliance with refrigerant management practices.
 - 3. Product Data: For energy performance.

1.3 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.
- B. Warranty: Sample of special warranty.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for

storage and identified with labels describing contents.

1. Filters: [One]<Insert number> set(s) for each air-handling unit.
2. Gaskets: [One]<Insert number> set(s) for each access door.
3. Fan Belts: [One]<Insert number> set(s) for each air-handling unit fan.

1.6 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASHRAE Compliance:
 1. Fabricate and label refrigeration system to comply with ASHRAE 15.
 2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Procedures," and Section 7 - "Construction and System Start-up."
- C. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

1.7 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete."
- B. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.8 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.
 1. Warranty Period:
 - a. For Compressor: [One][Five]<Insert number> year(s) from date of Substantial Completion.
 - b. For Parts: [One][Five]<Insert number> year(s) from date of Substantial Completion.
 - c. For Labor: [One][Five]<Insert number> year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SPLIT-SYSTEM AIR-CONDITIONERS

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

1. [Carrier Global Corporation]
2. [Coleman Company Inc. (The)]
3. [First Operations LP]
4. [Friedrich Air Conditioning Company]
5. [Koldwave, Inc.]
6. [Lennox]
7. [Mitsubishi Electric & Electronics USA, Inc.]
8. [Mitsubishi Electric Sales Canada Inc.]
9. [Mitsubishi Heavy Industries America, Inc]
10. [Rheem Manufacturing Company; Heating and Cooling Products]
11. [Samsung HVAC]
12. [SANYO North America Corporation]
13. [Trane]
14. [YORK; brand of Johnson Controls International plc, Building Solutions North America]
15. <Insert manufacturer's name>

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

1. [Carrier Global Corporation]
2. [Coleman Company Inc. (The)]
3. [First Operations LP]
4. [Friedrich Air Conditioning Company]
5. [Koldwave, Inc.]
6. [Lennox]
7. [Mitsubishi Electric & Electronics USA, Inc.]
8. [Mitsubishi Electric Sales Canada Inc.]
9. [Mitsubishi Heavy Industries America, Inc]
10. [Rheem Manufacturing Company; Heating and Cooling Products]
11. [Samsung HVAC]
12. [SANYO North America Corporation]
13. [Trane]
14. [YORK; brand of Johnson Controls International plc, Building Solutions North America]
15. <Insert manufacturer's name>

- C. Indoor Units (5 tons (18 kW) or Less):

1. Concealed Evaporator-Fan Components:
 - a. Chassis: Galvanized steel with flanged edges, removable panels for servicing, and insulation on back of panel.
 - b. Insulation: Faced, glass-fiber duct liner.
 - c. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.
 - d. Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)**; leak tested to **300 psig (2070 kPa)** underwater; with a two-position control valve.
 - e. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements; with refractory ceramic support bushings, automatic-reset thermal cutout, built-in magnetic contactors, manual-reset thermal cutout, airflow-proving device, and one-time fuses in terminal box for overcurrent protection.
 - f. Fan: Forward-curved, double-width wheel of galvanized steel; directly connected to motor.
 - g. Fan Motors:
 - 1) Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230500 "Common Work Results for

- HVAC."
- 2) Multitapped, multispeed with internal thermal protection and permanent lubrication.
- 3) Wiring Terminations: Connect motor to chassis wiring with plug connection.
- h. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- i. Filters: Permanent, cleanable.
- j. Condensate Drain Pans:
 - 1) Fabricated with [1][2] percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.
 - a) Length: Extend drain pan downstream from leaving face **[to comply with ASHRAE 62.1]<Insert distance>**.
 - b) Depth: A minimum of **[2 inches (50 mm)]<Insert depth>** deep.
 - 2) Single-wall, **[galvanized-][stainless]** steel sheet.
 - 3) Double-wall, **[galvanized-][stainless]** steel sheet with space between walls filled with foam insulation and moisture-tight seal.
 - 4) Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on **[one end][both ends]** of pan.
 - a) Minimum Connection Size: **[NPS 1 (DN 25)][NPS 2 (DN 50)]<Insert size>**.
 - 5) Pan-Top Surface Coating: Asphaltic waterproofing compound.
 - 6) Units with stacked coils are to have an intermediate drain pan to collect condensate from top coil.
- 2. Floor-Mounted, Evaporator-Fan Components:
 - a. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect.
 - 1) Discharge Grille: **[Steel with surface-mounted frame][Welded steel bars forming a linear grille and welded into supporting panel]**.
 - 2) Insulation: Faced, glass-fiber duct liner.
 - 3) Drain Pans: Galvanized steel, with connection for drain; insulated.
 - b. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.
 - c. Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)**; leak tested to **300 psig (2070 kPa)** underwater; with a two-position control valve.
 - d. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements; with refractory ceramic support bushings, automatic-reset thermal cutout, built-in magnetic contactors, manual-reset thermal cutout, airflow-proving device, and one-time fuses in terminal box for overcurrent protection.
 - e. Fan: Direct drive, centrifugal, **[with power-induced outside air]**.
 - f. Fan Motors:
 - 1) Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230500 "Common Work Results for HVAC."
 - 2) Multitapped, multispeed with internal thermal protection and permanent lubrication.

g. Air-Filtration Section:

1) General Requirements for Air-Filtration Section:

- a) Comply with NFPA 90A.
- b) Minimum MERV in accordance with ASHRAE 52.2.
- c) Filter-Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters are to be removable from one side or lifted out from access plenum.

2) Disposable Panel Filters:

- a) Factory-fabricated, viscous-coated, flat-panel type.
- b) Thickness: [1 inch (25 mm)][2 inches (50 mm)].
- c) Dust-Holding Capacity: <Insert lb (kg)>.
- d) Initial Resistance: <Insert inches wg (Pa)>.
- e) Recommended Final Resistance: <Insert inches wg (Pa)>.
- f) MERV in accordance with ASHRAE 52.2: [5]<Insert value>.
- g) Media: Interlaced glass fibers sprayed with nonflammable adhesive[and antimicrobial agent].
- h) Frame: Galvanized steel, with metal grid on outlet side, steel rod grid on inlet side, and hinged; with pull and retaining handles.

3) Extended-Surface, Disposable Panel Filters:

- a) Factory-fabricated, dry, extended-surface type.
- b) Thickness: [1 inch (25 mm)][2 inches (50 mm)][4 inches (100 mm)].
- c) Dust-Holding Capacity: <Insert lb (kg)>.
- d) Initial Resistance: <Insert inches wg (Pa)>.
- e) Recommended Final Resistance: <Insert inches wg (Pa)>.
- f) MERV in accordance with ASHRAE 52.2: [7]<Insert value>.
- g) Media: Fibrous material formed into deep-V-shaped pleats[with antimicrobial agent] and held by self-supporting wire grid.
- h) Media-Grid Frame: [Nonflammable cardboard][Galvanized steel][Fire-retardant, 3/4-inch (20-mm) particleboard with gaskets].
- i) Mounting Frames: Welded, galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

3. Wall-Mounted, Evaporator-Fan Components:

- a. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect, and discharge drain pans with drain connection.
- b. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.
- c. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements; with refractory ceramic support bushings, automatic-reset thermal cutout, built-in magnetic contactors, manual-reset thermal cutout, airflow-proving device, and one-time fuses in terminal box for overcurrent protection.
- d. Fan: Direct drive, centrifugal.
- e. Fan Motors:
 - 1) Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230500 "Common Work Results for HVAC."
 - 2) Multitapped, multispeed with internal thermal protection and permanent lubrication.
 - 3) Enclosure Type: Totally enclosed, fan cooled.



- 4) NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
 - 5) Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
 - 6) Mount unit-mounted disconnect switches on [exterior][interior] of unit.
 - 7) <Insert unique motor characteristics>.
- f. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- g. Condensate Drain Pans:
- 1) Fabricated with [1][2] percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.
 - a) Length: Extend drain pan downstream from leaving face [to comply with ASHRAE 62.1]<Insert distance>.
 - b) Depth: A minimum of [1 inch (25 mm)]<Insert depth> deep.
 - 2) Single-wall, [galvanized-][stainless] steel sheet.
 - 3) Double-wall, [galvanized-][stainless] steel sheet with space between walls filled with foam insulation and moisture-tight seal.
 - 4) Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on [one end][both ends] of pan.
 - 5) Minimum Connection Size: [NPS 1 (DN 25)][NPS 2 (DN 50)]<Insert size>.
 - 6) Pan-Top Surface Coating: Asphaltic waterproofing compound.
- h. Air-Filtration Section:
- 1) General Requirements for Air-Filtration Section:
 - a) Comply with NFPA 90A.
 - b) Minimum MERV in accordance with ASHRAE 52.2.
 - c) Filter-Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters are to be removable from one side or lifted out from access plenum.
 - 2) Disposable Panel Filters:
 - a) Factory-fabricated, viscous-coated, flat-panel type.
 - b) Thickness: [1 inch (25 mm)][2 inches (50 mm)].
 - c) Dust-Holding Capacity: <Insert lb (kg)>.
 - d) Initial Resistance: <Insert inches wg (Pa)>.
 - e) Recommended Final Resistance: <Insert inches wg (Pa)>.
 - f) MERV in accordance with ASHRAE 52.2: [5]<Insert value>.
 - g) Media: Interlaced glass fibers sprayed with nonflammable adhesive[and antimicrobial agent].
 - h) Frame: Galvanized steel, with metal grid on outlet side, steel rod grid on inlet side, and hinged; with pull and retaining handles.
 - 3) Extended-Surface, Disposable Panel Filters:
 - a) Factory-fabricated, dry, extended-surface type.
 - b) Thickness: [1 inch (25 mm)][2 inches (50 mm)][4 inches (100 mm)].
 - c) Dust-Holding Capacity: <Insert lb (kg)>.
 - d) Initial Resistance: <Insert inches wg (Pa)>.

- e) Recommended Final Resistance: <Insert inches wg (Pa)>.
- f) MERV in accordance with ASHRAE 52.2: [7]<Insert value>.
- g) Media: Fibrous material formed into deep-V-shaped pleats[with antimicrobial agent] and held by self-supporting wire grid.
- h) Media-Grid Frame: [Nonflammable cardboard][Galvanized steel][Fire-retardant, 3/4-inch (20-mm) particleboard with gaskets].
- i) Mounting Frames: Welded, galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

D. Indoor Units (6 tons (21 kW) or More:

1. Concealed Evaporator-Fan Components:

- a. Chassis: Galvanized steel with flanged edges, removable panels for servicing, and insulation on back of panel.
- b. Insulation: Faced, glass-fiber duct liner.
- c. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.
- d. Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)**; leak tested to **300 psig (2070 kPa)** underwater; with a two-position control valve.
- e. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements; with refractory ceramic support bushings, automatic-reset thermal cutout, built-in magnetic contactors, manual-reset thermal cutout, airflow-proving device, and one-time fuses in terminal box for overcurrent protection.
- f. Fan: Forward-curved, double-width wheel of galvanized steel; directly connected to motor.
- g. Fan Motors:
 - 1) Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230500 "Common Work Results for HVAC."
 - 2) Multitapped, multispeed with internal thermal protection and permanent lubrication.
 - 3) Three-phase, permanently lubricated, ball-bearing motors with built-in thermal-overload protection.
 - 4) Wiring Terminations: Connect motor to chassis wiring with plug connection.
- h. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- i. Filters: [**1 inch (25 mm) thick, in fiberboard frames**][Permanent, cleanable].
- j. Condensate Drain Pans:
 - 1) Fabricated with [**1**][**2**] percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.
 - a) Length: Extend drain pan downstream from leaving face [**to comply with ASHRAE 62.1**]<Insert distance>.
 - b) Depth: A minimum of [**2 inches (50 mm)**]<Insert depth> deep.
 - 2) Single-wall, [**galvanized-**][**stainless**] steel sheet.
 - 3) Double-wall, [**galvanized-**][**stainless**] steel sheet with space between walls filled with foam insulation and moisture-tight seal.
 - 4) Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on [**one end**][**both ends**] of pan.
 - a) Minimum Connection Size: [**NPS 1 (DN 25)**][**NPS 2 (DN 50)**]<Insert size>.



- 5) Pan-Top Surface Coating: Asphaltic waterproofing compound.
 - 6) Units with stacked coils are to have an intermediate drain pan to collect condensate from top coil.
2. Floor-Mounted, Evaporator-Fan Components:
- a. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect.
 - 1) Discharge Grille: **[Steel with surface-mounted frame][Welded steel bars forming a linear grille and welded into supporting panel]**.
 - 2) Insulation: Faced, glass-fiber duct liner.
 - b. Condensate Drain Pans:
 - 1) Fabricated with **[1][2]** percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.
 - a) Length: Extend drain pan downstream from leaving face **[to comply with ASHRAE 62.1]<Insert distance>**.
 - b) Depth: A minimum of **[2 inches (50 mm)]<Insert depth>** deep.
 - 2) Single-wall, **[galvanized-][stainless]** steel sheet.
 - 3) Double-wall, **[galvanized-][stainless]** steel sheet with space between walls filled with foam insulation and moisture-tight seal.
 - 4) Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on **[one end][both ends]** of pan.
 - a) Minimum Connection Size: **[NPS 1 (DN 25)][NPS 2 (DN 50)]<Insert size>**.
 - 5) Pan-Top Surface Coating: Asphaltic waterproofing compound.
 - 6) Units with stacked coils are to have an intermediate drain pan to collect condensate from top coil.
 - c. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.
 - d. Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)**; leak tested to **300 psig (2070 kPa)** underwater; with a two-position control valve.
 - e. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements; with refractory ceramic support bushings, automatic-reset thermal cutout, built-in magnetic contactors, manual-reset thermal cutout, airflow-proving device, and one-time fuses in terminal box for overcurrent protection.
 - f. Fan: Direct drive, centrifugal, **[with power-induced outside air]**.
 - g. Fan Motors:
 - 1) Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230500 "Common Work Results for HVAC."
 - 2) Multitapped, multispeed with internal thermal protection and permanent lubrication.
 - 3) Enclosure Type: Totally enclosed, fan cooled.
 - 4) NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
 - 5) Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.

- 6) Mount unit-mounted disconnect switches on [exterior][interior] of unit.
- 7) **<Insert unique motor characteristics>.**

h. Air-Filtration Section:

1) General Requirements for Air-Filtration Section:

- a) Comply with NFPA 90A.
- b) Minimum MERV in accordance with ASHRAE 52.2.
- c) Filter-Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters are to be removable from one side or lifted out from access plenum.

2) Disposable Panel Filters:

- a) Factory-fabricated, viscous-coated, flat-panel type.
- b) Thickness: **[1 inch (25 mm)][2 inches (50 mm)]**.
- c) Dust-Holding Capacity: **<Insert lb (kg)>.**
- d) Initial Resistance: **<Insert inches wg (Pa)>.**
- e) Recommended Final Resistance: **<Insert inches wg (Pa)>.**
- f) MERV in accordance with ASHRAE 52.2: **[5]<Insert value>.**
- g) Media: Interlaced glass fibers sprayed with nonflammable adhesive[**and antimicrobial agent**].
- h) Frame: Galvanized steel, with metal grid on outlet side, steel rod grid on inlet side, and hinged; with pull and retaining handles.

3) Extended-Surface, Disposable Panel Filters:

- a) Factory-fabricated, dry, extended-surface type.
- b) Thickness: **[1 inch (25 mm)][2 inches (50 mm)][4 inches (100 mm)]**.
- c) Dust-Holding Capacity: **<Insert lb (kg)>.**
- d) Initial Resistance: **<Insert inches wg (Pa)>.**
- e) Recommended Final Resistance: **<Insert inches wg (Pa)>.**
- f) MERV in accordance with ASHRAE 52.2: **[7]<Insert value>.**
- g) Media: Fibrous material formed into deep-V-shaped pleats[**with antimicrobial agent**] and held by self-supporting wire grid.
- h) Media-Grid Frame: **[Nonflammable cardboard][Galvanized steel][Fire-retardant, 3/4-inch (20-mm) particleboard with gaskets]**.
- i) Mounting Frames: Welded, galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

3. Variable-Frequency Controllers:

- a. Description: NEMA ICS 2, IGBT, PWM, VFC; listed and labeled as a complete unit and arranged to provide variable speed of an NEMA MG 1, Design B, three-phase induction motor by adjusting output voltage and frequency.
- b. Output Rating: Three-phase; 6 to **[60 Hz, with voltage proportional to frequency throughout voltage range][66 Hz, with torque constant as speed changes][120 Hz, with horsepower constant throughout speed range]**.
- c. Unit Operating Requirements:
 - 1) Input ac voltage tolerance of **[208 V, plus or minus 5][380 to 500 V, plus or minus 10][525 to 575 V, plus or minus 10]** percent.
 - 2) Input-frequency tolerance of 06/11 Hz, plus or minus 6 percent.
 - 3) Minimum Efficiency: 96 percent at 60 Hz, full load.
 - 4) Minimum Displacement Primary-Side Power Factor: 96 percent.

- 5) Overload Capability: 1.1 times the base load current for 60 seconds; 2.0 times the base load current for 3 seconds.
- 6) Starting Torque: 100 percent of rated torque or as indicated.
- 7) Speed Regulation: Plus or minus 1 percent.
- d. Isolated control interface to allow controller to follow control signal over an 11:1 speed range.
- e. Internal Adjustability Capabilities:
 - 1) Minimum Speed: 5 to 25 percent of maximum rpm.
 - 2) Maximum Speed: 80 to 100 percent of maximum rpm.
 - 3) Acceleration: 2 seconds to a minimum of 22 seconds.
 - 4) Deceleration: 2 seconds to a minimum of 22 seconds.
 - 5) Current Limit: 50 percent to a minimum of 110 percent of maximum rating.
- f. Self-Protection and Reliability Features:
 - 1) Input transient protection by means of surge protection devices (SPDs).
 - 2) Undervoltage and overvoltage trips; inverter overtemperature, overload, and overcurrent trips.
 - 3) Adjustable motor overload relays capable of NEMA ICS 2, **[Class 10][Class 20][Class 30]** performance.
 - 4) Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.
 - 5) Instantaneous line-to-line and line-to-ground overcurrent trips.
 - 6) Loss-of-phase protection.
 - 7) Reverse-phase protection.
 - 8) Short-circuit protection.
 - 9) Motor overtemperature fault.
- g. Automatic Reset/Restart: Attempts three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Bidirectional autospeed search is to be capable of starting into rotating loads, spinning in either direction, and returning motor to set speed in proper direction, without damage to controller, motor, or load.
- h. Power-Interruption Protection: Prevents motor from re-energizing after a power interruption until motor has stopped.
- i. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.
- j. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back, based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.
- k. Door-mounted, digital status lights indicate the following conditions:
 - 1) Power on.
 - 2) Run.
 - 3) Overvoltage.
 - 4) Line fault.
 - 5) Overcurrent.
 - 6) External fault.
- l. Panel-Mounted Operator Station: Start-stop and auto-manual selector switches with manual-speed-control potentiometer and elapsed-time meter.
- m. Meters or digital readout devices and selector switch, mounted flush in controller door and connected, are to indicate the following controller parameters:

- 1) Output frequency (hertz).
 - 2) Motor speed (rpm).
 - 3) Motor status (running, stop, fault).
 - 4) Motor current (amperes).
 - 5) Motor torque (percent).
 - 6) Fault or alarming status (code).
 - 7) Proportional-integral-derivative feedback signal (percent).
 - 8) DC-link voltage (volts dc).
 - 9) Set-point frequency (hertz).
 - 10) Motor output voltage (volts).
- n. Control Signal Interface:
- 1) Electric Input Signal Interface: A minimum of two analog inputs (0 to 10 V or 0/4-20 mA) and six programmable digital inputs.
 - 2) Remote signal inputs capable of accepting any of the following speed-setting input signals from the control system:
 - a) 0 to 10 V dc.
 - b) 0-20 or 4-20 mA.
 - c) Potentiometer using up/down digital inputs.
 - d) Fixed frequencies using digital inputs.
 - e) RS485.
 - f) Keypad display for local hand operation.
 - 3) Output signal interface with a minimum of one analog output signal (0/4-20 mA), which can be programmed to any of the following:
 - a) Output frequency (hertz).
 - b) Output current (load).
 - c) DC-link voltage (volts dc).
 - d) Motor torque (percent).
 - e) Motor speed (rpm).
 - f) Set-point frequency (hertz).
 - 4) Remote indication interface with a minimum of two dry circuit relay outputs (120 V ac, 1 A) for remote indication of the following:
 - a) Motor running.
 - b) Set-point speed reached.
 - c) Fault and warning indication (overtemperature or overcurrent).
 - d) High- or low-speed limits reached.
- o. Communications: RS485 interface allows VFC to be used with an external system within a multidrop LAN configuration. Interface allows all parameter settings of VFC to be programmed via BMS control. Provide capability for VFC to retain these settings within the nonvolatile memory.
- p. Integral Disconnecting Means: **[NEMA AB 1, instantaneous-trip circuit breaker][NEMA AB 1, molded-case switch][NEMA KS 1, nonfusible switch][NEMA KS 1, fusible switch]** with lockable handle.
- q. Accessories:
- 1) Devices are to be factory installed in controller enclosure unless otherwise indicated.
 - 2) Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.
 - 3) Standard Displays:

- a) Output frequency (hertz).
- b) Set-point frequency (hertz).
- c) Motor current (amperes).
- d) DC-link voltage (volts dc).
- e) Motor torque (percent).
- f) Motor speed (rpm).
- g) Motor output voltage (volts).

E. Outdoor Units (5 tons (18 kW) or Less:

1. Air-Cooled, Compressor-Condenser Components:

- a. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
- b. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor is to have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
 - 1) Compressor Type: Scroll.
 - 2) Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
 - 3) Refrigerant: **[R-454B]<Insert type>**.
 - 4) Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 206/110.
- c. Heat-Pump Components: Reversing valve and low-temperature-air cutoff thermostat.
- d. Fan: Aluminum-propeller type, directly connected to motor.
- e. Motor: Permanently lubricated, with integral thermal-overload protection.
- f. Low Ambient Kit: Permits operation down to **45 deg F (7 deg C)**.
- g. Mounting Base: Polyethylene.

F. Outdoor Units (6 tons (21 kW) or More:

1. Air-Cooled, Compressor-Condenser Components:

- a. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
- b. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor is to have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
 - 1) Compressor Type: Scroll.
 - 2) Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
 - 3) Refrigerant: **[R-454B]<Insert type>**.
 - 4) Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 206/110.
- c. Heat-Pump Components: Reversing valve and low-temperature-air cutoff thermostat.
- d. Fan: Aluminum-propeller type, directly connected to motor.
- e. Motor: Permanently lubricated, with integral thermal-overload protection.
- f. Low Ambient Kit: Permits operation down to **45 deg F (7 deg C)**.
- g. Mounting Base: Polyethylene.

2. Water-Cooled, Compressor-Condenser Components:

- a. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
- b. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor is to have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
 - 1) Compressor Type: Scroll.
 - 2) Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
 - 3) Refrigerant: [R-22][R-407C][R-410A]<Insert type>.
- c. Heat-Pump Components: Reversing valve.
- d. Heat Exchanger: Copper tubes in copper tube or in steel shell, with water-temperature-actuated, water-regulating valve.

G. Accessories:

1. Control equipment and sequence of operation are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."
2. Thermostat:
 - a. Low voltage with subbase to control compressor and evaporator fan.
 - b. Wireless infrared functioning to remotely control compressor and evaporator fan, with the following features:
 - 1) Compressor time delay.
 - 2) 24-hour time control of system stop and start.
 - 3) Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.
 - 4) Fan-speed selection including auto setting.
3. Automatic-reset timer to prevent rapid cycling of compressor.
4. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.
5. Drain Hose: For condensate.
6. Monitoring:
 - a. Monitor constant and variable motor loads.
 - b. Monitor variable-frequency-drive operation.
 - c. Monitor economizer cycle.
 - d. Monitor cooling load.
 - e. Monitor air distribution static pressure and ventilation air volumes.

H. Capacities and Characteristics

1. Cooling Capacity:
 - a. Total: <Insert value> Btu/h (kW).
 - b. Sensible: <Insert value> Btu/h (kW).
 - c. SEER: [10.0][12.0][13.0][14.0][16.0]<Insert ratio>.
 - d. EER: [10.0][12.0][13.0][14.0][16.0]<Insert ratio>.
 - e. Moisture Removal: <Insert pints/h (L/h)>.

- f. Entering-Air Temperature:
 - 1) Dry Bulb: <Insert deg F (deg C)>.
 - 2) Wet Bulb: <Insert deg F (deg C)>.
- g. Leaving-Air Temperature:
 - 1) Dry Bulb: <Insert deg F (deg C)>.
 - 2) Wet Bulb: <Insert deg F (deg C)>.
- 2. Heating Capacity:
 - a. Type: [Electric][Natural gas].
 - b. Total Capacity: <Insert Btu/h (kW)>.
 - c. Air-Temperature Rise: <Insert deg F (deg C)>.
 - d. Coefficient of Performance: <Insert value>.
 - e. Heating Season Performance Factor: [7.7][8.0]<Insert value>.
 - f. Hot Water:
 - 1) Entering-Water Temperature: <Insert deg F (deg C)>.
 - 2) Leaving-Water Temperature: <Insert deg F (deg C)>.
 - 3) Water Flow: <Insert gpm (L/s)>.
 - 4) Water Pressure Drop: <Insert feet of head (kPa)>.
 - g. Electric Heating Coil:
 - 1) Total Capacity: <Insert value> kW.
 - 2) Volts: [120][208][230][460]<Insert value> V ac.
 - 3) Phase: [Single][Poly].
 - 4) Frequency: 60 Hz.
 - 5) Steps: [One][Two][Three]<Insert number>.
 - h. Gas-Heating Section:
 - 1) Input: <Insert cfh (mL/s)>.
 - 2) Output: <Insert cfh (mL/s)>.
- 3. Auxiliary Heating Capacity:
 - a. Type: [Electric][Natural gas][Propane].
 - b. Total Capacity: <Insert Btu/h (kW)>.
 - c. Volts: [120][208][230][460]<Insert value> V ac.
 - d. Phase: [Single][Poly].
 - e. Hertz: 60.
 - f. Steps: [One][Two][Three]<Insert number>.
 - g. Input: <Insert cfh (mL/s)>.
 - h. Output: <Insert cfh (mL/s)>.
- 4. Indoor Unit:
 - a. Fan Motor Electrical Characteristics:
 - 1) Volts: [120][208][230][460]<Insert value>.
 - 2) Phase: [Single][Poly].
 - 3) Hertz: 60.

- b. Airflow: **<Insert cfm (L/s)>**.
- 5. Outdoor Unit:
 - a. Type: **[Air cooled][Water cooled]**.
 - b. Electrical Characteristics:
 - 1) Volts: **[120][208][230][460]<Insert value>**.
 - 2) Phase: **[Single][Poly]**.
 - 3) Hertz: 60.
 - 4) Minimum Circuit Ampacity: **<Insert value> A**.
 - 5) Maximum Overcurrent Protection: **<Insert value> A**.
 - 6) Fan Motor Full-Load Amperes: **<Insert value> A**.
 - 7) Compressor Full-Load Amperes: **<Insert value> A**.
 - 8) Compressor Locked-Rotor Amperes: **<Insert value> A**.
 - c. Sound-Pressure Level: **<Insert value> dBa**.
 - d. Water:
 - 1) Entering-Water Temperature: **<Insert deg F (deg C)>**.
 - 2) Water Flow: **<Insert gpm (L/s)>**.
 - 3) Water Pressure Drop: **<Insert feet of head (kPa)>**.

PART 3 - EXECUTION

3.1 INSTALLATION OF SPLIT-SYSTEM AIR-CONDITIONERS

- A. Install units level and plumb.
- B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.
- C. Install roof-mounted, compressor-condenser components on equipment supports specified in Section 077200 "Roof Accessories." Anchor units to supports with removable, cadmium-plated fasteners.
- D. Equipment Mounting:
 - 1. Install ground-mounted, compressor-condenser components on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 2. Install ground-mounted, compressor-condenser components on polyethylene mounting base.
 - 3. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 4. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- E. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement

of piping, fittings, and specialties.

1. Water Coil Connections: Comply with requirements specified in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties." Connect hydronic piping to supply and return coil connections with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.
2. Remote, Water-Cooled Condenser Connections: Comply with requirements specified in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties." Connect hydronic piping to supply and return connections with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.

- B. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.
- C. Duct Connections: Duct installation requirements are specified in Section 233113 "Metal Ducts." Drawings indicate the general arrangement of ducts. Connect supply[**and return**] ducts to split-system air-conditioning units with flexible duct connectors. Flexible duct connectors are specified in Section 233300 "Air Duct Accessories."

3.3 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- B. Perform tests and inspections.
1. Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- C. Tests and Inspections:
1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Remove and replace malfunctioning units and retest as specified above.
- E. Prepare test and inspection reports.

3.4 STARTUP SERVICE

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.
1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 2. **<Insert startup steps if any>.**

3.5 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

personnel to adjust, operate, and maintain units.

END OF SECTION 23 81 26 00



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23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 81 26 00	23 81 00 00	Variable-Refrigerant-Flow HVAC Systems
23 81 26 13	23 81 26 00	Split-System Air-Conditioners
23 81 26 13	23 81 00 00	Variable-Refrigerant-Flow HVAC Systems
23 81 26 16	23 81 26 00	Split-System Air-Conditioners
23 81 26 16	23 81 00 00	Variable-Refrigerant-Flow HVAC Systems
23 81 43 00	23 81 00 00	Variable-Refrigerant-Flow HVAC Systems



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SECTION 23 81 46 00 - WATER-SOURCE UNITARY HEAT PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Water-source unitary heat pumps larger than 6 tons (21 kW).
2. Water-source unitary heat pumps, 6 tons (21 kW) and smaller.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each water-source unitary heat pump.
2. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Sustainable Design Submittals:

1. Refrigerant: Product Data for refrigerants, indicating compliance with refrigerant management practices.
2. Product Data: For refrigerants, indicating compliance with refrigerant management practices.
3. Product Data: For energy performance.

C. Shop Drawings:

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For water-source unitary heat pumps, accessories, and components, from manufacturer.

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

B. Product Certificates: For each type of water-source unitary heat pump, signed by product manufacturer.

C. Field quality-control reports.

- D. Sample Warranty: For manufacturer's warranty.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For water-source unitary heat pumps to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. **[One]<Insert number>** spare heat-pump unit(s) of each size and model furnished.

1.6 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of water-source unitary heat pumps that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, refrigeration components.
2. Warranty Period: **[Four]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. ASHRAE Compliance:
 1. ASHRAE 15.
- B. Comply with NFPA 70.
- C. Comply with safety requirements in UL 484 for assembly of free-delivery, water-source heat pumps.

2.2 WATER-SOURCE UNITARY HEAT PUMPS, 6 TONS (21 kW) AND SMALLER

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

1. **[Carrier Global Corporation]**
2. **[ClimateMaster, Inc.]**
3. **[FHP Manufacturing Inc.]**
4. **[Hydro-Temp Corporation, Inc.]**
5. **[Mammoth; a brand of Nortek Air Solutions]**
6. **[Trane Inc.]**
7. **[WaterFurnace International, Inc.]**
8. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Carrier Global Corporation]**
 2. **[ClimateMaster, Inc.]**
 3. **[FHP Manufacturing Inc.]**
 4. **[Hydro-Temp Corporation, Inc.]**
 5. **[Mammoth; a brand of Nortek Air Solutions]**
 6. **[Trane Inc.]**
 7. **[WaterFurnace International, Inc.]**
 8. **<Insert manufacturer's name>**
- C. Description: Packaged water-source unitary heat pump with temperature controls; factory assembled, piped, wired, tested, and rated according to ASHRAE/ARI/ISO-13256-1.
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. Cabinet and Chassis: Galvanized-steel casing with the following features:
1. Access panel for access and maintenance of internal components.
 2. Knockouts for electrical and piping connections.
 3. Cabinet Insulation: Glass-fiber liner, minimum **[1/2 inch (13 mm)]**, **[3/4 inch (19 mm)]** thick, complying with UL 181, ASTM C1071, and ASTM G21.
- E. Water Circuits:
1. Refrigerant-to-Water Heat Exchangers:
 - a. Source-side coaxial heat exchangers with **[copper][cupronickel][internal vented double wall]** water tube, with enhanced heat-transfer surfaces inside a steel shell; both shell and tube are leak tested to **450 psig (3102 kPa)** on refrigerant side and **400 psig (2758 kPa)** on water side.
 - b. Load-side coaxial heat exchangers with **[copper][cupronickel]** water tube, with enhanced heat-transfer surfaces inside a steel shell; both shell and tube are leak tested to **450 psig (3102 kPa)** on refrigerant side and **400 psig (2758 kPa)** on water side.
 - c. Stainless-steel, brazed-plate heat exchanger is leak tested to **450 psig (3102 kPa)** on refrigerant side and **400 psig (2758 kPa)** on water side. Factory mount heat exchanger in unit on resilient rubber vibration isolators.
 - d. Hot-water generator, **[copper water tube][vented double wall copper tube]** with enhanced heat-transfer surfaces inside a steel shell; both shell and tube are leak tested to **450 psig (3102 kPa)** on refrigerant side and **400 psig (2758 kPa)** on water side, pump, circuit breaker, high water temperature and low water refrigerant cutoffs, and tank connection.
- F. Refrigerant Circuit Components:
1. Sealed Refrigerant Circuit: Charge with R-410A refrigerant.
 2. Filter-Dryer: Factory installed to clean and dehydrate the refrigerant circuit.
 3. Charging Connections: Service fittings on suction and liquid for charging and testing on each circuit.
 4. Reversing Valve: Four-way, solenoid-activated valve designed to be fail-safe in heating position with replaceable magnetic coil.
 5. Compressor:
 - a. Scroll.

- b. **[Single stage][Two stage][Variable speed].**
- c. Installed on vibration isolators and mounted on a structural steel base plate and full-length channel stiffeners.
- d. Exterior of compressor shall be wrapped with a high-density sound-attenuating blanket and housed in an acoustically treated enclosure.
- e. Factory-Installed Safeties:
 - 1) Antirecycle timer.
 - 2) High-pressure cutout.
 - 3) Low-pressure cutout or loss of charge switch.
 - 4) Internal thermal-overload protection.
 - 5) Freezestat to stop compressor if water-loop temperature in refrigerant-to-water heat exchanger falls below **[35 deg F (2 deg C)]<Insert temperature>**.
 - 6) Water-coil, low-temperature switch.
- 6. Refrigerant Piping Materials: ASTM B743 copper tube with wrought-copper fittings and brazed joints.
- 7. Pipe Insulation: Refrigerant minimum **3/8-inch- (10-mm-)** thick, flexible elastomeric insulation on piping exposed to airflow through the unit. Maximum 25/50 flame-spread/smoke-developed indexes according to ASTM E84.
- 8. Refrigerant Metering Device:
 - a. Thermal-expansion valve.
 - b. Dual-port, thermal-expansion valve to allow specified operation with entering-water temperatures from **[25 to 125 deg F (minus 4 to plus 52 deg C)]<Insert temperature range>**.
- G. Control equipment and sequence of operation are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."
- H. Controls:
 - 1. Basic Unit Control Modes and Devices:
 - a. Unit shutdown on high or low refrigerant pressures.
 - b. Unit shutdown on low water temperature.
 - c. Low- and high-voltage protection.
 - d. Overcurrent protection for compressor.
 - e. Random time delay, three to 10 seconds, start on power-up.
 - f. Time delay override for servicing.
 - g. Control voltage transformer.
 - h. Water-coil freeze protection (selectable for water or antifreeze).
 - i. Automatic intelligent reset. Unit shall automatically reset five minutes after trip if the fault has cleared. Should a fault reoccur three times sequentially, lockout requiring manual reset occurs.
 - j. Ability to defeat time delays for servicing.
 - k. Digital display to indicate high pressure, low pressure, low voltage, and high voltage.
 - l. The low-pressure switch shall not be monitored for the first 90 seconds after a compressor start command to prevent nuisance safety trips.
 - m. Remote fault-type indication at thermostat.
 - n. Selectable 24-V dc or pilot duty dry contact alarm output.
 - o. 24-V dc output to cycle a motorized water valve with compressor contactor.
 - p. Service test mode for troubleshooting and service.
 - q. Unit-performance sentinel warns when heat pump is running inefficiently.
 - r. Compressor soft start.

2. Thermostat:
 - a. Wall-Mounted Thermostat:
 - 1) Heat-cool-off switch.
 - 2) **[Five day][Seven day]**, programmable.
 - 3) **[Manual][Automatic]** changeover.
 - 4) **[Concealed][Exposed]** temperature set point.
 - 5) **[Concealed][Exposed]** temperature indication.
 - 6) Deg **[F][C]** indication.
 - b. Wall-mounted temperature sensor.
 - c. Duct-mounted temperature sensor
 - d. Unoccupied period override push button.
 - e. Digital display to indicate fault condition at heat pump.
 - f. Data entry and access port.
 - 1) Input data include room temperature and humidity set points for occupied and unoccupied periods.
 - 2) Output data include room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.
3. Terminal Controller:
 - a. Scheduled operation for occupied and unoccupied periods on **[seven][365]**-day clock with minimum of four programmable periods per day.
 - b. **[Two]<Insert number>**-hour unoccupied override period.
 - c. Remote-control panel to contain programmable timer and digital display for fault condition.
 - d. Compressor-disable relay to stop compressor operation for demand limiting or switch to unoccupied operation.
 - e. Automatic restart after five minutes if fault clears. Lockout after three attempts to restart following fault. Indicate fault for service technician.
 - f. Backup for volatile memory.
4. DDC interface requirements as further described in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."
 - a. Interface relay for scheduled operation.
 - b. Interface relay to provide indication of fault at central workstation.
 - c. Provide **[BAC-net][or][LonWorks]** interface for central DDC workstation for the following functions:
 - 1) Set-point adjustment.
 - 2) Start/stop and operating status of heat-pump unit.
 - 3) Data inquiry to include supply-air and room-air temperature and humidity, and entering-water temperature.
 - 4) Occupied and unoccupied schedules.
- I. Electrical Connection: Single electrical connection **[with fused disconnect]**.
- J. Capacities and Characteristics:
 1. Source-Side Water Supply:
 - a. Water Flow: **<Insert gpm (L/s)>**.
 - b. Pressure Loss: **<Insert feet wg (kPa)>**.

- c. Entering-Water Temperature (Cooling): **<Insert deg F (deg C)>**.
- d. Entering-Water Temperature (Heating): **<Insert deg F (deg C)>**.
- e. Antifreeze Protection Chemical: **<Insert chemical name>**.
- f. Antifreeze Concentration: **<Insert percentage>**.

2. Load-Side Water Supply:

- a. Water Flow: **<Insert gpm (L/s)>**.
- b. Pressure Loss: **<Insert feet wg (kPa)>**.
- c. Entering-Water Temperature (Cooling): **<Insert deg F (deg C)>**.
- d. Entering-Water Temperature (Heating): **<Insert deg F (deg C)>**.
- e. Antifreeze Protection Chemical: **<Insert chemical name>**.
- f. Antifreeze Concentration: **<Insert percentage>**.

3. Cooling:

- a. Total Capacity: **<Insert Btu/h (kW)>**.
- b. Sensible Capacity: **<Insert Btu/h (kW)>**.
- c. Minimum Energy-Efficiency Ratio (EER): **<Insert value>**.

4. Heating:

- a. Capacity: **<Insert Btu/h (kW)>**.
- b. Minimum Coefficient of Performance (COP): **<Insert value>**.

5. Electrical Characteristics for Single Connection:

- a. Volts: **[120][208][230]<Insert number> V**.
- b. Phase: **[Single][Three]**.
- c. Hertz: **60**.
- d. Full-Load Amperes (FLA): **<Insert number> A**.
- e. Maximum Circuit Amperage (MCA): **<Insert number> A**.
- f. Maximum Overcurrent Protection (MOCP): **<Insert number> A**.

2.3 WATER-SOURCE UNITARY HEAT PUMPS LARGER THAN 6 TONS (21 kW)

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

- 1. **[Carrier Global Corporation]**
- 2. **[ClimateMaster, Inc.]**
- 3. **[FHP Manufacturing Inc.]**
- 4. **[Hydro-Temp Corporation, Inc.]**
- 5. **[Mammoth; a brand of Nortek Air Solutions]**
- 6. **[Trane]**
- 7. **[WaterFurnace International, Inc.]**
- 8. **<Insert manufacturer's name>**

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

- 1. **[Carrier Global Corporation]**
- 2. **[ClimateMaster, Inc.]**

3. [FHP Manufacturing Inc.]
 4. [Hydro-Temp Corporation, Inc.]
 5. [Mammoth; a brand of Nortek Air Solutions]
 6. [Trane]
 7. [WaterFurnace International, Inc.]
 8. <Insert manufacturer's name>
- C. Description: Packaged water-source unitary heat pump with temperature controls; factory assembled, piped, wired, tested, and rated according to ASHRAE/ARI/ISO-13256-1.
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency and marked for intended location and application.
- D. Cabinet and Chassis: Galvanized-steel casing with the following features:
1. Access panel for access and maintenance of internal components.
 2. Knockouts for electrical and piping connections.
 3. Cabinet Insulation: Glass-fiber liner, minimum [1/2 inch (13 mm)], [3/4 inch (19 mm)] thick, complying with UL 181, ASTM C1071, and ASTM G21.
- E. Water Circuits:
1. Refrigerant-to-Water Heat Exchangers:
 - a. Source-side coaxial heat exchangers with [copper][cupronickel][internal vented double wall] water tube, with enhanced heat-transfer surfaces inside a steel shell; both shell and tube are leak tested to **450 psig (3102 kPa)** on refrigerant side and **400 psig (2758 kPa)** on water side.
 - b. Load-side coaxial heat exchangers with [copper][cupronickel] water tube, with enhanced heat-transfer surfaces inside a steel shell; both shell and tube are leak tested to **450 psig (3102 kPa)** on refrigerant side and **400 psig (2758 kPa)** on water side.
 - c. Stainless-steel, brazed-plate heat exchanger is leak tested to **450 psig (3102 kPa)** on refrigerant side and **400 psig (2758 kPa)** on water side. Factory mount heat exchanger in unit on resilient rubber vibration isolators.
 - d. Hot-water generator, [copper water tube][vented double wall copper tube] with enhanced heat-transfer surfaces inside a steel shell; both shell and tube are leak tested to **450 psig (3102 kPa)** on refrigerant side and **400 psig (2758 kPa)** on water side, pump, circuit breaker, high water temperature and low water refrigerant cutoffs, and tank connection.
- F. Refrigerant Circuit Components:
1. Sealed Refrigerant Circuit: Charge with R-410A refrigerant.
 2. Filter-Dryer: Factory installed to clean and dehydrate the refrigerant circuit.
 3. Charging Connections: Service fittings on suction and liquid for charging and testing on each circuit.
 4. Reversing Valve: Four-way, solenoid-activated valve designed to be fail-safe in heating position with replaceable magnetic coil.
 5. Compressor:
 - a. Scroll.
 - b. [Single stage][Two stage][Variable speed].
 - c. Installed on vibration isolators and mounted on a structural steel base plate and full-length channel stiffeners.
 - d. Exterior of compressor shall be wrapped with a high-density sound-attenuating blanket and housed in an acoustically treated enclosure.

- e. Factory-Installed Safeties:
 - 1) Antirecycle timer.
 - 2) High-pressure cutout.
 - 3) Low-pressure cutout or loss of charge switch.
 - 4) Internal thermal-overload protection.
 - 5) Freezestat to stop compressor if water-loop temperature in refrigerant-to-water heat exchanger falls below **[35 deg F (2 deg C)]<Insert temperature>**.
 - 6) Water-coil, low-temperature switch.
- 6. Refrigerant Piping Materials: ASTM B743 copper tube with wrought-copper fittings and brazed joints.
- 7. Pipe Insulation: Refrigerant minimum **3/8-inch- (10-mm-)** thick, flexible elastomeric insulation on piping exposed to airflow through the unit. Maximum 25/50 flame-spread/smoke-developed indexes according to ASTM E84.
- 8. Refrigerant Metering Device:
 - a. Thermal-expansion valve.
 - b. Dual-port, thermal-expansion valve to allow specified operation with entering-water temperatures from **[25 to 125 deg F (minus 4 to plus 52 deg C)]<Insert temperature range>**.
- G. Control equipment and sequence of operation are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."
- H. Controls:
 - 1. Basic Unit Control Modes and Devices:
 - a. Unit shutdown on high or low refrigerant pressures.
 - b. Unit shutdown on low water temperature.
 - c. Low- and high-voltage protection.
 - d. Overcurrent protection for compressor.
 - e. Random time delay, three to 10 seconds, start on power-up.
 - f. Time delay override for servicing.
 - g. Control voltage transformer.
 - h. Water-coil freeze protection (selectable for water or antifreeze).
 - i. Automatic intelligent reset. Unit shall automatically reset five minutes after trip if the fault has cleared. Should a fault reoccur three times sequentially, lockout requiring manual reset occurs.
 - j. Ability to defeat time delays for servicing.
 - k. Digital display to indicate high pressure, low pressure, low voltage, and high voltage.
 - l. The low-pressure switch shall not be monitored for the first 90 seconds after a compressor start command to prevent nuisance safety trips.
 - m. Remote fault-type indication at thermostat.
 - n. Selectable 24-V dc or pilot duty dry contact alarm output.
 - o. 24-V dc output to cycle a motorized water valve with compressor contactor.
 - p. Service test mode for troubleshooting and service.
 - q. Unit-performance sentinel warns when heat pump is running inefficiently.
 - r. Compressor soft start.
 - 2. Thermostat:
 - a. Wall-Mounted Thermostat:

- 1) Heat-cool-off switch.
 - 2) **[Five day][Seven day]**, programmable
 - 3) **[Manual][Automatic]** changeover.
 - 4) **[Concealed][Exposed]** temperature set point.
 - 5) **[Concealed][Exposed]** temperature indication.
 - 6) Deg **[F][C]** indication.
- b. Wall-mounted temperature sensor.
 - c. Duct-mounted temperature sensor
 - d. Unoccupied period override push button.
 - e. Digital display to indicate fault condition at heat pump.
 - f. Data entry and access port.
- 1) Input data include room temperature and humidity set points for occupied and unoccupied periods.
 - 2) Output data include room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.
3. Terminal Controller:
 - a. Scheduled operation for occupied and unoccupied periods on **[seven][365]**-day clock with minimum of four programmable periods per day.
 - b. **[Two]<Insert number>**-hour unoccupied override period.
 - c. Remote-control panel to contain programmable timer and digital display for fault condition.
 - d. Compressor-disable relay to stop compressor operation for demand limiting or switch to unoccupied operation.
 - e. Automatic restart after five minutes if fault clears. Lockout after three attempts to restart following fault. Indicate fault for service technician.
 - f. Backup for volatile memory.
 4. DDC interface requirements as further described in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."
 - a. Interface relay for scheduled operation.
 - b. Interface relay to provide indication of fault at central workstation.
 - c. Provide **[BAC-net][or][LonWorks]** interface for central DDC workstation for the following functions:
 - 1) Set-point adjustment.
 - 2) Start/stop and operating status of heat-pump unit.
 - 3) Data inquiry to include supply-air and room-air temperature and humidity, and entering-water temperature.
 - 4) Occupied and unoccupied schedules.
- I. Electrical Connection: Single electrical connection **[with fused disconnect]**.
 - J. Capacities and Characteristics:
 1. Source-Side Water Supply:
 - a. Water Flow: **<Insert gpm (L/s)>**.
 - b. Pressure Loss: **<Insert feet wg (kPa)>**.
 - c. Entering-Water Temperature (Cooling): **<Insert deg F (deg C)>**.
 - d. Entering-Water Temperature (Heating): **<Insert deg F (deg C)>**.
 - e. Antifreeze Protection Chemical: **<Insert chemical name>**.
 - f. Antifreeze Concentration: **<Insert percentage>**.

2. Load-Side Water Supply:
 - a. Water Flow: **<Insert gpm (L/s)>**.
 - b. Pressure Loss: **<Insert feet wg (kPa)>**.
 - c. Entering-Water Temperature (Cooling): **<Insert deg F (deg C)>**.
 - d. Entering-Water Temperature (Heating): **<Insert deg F (deg C)>**.
 - e. Antifreeze Protection Chemical: **<Insert chemical name>**.
 - f. Antifreeze Concentration: **<Insert percentage>**.
3. Cooling:
 - a. Total Capacity: **<Insert Btu/h (kW)>**.
 - b. Sensible Capacity: **<Insert Btu/h (kW)>**.
 - c. Minimum Energy-Efficiency Ratio (EER): **<Insert value>**.
4. Heating:
 - a. Capacity: **<Insert Btu/h (kW)>**.
 - b. Minimum Coefficient of Performance (COP): **<Insert value>**.
5. Electrical Characteristics for Single Connection:
 - a. Volts: **[120][208][230]<Insert number> V**.
 - b. Phase: **[Single][Three]**.
 - c. Hertz: 60.
 - d. Full-Load Amperes (FLA): **<Insert number> A**.
 - e. Maximum Circuit Amperage (MCA): **<Insert number> A**.
 - f. Maximum Overcurrent Protection (MOCP): **<Insert number> A**.

2.4 ACCESSORIES

- A. Hose Kits: Tag hose kits to equipment designations.
 1. Minimum Working Pressure: **400 psig (2758 kPa)**.
 2. Operating Temperatures: From **33 to 211 deg F (1 to 100 deg C)**.
 3. Hose Length: **[24 inches (600 mm)][36 inches (900 mm)]<Insert dimension>**.
 4. Minimum Hose Diameter: Equal to water-source unitary heat-pump piping connection.
 5. Hose Material: Braided stainless steel with adapters for pipe connections.
 6. Isolation Valves: Two-piece, bronze-body ball valves with stainless-steel ball and stem, standard-port threaded connections, and galvanized-steel lever handle. Valves shall be factory installed on supply and return connections of both load-side and source-side heat exchangers. If balancing valve is combination shutoff type with memory stop, the isolation valve may be omitted on the return.
 7. Strainer: Y-pattern with blowdown valve in supply connections of both load and source side of heat exchangers.
 8. Balancing Valves: Mount in return connection. Include meter ports to allow flow measurement with differential pressure gage.
 - a. Automatic balancing valve, factory set to operate within 10 percent of design flow rate over a pressure range of **2 to 80 psig (13.8 to 552 kPa)**.
 - b. Manual, calibrated-orifice balancing valve with memory stop.
 - c. Manual, venturi-type balancing valve with memory stop.
 9. Water-Regulating Valve Assemblies: A direct acting valve regulates discharge pressure during

- the cooling cycle, and a reverse acting valve regulates the suction pressure during the heating cycle. Valves shall close when heat-pump compressor is not running.
10. Motorized Water Valve: Stop water flow through the unit when compressor is off. Slow-acting, 24-V dc valve with threaded connections is installed between isolation valves and heat exchanger.
- B. Hose Kit Assemblies:
1. Minimum Working Pressure: **400-psig (2758-kPa)**.
 2. Operating Temperatures: From **33 to 211 deg F (1 to 100 deg C)**.
 3. Hose Length: **[24 inches (600 mm)][36 inches (900 mm)]<Insert dimension>**.
 4. Minimum Hose Diameter: Equal to water-source unitary heat-pump piping connection.
 5. Hose Material: Braided stainless steel with adapters for pipe connections.
 6. Supply and return hoses having ball valve with pressure-temperature port.
 7. Supply hose having ball valve with pressure-temperature port; return hose having automatic flow regulator valve with pressure-temperature ports and ball valve.
 8. Supply hose having Y-pattern strainer with blowdown valve and ball valve with pressure-temperature port; return hose having automatic flow regulator with pressure-temperature ports and ball valve.
 9. Supply hose having Y-pattern strainer with blowdown valve and ball valve with pressure-temperature port; return hose having ball valve with pressure-temperature port.
- C. Loop Controller: Six stages; two stages for heating and four stages for cooling.
- D. Pump Module:
1. Minimum **[1/6-hp]<Insert motor size>**, **[230-V][120-V]**, single-phase pump, rated for at least **[16 gpm (1 L/s)]<Insert value>** at **[20 feet of head (59 kPa)]<Insert value>**.
 2. General requirements for motors are specified in Section 230500 "Common Work Results for HVAC."
 3. Include pump module hose kit with thread to barb fittings, hose, and hose clamps.
 4. Three-way brass shut-off/flushing/purging valve.
 5. Include controls to operate pump as required to maintain room temperature and ventilation set points.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping and electric installations for water-source unitary heat pumps to verify actual locations of piping connections and electrical conduits before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF WATER-SOURCE UNITARY HEAT PUMPS

- A. Equipment Mounting:
 1. Install water-source, unitary heat pumps on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."

2. Comply with requirements for vibration-isolation and seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration-isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

- B. Suspend water-source, unitary heat pumps from structure with all-thread hanger rods and **[elastomeric hangers][spring hangers][spring hangers with vertical-limit stop]**. Hanger rods and attachments to structure are specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment." Vibration hangers are specified in **[Section 230548 "Vibration and Seismic Controls for HVAC."][Section 230548.13 "Vibration Controls for HVAC."]**
- C. Install wall-mounting thermostats and switch controls in electrical outlet boxes at heights to match lighting controls or as required in Section 230923 "Direct Digital Control (DDC) System for HVAC."

3.3 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
 1. Connect supply and return hydronic piping to heat pump with **[unions and shutoff valves][hose kits]**.
- B. Install electrical devices furnished by manufacturer but not specified to be factory mounted.
- C. Install piping adjacent to machine to allow space for service and maintenance.

3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform the following field tests and inspections:
 1. After installing water to water heat pumps and after electrical circuitry has been energized, test units for compliance with requirements.
 2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Heat pumps will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

3.5 STARTUP SERVICE

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.
 1. Complete installation and startup checks according to manufacturer's written instructions.
 2. Inspect for visible damage to unit casing.

3. Inspect for visible damage to compressor and coils.
4. Inspect internal insulation.
5. Verify that labels are clearly visible.
6. Verify that clearances have been provided for servicing.
7. Verify that controls are connected and operable.
8. Adjust vibration isolators.
9. Start unit according to manufacturer's written instructions.
10. Complete startup sheets and attach copy with Contractor's startup report.
11. Inspect and record performance of interlocks and protective devices; verify sequences.
12. Operate unit for an initial period as recommended or required by manufacturer.
13. Verify thermostat calibration.
14. Inspect controls for correct sequencing of heating, refrigeration, and normal and emergency shutdown.

3.6 ADJUSTING

- A. Adjust initial temperature set points.
- B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- C. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to **[two]<Insert number>** visits to Project during other-than-normal occupancy hours for this purpose.

3.7 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain water-source unitary heat pumps.

END OF SECTION 23 81 46 00



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SECTION 23 81 46 00A - WATER-TO-AIR HEAT PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Concealed water-source heat pumps, 6 tons (21 kW) and smaller.
2. Concealed water-source heat pumps larger than 6 tons (21 kW).
3. Vertical-stack, water-source heat pumps.
4. Exposed, console water-source heat pumps.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, furnished specialties, and accessories for each model.

B. Sustainable Design Submittals:

1. Product data showing compliance with ASHRAE 62.1.
2. Product Data: For energy performance.

C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

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

D. Samples: For each exposed product and for each color and texture specified.

E. Samples for Initial Selection: For units with factory-applied color finishes.

F. Samples for Verification: For each type of unit indicated.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which heat pumps are attached.
3. Method of attaching hangers to building structure.
4. Size and location of initial access modules for acoustical tile.
5. Items penetrating finished ceiling, including the following:
 - a. Lighting fixtures.
 - b. Air outlets and inlets.
 - c. Speakers.



- d. Sprinklers.
- e. Access panels.
- f. <Insert item>.

- B. Product Certificates: For each type of water-source unitary heat pump, signed by product manufacturer.
- C. Seismic Qualification Data: Submit certification that water-source heat pumps, accessories, and components will withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC." Include the following:
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
 - b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified, and the unit will be fully operational after the seismic event."
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity, and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. Field quality-control reports.
- E. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For water-to-air heat pumps to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. [One]<Insert number> set(s) of matched fan belts for each belt-driven fan.
 - 2. [One]<Insert number> set(s) of filters for each unit.
 - 3. [One]<Insert number> spare heat-pump unit(s) of each size and model furnished.

1.6 QUALITY ASSURANCE

- A. ASHRAE Compliance:
 - 1. ASHRAE 15.
 - 2. Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- B. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating,

Ventilating, and Air-Conditioning."

- C. Comply with NFPA 70.
- D. Comply with safety requirements in UL 484 for assembly of free-delivery, water-source heat pumps.
- E. Comply with safety requirements in UL 1995 for duct-system connections.

1.7 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of water-source heat pumps that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, refrigeration components.
 - 2. Warranty Period: **[Four]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 CONCEALED WATER-SOURCE HEAT PUMPS, 6 TONS (21 kW) AND SMALLER

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1. **[Carrier Global Corporation]**
 - 2. **[ClimateMaster, Inc.]**
 - 3. **[FHP Manufacturing Inc.]**
 - 4. **[Hydro-Temp Corporation, Inc.]**
 - 5. **[Mammoth; a brand of Nortek Air Solutions]**
 - 6. **[Trane Inc.]**
 - 7. **[WaterFurnace International, Inc.]**
 - 8. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Carrier Global Corporation]**
 - 2. **[ClimateMaster, Inc.]**
 - 3. **[FHP Manufacturing Inc.]**
 - 4. **[Hydro-Temp Corporation, Inc.]**
 - 5. **[Mammoth; a brand of Nortek Air Solutions]**
 - 6. **[Trane Inc.]**
 - 7. **[WaterFurnace International, Inc.]**
 - 8. **<Insert manufacturer's name>**
- C. Description: Packaged water-source heat pump with temperature controls; factory assembled, tested, and rated according to ASHRAE/ARI/ISO-13256-1.
 - 1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended location and application.

- D. Cabinet and Chassis: Galvanized-steel casing with the following features:
1. Access panel for access and maintenance of internal components.
 2. Knockouts for electrical and piping connections.
 3. Flanged duct connections.
 4. Cabinet Insulation: Glass-fiber liner, minimum **1/2 inch (13 mm)** thick, complying with UL 181, ASTM C1071, and ASTM G21.
 5. Units field convertible for various discharge configurations.
 6. Condensate Drainage: High-density polyethylene plastic or stainless-steel drain pan with condensate drain piping projecting through unit cabinet and complying with ASHRAE 62.1.
 - a. Condensate Overflow Protection Switch: Solid state electronic; mechanical float switch not permitted.
 7. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
 8. Sound Attenuation Package: Provide one or more of the following:
 - a. Minimum **0.598-inch- (1.5-mm-)** thick compressor enclosure and front panel. Minimum **0.0937-inch- (2.38-mm-)** thick foam gasket around the compressor and perimeter of end panel.
 - b. Sound attenuating blanket over compressor.
 - c. Hot-gas muffler.
 - d. **<Insert method>**.
- E. Fan: Direct driven, centrifugal, with multispeed motor resiliently mounted in fan inlet and with inlet rings to allow wheel removal from one side without removing housing.
1. General requirements for motors are specified in Section 230500 "Common Work Results for HVAC."
 2. Motor: Multispeed, permanently lubricated, **[permanent split capacitor][ECM]** motor.
- F. Water Circuit:
1. Refrigerant-to-Water Heat Exchangers:
 - a. Coaxial heat exchangers with **[copper][cupronickel]** water tube with enhanced heat-transfer surfaces inside a steel shell; both shell and tube are leak tested to **450 psig (3102 kPa)** on refrigerant side and **400 psig (2758 kPa)** on water side. Factory mount heat exchanger in unit on resilient rubber vibration isolators.
 - b. Stainless-steel, brazed-plate heat exchanger is leak tested to **450 psig (3102 kPa)** on refrigerant side and **400 psig (2758 kPa)** on water side. Factory mount heat exchanger in unit on resilient rubber vibration isolators.
 2. Water-Regulating Valves: Limit water flow through refrigerant-to-water heat exchanger, and control head pressure on compressor during cooling and heating. Valves shall close when heat-pump compressor is not running.
 3. Motorized Water Valve: Stop water flow through the unit when compressor is off.
- G. Refrigerant-to-Air Coils: Copper tubes with aluminum fins, leak tested to **450 psig (3102 kPa)**.
- H. Refrigerant Circuit Components:
1. Sealed Refrigerant Circuit: Charge with R-410A refrigerant.
 2. Filter-Dryer: Factory installed to clean and dehydrate the refrigerant circuit.

3. Charging Connections: Service fittings on suction and liquid for charging and testing on each circuit.
4. Reversing Valve: Four-way, solenoid-activated valve designed to be fail-safe in heating position with replaceable magnetic coil.
5. Compressor: Hermetic **[rotary][reciprocating][scroll]**, **[single-stage][two-stage]** compressor installed on vibration isolators and housed in an acoustically treated enclosure with factory-installed safeties as follows:
 - a. Antirecycle timer.
 - b. High-pressure cutout.
 - c. Low-pressure cutout or loss of charge switch.
 - d. Internal thermal-overload protection.
 - e. Freezestat to stop compressor if water-loop temperature in refrigerant-to-water heat exchanger falls below **[35 deg F (2 deg C)]<Insert temperature>**.
 - f. Condensate overflow switch to stop compressor with high condensate level in condensate drain pan.
 - g. Water-coil, low-temperature switch.
 - h. Air-coil, low-temperature switch.
6. Refrigerant Piping Materials: ASTM B743 copper tube with wrought-copper fittings and brazed joints.
7. Pipe Insulation: Refrigerant minimum **3/8-inch- (10-mm-)** thick, flexible elastomeric insulation on piping exposed to airflow through the unit. Maximum 25/50 flame-spread/smoke-developed indexes according to ASTM E84.
8. Refrigerant Metering Device:
 - a. Thermal-expansion valve.
 - b. Refrigerant Metering Device: Dual-port, thermal-expansion valve to allow specified operation with entering-water temperatures from **[25 to 125 deg F (minus 4 to plus 52 deg C)]<Insert temperature range>**.
9. Hot-Gas Reheat Valve: Pilot-operated, sliding-type valve with replaceable magnetic coil.
- I. Electric Heating Coil: Helix-wound, nickel-chromium, wire-heating elements in ceramic insulators mounted on steel supports. Energize on call for heating when entering-water-loop temperature is less than **[25 deg F (minus 4 deg C)][40 deg F (5 deg C)][60 deg F (15 deg C)]<Insert temperature>**.
- J. Hot-Gas Reheat: Reheat valve diverts refrigerant hot gas to reheat coil when remote humidistat calls for dehumidification.
- K. Filters:
 1. Disposable, glass-fiber, flat type, **[1 inch (25 mm)]<Insert dimension>** thick, treated with adhesive, and having a minimum efficiency reporting value of 5 according to ASHRAE 52.2.
 2. Disposable, pleated type, **[1 inch (25 mm)]<Insert dimension>** thick and with a minimum efficiency reporting value of 7 according to ASHRAE 52.2.
 3. Electronic air cleaner type; **1 inch (25 mm)**; cleanable.
 4. Disposable, pleated type, **[4 inches (100 mm)]<Insert dimension>** thick and with a minimum efficiency reporting value of 13 according to ASHRAE 52.2.
 5. Disposable, pleated type, **[2 inches (50 mm)]<Insert dimension>** thick and with a minimum efficiency reporting value of 11 according to ASHRAE 52.2.
- L. Control equipment and sequence of operation are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."
- M. Controls:

1. Basic Unit Control Modes and Devices:
 - a. Dehumidification mode.
 - b. Unit shutdown on high or low refrigerant pressures.
 - c. Unit shutdown on low water temperature.
 - d. Low- and high-voltage protection.
 - e. Overcurrent protection for compressor and fan motor.
 - f. Random time delay, three to ten seconds, start on power-up.
 - g. Time delay override for servicing.
 - h. Control voltage transformer.
 - i. Water-coil freeze protection (selectable for water or antifreeze).
 - j. Air-coil freeze protection (check filter switch).
 - k. Condensate overflow shutdown switch.
 - l. Option to reset unit at thermostat or disconnect.
 - m. Fault type shall be retained in memory if reset at thermostat.
 - n. Automatic intelligent reset. Unit shall automatically reset five minutes after trip if the fault has cleared. Should a fault reoccur three times sequentially, lockout requiring manual reset occurs.
 - o. Ability to defeat time delays for servicing.
 - p. Light-emitting diodes (LED) to indicate high pressure, low pressure, low voltage, and high voltage.
 - q. The low-pressure switch SHALL NOT be monitored for the first 90 seconds after a compressor start command to prevent nuisance safety trips.
 - r. Remote fault-type indication at thermostat.
 - s. Selectable 24-V dc or pilot duty dry contact alarm output.
 - t. 24-V dc output to cycle a motorized water valve with compressor contactor.
 - u. Electric heat output to control two stages of electric heat (emergency heat).
 - v. Service test mode for troubleshooting and service.
 - w. Unit-performance sentinel warns when the heat pump is running inefficiently.
2. Thermostat:
 - a. Wall-Mounted Thermostat:
 - 1) Heat-cool-off switch.
 - 2) Fan on-auto switch.
 - 3) **[Manual][Automatic]** changeover.
 - 4) **[Concealed][Exposed]** temperature set point.
 - 5) **[Concealed][Exposed]** temperature indication.
 - 6) Deg **[F][C]** indication.
 - b. Wall-Mounted Humidistat: **[Concealed][Exposed]**.
 - 1) Temperature set point.
 - 2) Temperature indication.
 - c. Wall-mounted temperature sensor.
 - d. Unoccupied period override push button.
 - e. LED to indicate fault condition at heat pump.
 - f. Data entry and access port.
 - 1) Input data include room temperature and humidity set points for occupied and unoccupied periods.
 - 2) Output data include room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.

3. Terminal Controller:
 - a. Scheduled operation for occupied and unoccupied periods on [seven][365]-day clock with minimum of four programmable periods per day.
 - b. [Two]<Insert number>-hour unoccupied override period.
 - c. Remote-control panel to contain programmable timer and LED for fault condition.
 - d. Compressor disable relay to stop compressor operation for demand limiting or switch to unoccupied operation.
 - e. Automatic restart after five minutes if fault clears. Lockout after three attempts to restart following fault. Indicate fault for service technician.
 - f. Return-air temperature high-limit (firestat). Stop unit on high temperature.
 - g. Backup for volatile memory.
 - h. Differential pressure switch to indicate fan status. Fan failure alarm.
 - i. Differential pressure switch to indicate filter status. Dirty filter alarm.
4. Interface with DDC system for HVAC requirements as further described in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."
 - a. Interface relay for scheduled operation.
 - b. Interface relay to provide indication of fault at central workstation.
 - c. Provide [BAC-net][or][LonWorks] interface for central DDC system for HVAC workstation for the following functions:
 - 1) Set-point adjustment for set points identified in this Section.
 - 2) Start/stop and operating status of heat-pump unit.
 - 3) Data inquiry to include supply air, room air temperature and humidity, and entering-water temperature.
 - 4) Occupied and unoccupied schedules.
- N. Electrical Connection: Single electrical connection[with fused disconnect].
- O. Capacities and Characteristics:
 1. Fan:
 - a. Airflow: <Insert cfm (L/s)>.
 - b. External Static Pressure: <Insert inches wg (kPa)>.
 - c. Fan Speed: <Insert rpm>.
 - d. Motor Speed: <Insert rpm>.
 - e. Motor Horsepower: <Insert value>.
 2. Water Supply:
 - a. Water Flow: <Insert gpm (L/s)>.
 - b. Pressure Loss: <Insert feet wg (kPa)>.
 - c. Entering-Water Temperature (Cooling): <Insert deg F (deg C)>.
 - d. Entering-Water Temperature (Heating): <Insert deg F (deg C)>.
 - e. Antifreeze Protection Chemical: <Insert chemical name>.
 - f. Antifreeze Concentration: <Insert percentage>.
 3. Cooling:
 - a. Total Capacity: <Insert Btu/h (kW)>.
 - b. Sensible Capacity: <Insert Btu/h (kW)>.
 - c. Minimum Energy-Efficiency Ratio (EER): <Insert value>.

- d. Entering-Air Temperature Dry Bulb: **<Insert deg F (deg C)>**.
- e. Entering-Air Temperature Wet Bulb: **<Insert deg F (deg C)>**.
- 4. Heating:
 - a. Capacity: **<Insert Btu/h (kW)>**.
 - b. Entering-Air Temperature: **<Insert deg F (deg C)>**.
 - c. Air Temperature Rise: **<Insert deg F (deg C)>**.
 - d. Minimum Coefficient of Performance (COP): **<Insert value>**.
- 5. Electric Heating Coil (Optional Feature):
 - a. Capacity: **<Insert Btu/h (kW)>**.
 - b. Number of Steps: **<Insert number>**.
- 6. Filters:
 - a. Face Area: **<Insert sq. ft. (sq. m)>**.
 - b. Maximum Face Velocity: **<Insert fpm (m/s)>**.
- 7. Electrical Characteristics for Single Connection:
 - a. Volts: **[120][208][230]<Insert value>**.
 - b. Phase: **[Single][Three]**.
 - c. Hertz: 60.
 - d. Full-Load Amperes (F.L.A.): **<Insert value>**.
 - e. Maximum Circuit Amperage (MCA): **<Insert value>**.
 - f. Maximum Overcurrent Protection (MOCP): **<Insert amperes>**.

2.2 CONCEALED WATER-SOURCE HEAT PUMPS LARGER THAN 6 TONS (21 kW)

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Carrier Global Corporation]**
 - 2. **[ClimateMaster, Inc.]**
 - 3. **[FHP Manufacturing Inc.]**
 - 4. **[Hydro-Temp Corporation, Inc.]**
 - 5. **[Mammoth; a brand of Nortek Air Solutions]**
 - 6. **[Trane Inc.]**
 - 7. **[WaterFurnace International, Inc.]**
 - 8. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Carrier Global Corporation]**
 - 2. **[ClimateMaster, Inc.]**
 - 3. **[FHP Manufacturing Inc.]**
 - 4. **[Hydro-Temp Corporation, Inc.]**
 - 5. **[Mammoth; a brand of Nortek Air Solutions]**
 - 6. **[Trane Inc.]**
 - 7. **[WaterFurnace International, Inc.]**

8. <Insert manufacturer's name>
- C. Description: Packaged water-source heat pump with temperature controls; factory assembled, tested, and rated according to ASHRAE/ARI/ISO-13256-1.
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended location and application.
- D. Cabinet and Chassis: Galvanized-steel casing with the following features:
1. Access panel for access and maintenance of internal components.
2. Knockouts for electrical and piping connections.
3. Flanged duct connections.
4. Cabinet Insulation: Glass-fiber liner, minimum **1/2 inch (13 mm)** thick, complying with UL 181, ASTM C1071, and ASTM G21.
5. Units field convertible for various discharge configurations.
6. Condensate Drainage: High-density polyethylene plastic or stainless-steel drain pan with condensate drain piping projecting through unit cabinet and complying with ASHRAE 62.1.
- a. Condensate Overflow Protection Switch: Solid state electronic; mechanical float switch not permitted.
7. Airstream Surfaces: Surfaces lined with one-half-thick, foil-backed fiber insulation in contact with the airstream shall comply with requirements in ASHRAE 62.1.
8. Sound Attenuation Package: Provide one or more of the following:
- a. Minimum **0.598-inch- (1.5-mm-)** thick compressor enclosure and front panel. Minimum **0.0937-inch- (2.38-mm-)** thick foam gasket around the compressor and perimeter of end panel.
- b. Sound attenuating blanket over compressor.
- c. Hot-gas muffler.
- d. <Insert method>.
- E. Fan: Belt driven, centrifugal, with motor installed on an adjustable fan base resiliently mounted in chassis and with inlet rings to allow wheel removal from one side without removing housing.
1. General requirements for motors are specified in Section 230500 "Common Work Results for HVAC."
2. Motor: Single-speed, permanently lubricated, ECM motor.
- F. Water Circuit:
1. Refrigerant-to-Water Heat Exchanger:
- a. **[Coaxial][Coil-in-shell][Shell-and-tube]** heat exchanger with **[copper][cupronickel]** water tube with enhanced heat-transfer surfaces inside a steel shell; both shell and tube are leak tested to **450 psig (3102 kPa)** on refrigerant side and **400 psig (2758 kPa)** on water side. Factory mount heat exchanger in unit on resilient rubber vibration isolators.
- b. Stainless-steel, brazed-plate heat exchanger is leak tested to **450 psig (3102 kPa)** on refrigerant side and **400 psig (2758 kPa)** on water side. Factory mount heat exchanger in unit on resilient rubber vibration isolators.
2. Water-Regulating Valves: Limit water flow through refrigerant-to-water heat exchanger, and control head pressure on compressor during cooling and heating. Valves shall close when heat-pump compressor is not running.

3. Motorized Water Valve: Stop water flow through the unit when compressor is off.
- G. Refrigerant-to-Air Coils: Copper tubes with aluminum fins, leak tested to **450 psig (3102 kPa)**.
- H. Refrigerant Circuit Components:
 1. Sealed Refrigerant Circuit: Minimum of two circuits required for units [**10 tons (35 kW)**]**<Insert value>** and larger. Intertwine circuits in refrigerant to air coil.
 - a. Charge with R-410A refrigerant.
 2. Filter-Dryer: Factory installed to clean and dehydrate each refrigerant circuit.
 3. Charging Connections: Service fittings on suction and liquid for charging and testing on each circuit.
 4. Reversing Valve: Four-way, solenoid-activated valve designed to be fail-safe in heating position with replaceable magnetic coil.
 5. Compressor: [**Hermetic reciprocating**][**Scroll**][**Single-stage**][**Two-stage**] compressor installed on vibration isolators housed in an acoustically treated enclosure with factory-installed safeties as follows:
 - a. Antirecycle timer.
 - b. High-pressure cutout.
 - c. Low-pressure cutout or loss of charge switch.
 - d. Internal thermal-overload protection.
 - e. Freezestat to stop compressor if water-loop temperature in refrigerant-to-water heat exchanger falls below [**35 deg F (2 deg C)**]**<Insert temperature>**.
 - f. Condensate overflow switch to stop compressor with high condensate level in condensate drain pan.
 - g. Water-coil, low-temperature switch.
 - h. Air-coil, low-temperature switch.
 6. Refrigerant Piping Materials: ASTM B743 copper tube with wrought-copper fittings and brazed joints.
 7. Pipe Insulation: Refrigerant minimum **3/8-inch- (10-mm-)** thick, flexible elastomeric insulation on piping exposed to airflow through the unit. Maximum 25/50 flame-spread/smoke-developed indexes per ASTM E84.
 8. Refrigerant Metering Device: Dual-port, thermal-expansion valve to allow specified operation with entering-water temperatures from **25 to 125 deg F (minus 4 to plus 52 deg C)**.
 9. Hot-Gas Reheat Valve: Pilot-operated, sliding-type valve with replaceable magnetic coil.
- I. Electric Heating Coil: Helix-wound, nickel-chromium, wire-heating elements in ceramic insulators mounted on steel supports. Energize on call for heating when entering-water-loop temperature is less than [**25 deg F (minus 4 deg C)**][**40 deg F (5 deg C)**][**60 deg F (15 deg C)**]**<Insert temperature>**.
- J. Hot-Gas Reheat: Reheat valve diverts refrigerant hot gas to reheat coil when remote humidistat calls for dehumidification.
- K. Hot-Gas Bypass: Include constant pressure expansion valve, solenoid valve, and controls to maintain continuous refrigeration system operation at 10 percent of full load on lead compressor.
- L. Filters:
 1. Disposable, glass-fiber, flat type, [**1 inch (25 mm)**][**2 inches (50 mm)**][**4 inches (100 mm)**]**<Insert dimension>** thick, treated with adhesive, and having a minimum efficiency reporting value of 5 according to ASHRAE 52.2.

2. Disposable, pleated type, [1 inch (25 mm)]<Insert dimension> thick and with a minimum efficiency reporting value of 7 according to ASHRAE 52.2.
 3. Disposable, pleated type, [2 inches (50 mm)]<Insert dimension> thick and with a minimum efficiency reporting value of 11 according to ASHRAE 52.2.
 4. Disposable, pleated type, [4 inches (100 mm)]<Insert dimension> thick and with a minimum efficiency reporting value of 13 according to ASHRAE 52.2.
- M. Control equipment and sequence of operation are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."
- N. Controls:
1. Basic Unit Control Modes and Devices:
 - a. Dehumidification mode.
 - b. Unit shutdown on high or low refrigerant pressures.
 - c. Unit shutdown on low water temperature.
 - d. Low- and high-voltage protection.
 - e. Overcurrent protection for compressor and fan motor.
 - f. Random time delay, three to ten seconds, start on power-up.
 - g. Time delay override for servicing.
 - h. Control voltage transformer.
 - i. Water-coil freeze protection (selectable for water or antifreeze).
 - j. Air-coil freeze protection (check filter switch).
 - k. Condensate overflow shutdown switch.
 - l. Option to reset unit at thermostat or disconnect.
 - m. Fault type shall be retained in memory if reset at thermostat.
 - n. Automatic intelligent reset. Unit shall automatically reset five minutes after trip if the fault has cleared. Should a fault reoccur three times sequentially, lockout requiring manual reset occurs.
 - o. Ability to defeat time delays for servicing.
 - p. Light-emitting diodes (LED) to indicate high pressure, low pressure, low voltage, and high voltage.
 - q. The low-pressure switch SHALL NOT be monitored for the first 90 seconds after a compressor start command to prevent nuisance safety trips.
 - r. Remote fault-type indication at thermostat.
 - s. Selectable 24-V dc or pilot duty dry contact alarm output.
 - t. 24V dc output to cycle a motorized water valve with compressor contactor.
 - u. Electric heat output to control two stages of electric heat (emergency heat).
 - v. Service test mode for troubleshooting and service.
 - w. Unit-performance sentinel warns when the heat pump is running inefficiently.
 2. Thermostat:
 - a. Wall-Mounted Thermostat:
 - 1) Heat-cool-off switch.
 - 2) Fan on-auto switch.
 - 3) [Manual][Automatic] changeover.
 - 4) [Concealed][Exposed] temperature set point.
 - 5) [Concealed][Exposed] temperature indication.
 - 6) Deg [F][C] indication.
 - 7) [One][Two]-stage heating.
 - 8) [One][Two]-stage cooling.
 - b. Wall-Mounted Humidistat: [Concealed][Exposed].

- 1) Temperature set point.
 - 2) Temperature indication.
 - c. Wall-mounted temperature sensor.
 - d. Unoccupied period override push button.
 - e. LED to indicate fault condition at heat pump.
 - f. Data entry and access port.
 - 1) Input data include room temperature and humidity set points for occupied and unoccupied periods.
 - 2) Output data include room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.
3. Terminal Controller:
 - a. Scheduled operation for occupied and unoccupied periods on **[seven][365]**-day clock with minimum of four programmable periods per day.
 - b. **[Two]<Insert number>**-hour unoccupied override period.
 - c. Remote-control panel to contain programmable timer and LED for fault condition.
 - d. Compressor disable relay to stop compressor operation for demand limiting or switch to unoccupied operation.
 - e. Automatic restart after five minutes if fault clears. Lockout after three attempts to restart following fault. Indicate fault for service technician.
 - f. Return-air temperature high-limit (firestat). Stop unit on high temperature.
 - g. Smoke alarm with smoke detector installed in **[supply][return][supply and return]** air. Stop unit on smoke detection.
 - h. Backup for volatile memory.
 - i. Differential pressure switch to indicate fan status. Fan failure alarm.
 - j. Differential pressure switch to indicate filter status. Dirty filter alarm.
4. Interface with DDC system for HVAC requirements as further described in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."
 - a. Interface relay for scheduled operation.
 - b. Interface relay to provide indication of fault at central workstation.
 - c. Provide **[BAC-net][or][LonWorks]** interface for central DDC system for HVAC workstation for the following functions:
 - 1) Set-point adjustment for set points identified in this Section.
 - 2) Start/stop and operating status of heat-pump unit.
 - 3) Data inquiry to include supply air, room air temperature and humidity, and entering-water temperature.
 - 4) Occupied and unoccupied schedules.
- O. Electrical Connection: Single electrical connection **[with fused disconnect]**.
- P. Capacities and Characteristics:
 1. Fan:
 - a. Airflow: **<Insert cfm (L/s)>**.
 - b. External Static Pressure: **<Insert inches wg (kPa)>**.
 - c. Fan Speed: **<Insert rpm>**.
 - d. Motor Speed: **<Insert rpm>**.

- e. Motor Horsepower: **<Insert value>**.
- 2. Water Supply:
 - a. Water Flow: **<Insert gpm (L/s)>**.
 - b. Pressure Loss: **<Insert feet wg (kPa)>**.
 - c. Entering-Water Temperature (Cooling): **<Insert deg F (deg C)>**.
 - d. Entering-Water Temperature (Heating): **<Insert deg F (deg C)>**.
 - e. Antifreeze Protection Chemical: **<Insert chemical name>**.
 - f. Antifreeze Concentration: **<Insert percentage>**.
- 3. Cooling:
 - a. Total Capacity: **<Insert Btu/h (kW)>**.
 - b. Sensible Capacity: **<Insert Btu/h (kW)>**.
 - c. Minimum Energy-Efficiency Ratio (EER): **<Insert value>**.
 - d. Entering-Air Temperature Dry Bulb: **<Insert deg F (deg C)>**.
 - e. Entering-Air Temperature Wet Bulb: **<Insert deg F (deg C)>**.
- 4. Heating:
 - a. Capacity: **<Insert Btu/h (kW)>**.
 - b. Entering-Air Temperature: **<Insert deg F (deg C)>**.
 - c. Air Temperature Rise: **<Insert deg F (deg C)>**.
 - d. Minimum Coefficient of Performance (COP): **<Insert value>**.
- 5. Electric Heating Coil (Optional Feature):
 - a. Capacity: **<Insert Btu/h (kW)>**.
 - b. Number of Steps: **<Insert number>**.
- 6. Filters:
 - a. Face Area: **<Insert sq. ft. (sq. m)>**.
 - b. Maximum Face Velocity: **<Insert fpm (m/s)>**.
- 7. Electrical Characteristics for Single Connection:
 - a. Volts: **[120][208][230]<Insert value>**.
 - b. Phase: **[Single][Three]**.
 - c. Hertz: 60.
 - d. Full-Load Amperes (F.L.A.): **<Insert value>**.
 - e. Maximum Circuit Amperage (MCA): **<Insert value>**.
 - f. Maximum Overcurrent Protection (MOCP): **<Insert amperes>**.

2.3 VERTICAL-STACK, WATER-SOURCE HEAT PUMPS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[ClimateMaster, Inc.]**
 - 2. **[Trane Inc.]**
 - 3. **<Insert manufacturer's name>**



- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[ClimateMaster, Inc.]**
 2. **[Trane Inc.]**
 3. **<Insert manufacturer's name>**
- C. Description: Packaged water-source heat pump with temperature controls; factory assembled, tested, and rated according to ASHRAE/ARI/ISO-13256-1.
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended location and application.
- D. Cabinet and Chassis: Manufacturer's standard galvanized-steel casing with the following features:
1. Return-air opening with access panel for access to internal components.
 2. Knockouts for electrical and piping connections.
 3. Cabinet Insulation: Glass-fiber liner, minimum **1/2 inch (13 mm)** thick, complying with UL 181, ASTM C1071, and ASTM G21.
 4. Sound Attenuation Package: Provide one or more of the following.
 - a. Minimum **0.598-inch- (1.5-mm-)** thick compressor enclosure and front panel. Minimum **0.0937-inch (2.38-mm)** thick foam gasket around the compressor and perimeter of end panel.
 - b. **<Insert method>**.
 5. Condensate Drainage: High-density polyethylene plastic or stainless-steel drain pan with condensate drain piping projecting to unit exterior and complying with ASHRAE 62.1.
 - a. Condensate Overflow Protection: Solid state electronic; mechanical float switch not permitted.
 6. Discharge Grille: Double deflection grille for adjustable discharge air pattern.
 7. Discharge and Return Grille Color: Selected by Architect from manufacturer's **[standard][custom]** color selection.
 8. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
 9. Fan: Direct driven, centrifugal, with multispeed motor mounted on a removable fan-motor board and with inlet rings to allow wheel removal from one side without removing housing.
 10. General requirements for motors are specified in Section 230500 "Common Work Results for HVAC."
 11. Motor: Multispeed, permanently lubricated, **[permanent split capacitor][ECM]**.
- E. Water Circuit:
1. Refrigerant-to-Water Heat Exchanger: **[Coaxial][Coil-in-shell]** heat exchanger with **[copper][cupronickel]** water tube with enhanced heat-transfer surfaces inside a steel shell; both shell and tube are leak tested to **450 psig (3102 kPa)** on refrigerant side and **400 psig (2758 kPa)** on water side. Factory mount heat exchanger in unit on resilient rubber vibration isolators.
 2. Risers: **[ASTM B88, Type L (ASTM B88M, Type B)][ASTM B88, Type M (ASTM B88M Type C)]** copper pipe with hose and ball valve for system flushing.
- F. Refrigerant-to-Air Coil: Copper tubes with aluminum fins, leak tested to **450 psig (3102 kPa)**.

G. Refrigerant Circuit Components:

1. Sealed Refrigerant Circuit: Charge with R-410A refrigerant.
2. Filter-Dryer: Factory installed to clean and dehydrate the refrigerant circuit.
3. Charging Connections: Service fittings on suction and liquid for charging and testing.
4. Reversing Valve: Four-way, solenoid-activated valve designed to be fail-safe in heating position with replaceable magnetic coil.
5. Compressor: Hermetic **[rotary][scroll]** compressor installed on vibration isolators housed in an acoustically treated enclosure with factory-installed safeties as follows:
 - a. Antirecycle timer.
 - b. High-pressure cutout.
 - c. Low-pressure cutout or loss of charge switch.
 - d. Internal thermal-overload protection.
 - e. Freezestat to stop compressor if water-loop temperature in refrigerant-to-water heat exchanger falls below **[35 deg F (2 deg C)]<Insert temperature>**.
 - f. Condensate overflow switch to stop compressor with high condensate level in condensate drain pan.
 - g. Water-coil, low-temperature switch.
 - h. Air-coil, low-temperature switch.
6. Refrigerant Piping Materials: ASTM B743 copper tube with wrought-copper fittings and brazed joints.
7. Pipe Insulation: Refrigerant minimum **3/8-inch- (10-mm-)** thick, flexible elastomeric insulation on piping exposed to airflow through the unit. Maximum 25/50 flame-spread/smoke-developed indexes according to ASTM E84.
8. Refrigerant Metering Device: Thermal-expansion valve to allow specified operation with entering-water temperatures from **[65 to 100 deg F (minus 18 to plus 38 deg C)]<Insert temperature range>**.

H. Filters:

1. Disposable, glass-fiber, flat type, **[1 inch (25 mm)]<Insert dimension>** thick, treated with adhesive, and having a minimum efficiency reporting value of 5 according to ASHRAE 52.2.
2. Disposable, pleated type, **[1 inch (25 mm)]<Insert dimension>** thick and with a minimum efficiency reporting value of 7 according to ASHRAE 52.2.

I. Control equipment and sequence of operation are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."

J. Controls:

1. Basic Unit Control Modes and Devices:
 - a. Dehumidification mode.
 - b. Unit shutdown on high or low refrigerant pressures.
 - c. Unit shutdown on low water temperature.
 - d. Low- and high-voltage protection.
 - e. Overcurrent protection for compressor and fan motor.
 - f. Random time delay, three to ten seconds, start on power-up.
 - g. Time delay override for servicing.
 - h. Control voltage transformer.
 - i. Water-coil freeze protection (selectable for water or antifreeze).
 - j. Air-coil freeze protection (check filter switch).
 - k. Condensate overflow shutdown switch.
 - l. Option to reset unit at thermostat or disconnect.

- m. Fault type shall be retained in memory if reset at thermostat.
- n. Automatic intelligent reset. Unit shall automatically reset five minutes after trip if the fault has cleared. Should a fault reoccur three times sequentially, lockout requiring manual reset occurs.
- o. Ability to defeat time delays for servicing.
- p. Light-emitting diodes (LED) to indicate high pressure, low pressure, low voltage, and high voltage.
- q. The low-pressure switch SHALL NOT be monitored for the first 90 seconds after a compressor start command to prevent nuisance safety trips.
- r. Remote fault-type indication at thermostat.
- s. Selectable 24-V dc or pilot duty dry contact alarm output.
- t. 24-V dc output to cycle a motorized water valve with compressor contactor.
- u. Electric heat output to control two stages of electric heat (emergency heat).
- v. Service test mode for troubleshooting and service.
- w. Unit-performance sentinel warns when the heat pump is running inefficiently.

2. Thermostat:

a. Wall-Mounted Thermostat:

- 1) Heat-cool-off switch.
- 2) Fan on-auto switch.
- 3) **[Manual][Automatic]** changeover.
- 4) **[Concealed][Exposed]** temperature set point.
- 5) **[Concealed][Exposed]** temperature indication.
- 6) Deg **[F][C]** indication.

3. Terminal Controller:

- a. Scheduled operation for occupied and unoccupied periods on seven-day clock with minimum four periods per day.
- b. **[Two]<Insert number>**-hour unoccupied override period.
- c. Backup for volatile memory.

K. Electrical Connection: Single electrical connection[**with fused disconnect**].

L. Capacities and Characteristics:

1. Fan:

- a. Airflow: **<Insert cfm (L/s)>**.
- b. External Static Pressure: **<Insert inches wg (kPa)>**.
- c. Fan Speed: **<Insert rpm>**.
- d. Motor Speed: **<Insert rpm>**.
- e. Motor Horsepower: **<Insert value>**.

2. Water Supply:

- a. Water Flow: **<Insert gpm (L/s)>**.
- b. Pressure Loss: **<Insert feet wg (kPa)>**.
- c. Entering-Water Temperature (Cooling): **<Insert deg F (deg C)>**.
- d. Entering-Water Temperature (Heating): **<Insert deg F (deg C)>**.
- e. Antifreeze Protection Chemical: **<Insert chemical name>**.
- f. Antifreeze Concentration: **<Insert percentage>**.

3. Cooling:
 - a. Total Capacity: **<Insert Btu/h (kW)>**.
 - b. Sensible Capacity: **<Insert Btu/h (kW)>**.
 - c. Minimum Energy-Efficiency Ratio (EER): **<Insert value>**.
 - d. Entering-Air Temperature Dry Bulb: **<Insert deg F (deg C)>**.
 - e. Entering-Air Temperature Wet Bulb: **<Insert deg F (deg C)>**.
4. Heating:
 - a. Capacity: **<Insert Btu/h (kW)>**.
 - b. Entering-Air Temperature: **<Insert deg F (deg C)>**.
 - c. Air Temperature Rise: **<Insert deg F (deg C)>**.
 - d. Minimum Coefficient of Performance (COP): **<Insert value>**.
5. Filters:
 - a. Face Area: **<Insert sq. ft. (sq. m)>**.
 - b. Maximum Face Velocity: **<Insert fpm (m/s)>**.
6. Electrical Characteristics for Single Connection:
 - a. Volts: **[120][208][230]<Insert value>**.
 - b. Phase: **[Single][Three]**.
 - c. Hertz: 60.
 - d. Full-Load Amperes (F.L.A.): **<Insert value>**.
 - e. Maximum Circuit Amperage (MCA): **<Insert value>**.
 - f. Maximum Overcurrent Protection (MOCP): **<Insert amperes>**.

2.4 EXPOSED, CONSOLE WATER-SOURCE HEAT PUMPS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 1. **[Carrier Global Corporation]**
 2. **[ClimateMaster, Inc.]**
 3. **[FHP Manufacturing Inc.]**
 4. **[Hydro-Temp Corporation, Inc.]**
 5. **[Mammoth; a brand of Nortek Air Solutions]**
 6. **[Trane Inc.]**
 7. **[WaterFurnace International, Inc.]**
 8. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 1. **[Carrier Global Corporation]**
 2. **[ClimateMaster, Inc.]**
 3. **[FHP Manufacturing Inc.]**
 4. **[Hydro-Temp Corporation, Inc.]**
 5. **[Mammoth; a brand of Nortek Air Solutions]**
 6. **[Trane Inc.]**
 7. **[WaterFurnace International, Inc.]**
 8. **<Insert manufacturer's name>**



- C. Description: Packaged water-source heat pump with temperature controls; factory assembled, tested, and rated according to ASHRAE/ARI/ISO-13256-1.
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended location and application.
- D. Cabinet and Chassis: Manufacturer's **[standard][low][standard- and low]**-height, **[flat][sloped]**-top, **[extended]**galvanized-steel casing with the following features:
1. Access panel for access and maintenance of internal components.
 2. Knockouts for electrical and piping connections.
 3. Cabinet Insulation: Glass-fiber liner, minimum **1/2 inch (13 mm)** thick, complying with UL 181, ASTM C1071, and ASTM G21.
 4. Cabinet Insulation, Fibrous Glass Duct Liner Standard: Glass-fiber liner, minimum **1/2 inch (13 mm)** thick, complying with ASTM C1071 and NAIMA AH124, "Fibrous Glass Duct Liner Standard."
 5. Sound Attenuation Package: Provide one or more of the following:
 - a. Minimum **0.598-inch- (1.5-mm-)** thick compressor enclosure and front panel. Minimum **0.0937-inch (2.38-mm)** thick foam gasket around the compressor and perimeter of end panel.
 - b. **<Insert method>**.
 6. Condensate Drainage: High-density polyethylene plastic or stainless-steel drain pan with condensate drain piping projecting to unit exterior and complying with ASHRAE 62.1.
 - a. Condensate Overflow Protection: Solid state electronic; mechanical float switch not permitted.
 7. Discharge Grille: Steel, aluminum, or plastic grille for adjustable discharge air pattern.
 8. Color: Selected by Architect from manufacturer's **[standard][custom]** color selection.
 9. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- E. Fan: Direct driven, centrifugal, with multispeed motor mounted on a removable fan-motor board.
1. General requirements for motors are specified in Section 230500 "Common Work Results for HVAC."
 2. Motor: Multispeed, permanently lubricated, **[permanent split capacitor][ECM]**.
- F. Water Circuit:
1. Refrigerant-to-Water Heat Exchanger: Coaxial heat exchanger with **[copper][cupronickel]** water tube with enhanced heat-transfer surfaces inside a steel shell; both shell and tube are leak tested to **450 psig (3102 kPa)** for refrigerant side and **400 psig (2758 kPa)** for water side. Factory mount heat exchanger in unit on resilient rubber vibration isolators.
 2. Water-Regulating Valves: Limit water flow through refrigerant-to-water heat exchanger and control head pressure on compressor during cooling and heating. Valves shall close when heat-pump compressor is not running.
- G. Refrigerant-to-Air Coils: Copper tubes with aluminum fins, leak tested to **450 psig (3102 kPa)**.
- H. Refrigerant Circuit Components:

1. Sealed Refrigerant Circuit: Charge with R-410A refrigerant.
2. Filter-Dryer: Factory installed to clean and dehydrate the refrigerant circuit.
3. Charging Connections: Service fittings on suction and liquid for charging and testing.
4. Reversing Valve: Four-way, solenoid-activated valve designed to be fail-safe in heating position with replaceable magnetic coil.
5. Compressor: Hermetic rotary compressor installed on vibration isolators housed in an acoustically treated enclosure with factory-installed safeties as follows:
 - a. Antirecycle timer.
 - b. High-pressure cutout.
 - c. Low-pressure cutout or loss of charge switch.
 - d. Internal thermal-overload protection.
 - e. Freezestat to stop compressor if water-loop temperature in refrigerant-to-water heat exchanger falls below **[35 deg F (2 deg C)]<Insert temperature>**.
 - f. Condensate overflow switch to stop compressor with high condensate level in condensate drain pan.
 - g. Water-coil, low-temperature switch.
 - h. Air-coil, low-temperature switch.
6. Refrigerant Piping Materials: ASTM B743 copper tube with wrought-copper fittings and brazed joints.
7. Pipe Insulation: Refrigerant minimum **3/8-inch- (10-mm-)** thick, flexible elastomeric insulation on piping exposed to airflow through the unit. Maximum 25/50 flame-spread/smoke-developed indexes per ASTM E84.
8. Refrigerant Metering Device: Dual-port, thermal-expansion valve to allow specified operation with entering-water temperatures from **[25 to 125 deg F (minus 4 to 52 deg C)]<Insert temperature range>**.
9. Hot-Gas Reheat Valve: Pilot-operated, sliding-type valve with replaceable magnetic coil.
- I. Electric Heating Coil: Energized on call for heating when entering-water-loop temperature is less than **[60 deg F (15 deg C)]<Insert temperature>**.
- J. Hot-Gas Reheat: Reheat valve diverts refrigerant hot gas to reheat coil when **[remote][unit-mounted]** humidistat calls for dehumidification.
- K. Outdoor-Air Damper: Two-position, **[manual][motorized]** outdoor-air damper for fixed minimum intake up to 25 percent of fan capacity.
- L. Filters:
 1. Disposable, glass-fiber, flat type, **[1 inch (25 mm)]<Insert dimension>** thick, treated with adhesive, and having a minimum efficiency reporting value of 5 according to ASHRAE 52.2.
 2. Disposable, pleated type, **[1 inch (25 mm)]<Insert dimension>** thick and with a minimum efficiency reporting value of 7 according to ASHRAE 52.2.
- M. Control equipment and sequence of operation are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."
- N. Controls:
 1. Basic Unit Control Modes and Devices:
 - a. Dehumidification mode.
 - b. Unit shutdown on high or low refrigerant pressures.
 - c. Unit shutdown on low water temperature.
 - d. Low- and high-voltage protection.

- e. Overcurrent protection for compressor and fan motor.
 - f. Random time delay, three to ten seconds, start on power-up.
 - g. Time delay override for servicing.
 - h. Control voltage transformer.
 - i. Water-coil freeze protection (selectable for water or antifreeze).
 - j. Air-coil freeze protection (check filter switch).
 - k. Condensate overflow shutdown switch.
 - l. Option to reset unit at thermostat or disconnect.
 - m. Fault type shall be retained in memory if reset at thermostat.
 - n. Automatic intelligent reset. Unit shall automatically reset five minutes after trip if the fault has cleared. Should a fault reoccur three times sequentially, lockout requiring manual reset occurs.
 - o. Ability to defeat time delays for servicing.
 - p. Light-emitting diodes (LED) to indicate high pressure, low pressure, low voltage, and high voltage.
 - q. The low-pressure switch SHALL NOT be monitored for the first 90 seconds after a compressor start command to prevent nuisance safety trips.
 - r. Remote fault-type indication at thermostat.
 - s. Selectable 24-V dc or pilot duty dry contact alarm output.
 - t. 24V dc output to cycle a motorized water valve with compressor contactor.
 - u. Electric heat output to control two stages of electric heat (emergency heat).
 - v. Service test mode for troubleshooting and service.
 - w. Unit-performance sentinel warns when the heat pump is running inefficiently.
2. Thermostat:
- a. [Wall][Unit]-Mounted Thermostat:
 - 1) Heat-cool-off switch.
 - 2) Fan on-auto switch.
 - 3) [Manual][Automatic] changeover.
 - 4) [Concealed][Exposed] temperature set point.
 - 5) [Concealed][Exposed] temperature indication.
 - 6) Deg [F][C] indication.
 - b. [Wall][Unit]-Mounted Humidistat: [Concealed][Exposed].
 - 1) Temperature set point.
 - 2) Temperature indication.
 - c. [Wall][Unit]-mounted temperature sensor.
 - d. Unoccupied period override push button.
 - e. LED to indicate fault condition at heat pump.
 - f. Data entry and access port.
 - 1) Input data include room temperature and humidity set points for occupied and unoccupied periods.
 - 2) Output data include room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.
3. Terminal Controller:
- a. Scheduled operation for occupied and unoccupied periods on [seven][365]-day clock with minimum of four programmable periods per day.
 - b. [Two]<Insert number>-hour unoccupied override period.

- c. Compressor disable relay to stop compressor operation for demand limiting or switch to unoccupied operation.
 - d. Automatic restart after five minutes if fault clears. Lockout after three attempts to restart following fault. Indicate fault for service technician.
 - e. Backup for volatile memory.
 - f. Differential pressure switch to indicate fan status. Fan failure alarm.
 - g. Differential pressure switch to indicate filter status. Dirty filter alarm.
 4. Interface with DDC system for HVAC requirements as further described in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."
 - a. Interface relay for scheduled operation.
 - b. Interface relay to provide indication of fault at central workstation.
 - c. Provide **[BAC-net][or][LonWorks]** interface for central DDC system for HVAC workstation for the following functions:
 - 1) Set-point adjustment for set points identified in this Section.
 - 2) Start/stop and operating status of heat-pump unit.
 - 3) Data inquiry to include supply air, room air temperature and humidity, and entering-water temperature.
 - 4) Occupied and unoccupied schedules.
- O. Electrical Connection: Single electrical connection[**with fused disconnect**].
- P. Capacities and Characteristics:
 1. Fan:
 - a. Airflow: **<Insert cfm (L/s)>**.
 - b. External Static Pressure: **<Insert inches wg (kPa)>**.
 - c. Fan Speed: **<Insert rpm>**.
 - d. Motor Speed: **<Insert rpm>**.
 - e. Motor Horsepower: **<Insert value>**.
 2. Water Supply:
 - a. Water Flow: **<Insert gpm (L/s)>**.
 - b. Pressure Loss: **<Insert feet wg (kPa)>**.
 - c. Entering-Water Temperature (Cooling): **<Insert deg F (deg C)>**.
 - d. Entering-Water Temperature (Heating): **<Insert deg F (deg C)>**.
 - e. Antifreeze Protection Chemical: **<Insert chemical name>**.
 - f. Antifreeze Concentration: **<Insert percentage>**.
 3. Cooling:
 - a. Total Capacity: **<Insert Btu/h (kW)>**.
 - b. Sensible Capacity: **<Insert Btu/h (kW)>**.
 - c. Minimum Energy-Efficiency Ratio (EER): **<Insert value>**.
 - d. Entering-Air Temperature Dry Bulb: **<Insert deg F (deg C)>**.
 - e. Entering-Air Temperature Wet Bulb: **<Insert deg F (deg C)>**.
 4. Heating:
 - a. Capacity: **<Insert Btu/h (kW)>**.
 - b. Entering-Air Temperature: **<Insert deg F (deg C)>**.

- c. Air Temperature Rise: **<Insert deg F (deg C)>**.
 - d. Minimum Coefficient of Performance (COP): **<Insert value>**.
- 5. Electric Heating Coil (Optional Feature):
 - a. Capacity: **<Insert Btu/h (kW)>**.
 - b. Number of Steps: **<Insert number>**.
- 6. Filters:
 - a. Face Area: **<Insert sq. ft. (sq. m)>**.
 - b. Maximum Face Velocity: **<Insert fpm (m/s)>**.
- 7. Electrical Characteristics for Single Connection:
 - a. Volts/Phase/Hertz: **<Insert values>**.
 - b. Full-Load Amperes (F.L.A.): **<Insert value>**.
 - c. Maximum Circuit Amperage (MCA): **<Insert value>**.
 - d. Maximum Overcurrent Protection (MOCP): **<Insert amperes>**.

2.5 HOSE KITS

- A. General: Hose kits shall be designed for minimum **400-psig (2758-kPa)** working pressure and operating temperatures from **33 to 211 deg F (0.5 to 99 deg C)**. Tag hose kits to equipment designations.
- B. Hose: Length [**24 inches (600 mm)**][**36 inches (900 mm)**] braided stainless steel, complete with adapters, **<Insert dimension>**. Minimum diameter, equal to water-source, heat-pump connection size.
- C. Isolation Valves: Two-piece, bronze-body ball valves with stainless-steel, standard-port ball and stem with normal pipe thread (NPT) connections, and galvanized-steel lever handle. Provide valve for supply and return. If balancing device is combination shutoff type with memory stop, the isolation valve may be omitted on the return.
- D. Strainer: Y-type with blowdown valve in supply connection.
- E. Balancing Device: Mount in return connection. Include meter ports to allow flow measurement with differential pressure gage.
 - 1. Automatic balancing valve, factory set to operate within 10 percent of design flow rate over a 40:1 differential pressure range of **2 to 80 psig (13.8 to 552 kPa)**.
 - 2. Manual, calibrated-orifice balancing valve.
 - 3. Manual, venturi-type balancing valve.
- F. Motorized Water Valve: Slow-acting, 24-V dc, with NPT connections.

2.6 HOSE KIT ASSEMBLIES

- A. Supply and return hoses having ball valve with pressure temperature port.
- B. Supply hose having ball valve with pressure temperature port; return hose having automatic flow regulator valve with pressure temperature ports, and ball valve.

- C. Supply hose having "Y" strainer with blowdown valve, and ball valve with pressure temperature port; return hose having automatic flow regulator with PT ports, and ball valve.
- D. Supply hose having "Y" strainer with blowdown valve, and ball valve with pressure temperature port.
- E. Return hose having ball valve with pressure temperature port.

2.7 PUMP MODULE

- A. Minimum [1/6]<Insert value>-hp, 230-V, single-phase pump rated to move at least [16 gpm (1 L/s)]<Insert value> at [20-feet wg (59-kPa)]<Insert value> head pressure.
 - 1. General requirements for motors are specified in Section 230500 "Common Work Results for HVAC."
- B. Include pump module hose kit with thread to barb fittings, hose, and hose clamps.
- C. Three-way brass shut-off/flushing/purging valve.
- D. Include controls to operate pump as required to maintain room temperature and ventilation set points.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping and electric installations for water-source heat pumps to verify actual locations of piping connections and electrical conduits before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Equipment Mounting:
 - 1. Install water-source heat pumps on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- B. Install wall-mounting thermostats, humidistats, and switch controls in electrical outlet boxes at heights to match lighting controls or as required in Section 230923.27 "Temperature Instruments," Section 230923.19 "Moisture Instruments," and Section 230923 "Direct Digital Control (DDC) System for HVAC."

3.3 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
 - 1. Connect supply and return hydronic piping to heat pump with **[unions and shutoff valves][hose kits]**.
 - 2. Connect heat-pump condensate drain pan to indirect waste connection with condensate trap of adequate depth to seal against fan pressure. Install cleanouts in piping at changes of direction.
- B. Duct installation requirements are specified in other Sections. Drawings indicate general arrangement of ducts. Specific connection requirements are as follows:
 - 1. Connect supply and return ducts to water-source heat pumps with flexible duct connectors specified in Section 233300 "Air Duct Accessories."
- C. Install electrical devices furnished by manufacturer but not specified to be factory mounted.
- D. Install piping adjacent to machine to allow service and maintenance.
- E. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- F. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform the following field tests and inspections:
 - 1. After installing water-source heat pumps and after electrical circuitry has been energized, test units for compliance with requirements.
 - 2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Heat pumps will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

3.5 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
- B. Complete installation and startup checks according to manufacturer's written instructions and do the following:
 - 1. Inspect for visible damage to unit casing.
 - 2. Inspect for visible damage to compressor, coils, and fans.

3. Inspect internal insulation.
4. Verify that labels are clearly visible.
5. Verify that clearances have been provided for servicing.
6. Verify that controls are connected and operable.
7. Verify that filters are installed.
8. Adjust vibration isolators.
9. Inspect operation of barometric dampers.
10. Verify bearing lubrication on fan.
11. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
12. Adjust fan belts to proper alignment and tension.
13. Start unit according to manufacturer's written instructions.
14. Complete startup sheets and attach copy with Contractor's startup report.
15. Inspect and record performance of interlocks and protective devices; verify sequences.
16. Operate unit for an initial period as recommended or required by manufacturer.
17. Verify thermostat and humidistat calibration.
18. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
19. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
20. Start refrigeration system, and measure and record the following:
 - a. Coil leaving-air, dry- and wet-bulb temperatures.
 - b. Coil entering-air, dry- and wet-bulb temperatures.
 - c. Outdoor-air, dry-bulb temperature.
 - d. Outdoor-air-coil, discharge-air, dry-bulb temperature.
21. Measure and record the following minimum and maximum airflows. Plot fan volumes on fan curve.
 - a. Supply-air volume.
 - b. Return-air volume.
 - c. Relief-air volume.
 - d. Outdoor-air intake volume.

3.6 ADJUSTING

- A. Adjust initial temperature and humidity set points.
- B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to **[two]<Insert number>** visits to Project during other-than-normal occupancy hours for this purpose.

3.7 CLEANING

- A. Replace filters used during construction prior to air balance or Substantial Completion.
- B. After completing installation of exposed, factory-finished, water-source heat pumps, inspect exposed finishes and repair damaged finishes.

3.8 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust,



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

operate, and maintain water-source heat pumps.

END OF SECTION 23 81 46 00A



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 81 46 00	23 81 00 00	Variable-Refrigerant-Flow HVAC Systems
23 81 49 00	23 81 26 00	Split-System Air-Conditioners
23 81 49 00	23 81 00 00	Variable-Refrigerant-Flow HVAC Systems



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SECTION 23 82 00 00 - CHILLED BEAMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Passive chilled beams.
2. Active chilled beams.
3. Multiservice chilled beams.

1.2 ACTION SUBMITTALS

A. Product Data:

1. For each type of product.
 - a. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for chilled beams.
 - b. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories for chilled beams.
 - c. Submit sufficient information needed for direct comparison to each entry scheduled on Drawings.
 - d. Submit manufacturer's velocity and temperature profiles beneath passive chilled beams under conditions obtained in accordance with BS EN 14518 test procedures to show compliance.

B. Shop Drawings: For chilled beams.

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

C. Samples for Initial Selection: For units with factory-applied finishes.

D. Samples for Verification: For each type of exposed finish required, prepared on Samples of size indicated below.

1. Chilled-Beam Finishes: **<Insert size>**.

E. Product Schedule: For chilled beams.[Use same designations indicated on Drawings.]

F. Delegated Design Submittals: For chilled beams.

1. Include design calculations for selecting mounting[**and seismic restraints**].

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans, reflected ceiling plans, sections, and other details, or BIM model, drawn to scale, showing the items described in this Section and coordinated with all building trades.
- B. Seismic Qualification Data: Certificates, for chilled beams, accessories, and components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Field quality-control reports.
- D. Sample Warranty: For manufacturer's warranty.

1.4 QUALITY ASSURANCE

- A. Manufacturer Qualifications:
 - 1. Shipped chilled-beam products with similar requirements to those indicated for a continuous period of **[five][10]<Insert number>** years within time of bid.
 - 2. Chilled-beam products that have been successfully tested and in use on at least **[three][five]<Insert number>** completed projects.
 - 3. Having complete published catalog literature, installation, and operation and maintenance manuals for all products intended for use.
 - 4. Having full-time in-house employees for the following:
 - a. Product research and development.
 - b. Product and application engineering.
 - c. Product manufacturing, testing, and quality control.
 - d. Technical support for system installation training, startup, commissioning, and troubleshooting.
 - e. Owner training.
- B. Mockups: Build mockups to set quality standards for materials and execution.
 - 1. Build mockups to show a finished installation for each of the following applications:
 - a. For each different chilled beam type indicated on Drawings.
 - b. **<Insert mockup item>**.
 - 2. Mockups are to be fully operational.
 - 3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
 - 4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Chilled beams are to withstand the effects of earthquake motions determined in accordance with **[ASCE/SEI 7]<Insert requirement>**. See Section 230548 "Vibration and Seismic Controls for HVAC."
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified**[and the unit will be fully operational after the seismic event]**."
 - 2. Component Importance Factor: **[1.5][1.0]**.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- C. Capacities and Characteristics: See Drawings.

2.2 PASSIVE CHILLED BEAMS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Halton Company]**
 - 2. **[Price Industries Limited]**
 - 3. **[SEMCO, LLC; part of FlaktGroup]**
 - 4. **[Swegon Inc.]**
 - 5. **[Titus; brand of Johnson Controls International plc, Global Products]**
 - 6. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Halton Company]**
 - 2. **[Price Industries Limited]**
 - 3. **[SEMCO, LLC; part of FlaktGroup]**
 - 4. **[Swegon Inc.]**
 - 5. **[Titus; brand of Johnson Controls International plc, Global Products]**
 - 6. **<Insert manufacturer's name>**
- C. Source Limitations: Obtain chilled beams from single manufacturer.
- D. Description: Sheet metal casing with discharge grille, cooling hydronic coil assembly, **[and]**mounting brackets**[, and accessories]** suitable for location and mounting arrangement indicated on Drawings.
- E. Performance:
 - 1. ASHRAE 55 Compliance: Location and performance of passive chilled beams indicated on Drawings are to result in environmental space conditions in compliance with ASHRAE 55.
- F. Components:

1. Casing:
 - a. Materials, Exposed Units: Minimum [0.0375-inch- (0.95-mm-)]<Insert thickness> thick, [galvanized-]steel sheet.
 - b. Materials, Recessed Units: Minimum [0.0375-inch- (0.95-mm-)]<Insert thickness> thick, [galvanized-]steel sheet.
 - c. Mounting Brackets: Factory installed along long side of units, with not less than four supports located near corners of units; field adjustable.
2. Discharge Air Grille:
 - a. [Perforated face with 50 percent free area][or][linear bars, extending full length of long dimension, spaced not more than 1/2 inch (13 mm) o.c.][See Drawings for face type]<Insert requirements>.
 - b. Hinged on [one][or][two] sides to open from room side.
 - c. Removable from room side[without use of tools].
3. Hydronic Coil: Copper tube mechanically bonded to aluminum fins and mounted in a galvanized-steel coil casing; rated for minimum working pressure of [300 psig (2069 kPa)]<Insert pressure>.
 - a. Tube Thickness: Minimum [0.0016-inch (0.4-mm)]<Insert thickness> thick.
 - b. Fluid Tube Velocity (at Chilled-Water Design Flow Rate):
 - 1) Maximum: [4 fps (1.2 m/s)]<Insert velocity>.
 - 2) Minimum: [1 fps (0.3 m/s)]<Insert velocity>.
 - c. Fin Thickness: Minimum [0.006-inch (0.15-mm)]<Insert thickness> thick.
 - d. Fin Spacing: No closer than [10][12]<Insert spacing> fins per inch.
 - e. Field Piping Connections: [Press][Push-on][Solder][Threaded] ends with terminations oriented for field connection, as indicated on Drawings.
 - f. Include coil with manual air vent [and drain fitting][and drain fitting with valve].
 - g. Include coil face with removable lint screen that is easily accessible for inspection and cleaning from room side.
 - h. Include vertical-oriented coil(s) with drain pan constructed of [galvanized]steel and sloped at least 1 percent toward a NPS 1/2 (DN 13) capped drain connection.
4. Factory Piping: [ASTM B88, Type L (ASTM B88M, Type B)][ASTM B88, Type M (ASTM B88M, Type C)]<Insert type> copper tube with ASME B16.22 wrought-copper fittings.

G. Finish: [Baked enamel][Powder coat][See Drawings]<Insert finish>.

1. Color: Manufacturer's [standard][custom] paint color, as selected by Architect.
2. Appearance of Finished Work: Variations in same piece are unacceptable.[Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.]

H. Accessories:

1. Hoses: NPS 1/2 (DN 13); [18 inches (450 mm)][24 inches (600 mm)][36 inches (900 mm)]<Insert length> long; PTFE-lined flexible hose wrapped in a stainless steel braided jacket and fitted with NPT threaded swivel ends; rated for 300 psig (2069 kPa).
2. <Insert accessory>.

I. Source Quality Control:

1. Capacity: Tested and certified by manufacturer in accordance with BS EN 14518 to comply with scheduled performance.

2.3 ACTIVE CHILLED BEAMS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Dadanco USA]**
 2. **[Halton Company]**
 3. **[Price Industries Limited]**
 4. **[SEMCO, LLC; part of FlaktGroup]**
 5. **[Swegon Inc.]**
 6. **[Titus; brand of Johnson Controls International plc, Global Products]**
 7. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Dadanco USA]**
 2. **[Halton Company]**
 3. **[Price Industries Limited]**
 4. **[SEMCO, LLC; part of FlaktGroup]**
 5. **[Swegon Inc.]**
 6. **[Titus; brand of Johnson Controls International plc, Global Products]**
 7. **<Insert manufacturer's name>**
- C. Source Limitations: Obtain chilled beams from single manufacturer.
- D. Description: Sheet metal casing with primary-air, secondary-air, and mixed-air plenums; air nozzles; air inlet grille; supply-air discharge slot(s); cooling[**and heating**] hydronic coil assembly; [**and**]mounting brackets[; **and accessories**] suitable for location and mounting arrangement indicated on Drawings.
1. Maximum Overall Height (Exposed Units): **[See Drawings]<Insert dimension>**.
 2. Maximum Overall Height (Recessed Units): **[See Drawings]<Insert dimension>**.
- E. Components:
1. Casing:
 - a. Materials, Exposed Units: Minimum **[0.0375-inch- (0.95-mm-)]<Insert thickness>** thick, **[galvanized-]**steel sheet.
 - b. Materials, Recessed Units: Minimum **[0.0375-inch- (0.95-mm-)]<Insert thickness>** thick, **[galvanized-]**steel sheet.
 - c. Mounting Brackets: Factory installed along long side of units, with not less than four supports located near corners of units; field adjustable.
 - d. Commissioning Ports: Equip chilled beams with commissioning ports for field measurement of static pressure differential between primary-air plenum and room. Include an airflow calibration chart attached to each chilled beam.
 - e. Casing Leakage: Factory seal casing joints, seams, and penetrations of casing positive-pressure plenums to be airtight. Leakage in primary-air plenum is not to exceed **[5]<Insert number>** percent of airflow rate indicated on Drawings.
 - f. Primary-Air Plenum Duct Connections: Round or oval collar of sufficient length to accommodate a slip-on field-installed duct. Size as indicated on Drawings

- g. Insulation: Exterior or interior portions of casing capable of forming surface condensation are not to be insulated with **[mineral-fiber][or][fiber-free]** insulation to prevent condensation.
 - h. Blank (Filler) Sections: Where indicated on Drawings, chilled-beam manufacturer is to furnish blank (filler) sections to match external appearance of adjoining active portions.
 - i. Multiple Section Mating and Alignment: Where multiple sections are required to join end to end to make a longer contiguous unit, manufacturer to provide means to join multiple sections, so they appear as a single unit with no obvious obstructions or visual cues of multiple sections.
2. Air Nozzles: Quantity, size, and arrangement selected by chilled-beam manufacturer for performance indicated on Drawings. Primary air supplied through nozzles is to induce room (secondary) air across hydronic coil, and two air streams are to mix to supply conditioned air to room.
 - a. Material: **[Metal][or][plastic, complying with NFPA 90A and UL 94 V-0]**.
 - b. Field replaceable **[with different size nozzles to accommodate changes to performance]**.
 3. Inlet Air Grille: Mounted on face of chilled beam and arranged for room (secondary) air to enter grille and hydronic coil before mixing with primary air.
 - a. **[Perforated face with 50 percent free area][or][linear bars, extending full length of long dimension, spaced not more than 1/2 inch (13 mm) o.c.][See Drawings for face type]<Insert requirements>**.
 - b. Hinged on **[one][or][two]** sides to open from room side.
 - c. Removable from room side **[without use of tools]**.
 4. Supply-Air Discharge Slot(s): Size and arrangement selected by chilled-beam manufacturer for performance indicated on Drawings.
 - a. Material: Extruded aluminum or formed steel.
 - b. Field-Adjustable Discharge-Air Pattern: Include field-adjustable air pattern control to adjust the direction of the discharge air.
 5. Hydronic Coil: Copper tube mechanically bonded to aluminum fins and mounted in a galvanized-steel coil casing; rated for minimum working pressure of **[300 psig (2069 kPa)]<Insert pressure>**.
 - a. Tube Thickness: Minimum **[0.016-inch (0.4-mm)]<Insert thickness>** thick.
 - b. Fluid Tube Velocity (at Chilled-Water Design Flow Rate):
 - 1) Maximum: **[4 fps (1.2 m/s)]<Insert velocity>**.
 - 2) Minimum: **[1 fps (0.3 m/s)]<Insert velocity>**.
 - c. Fin Thickness: Minimum **[0.006-inch (0.15-mm)]<Insert thickness>** thick.
 - d. Fin Spacing: No closer than **[10][12]<Insert spacing>** fins per inch.
 - e. Field Piping Connections: **[Press][Push-on][Solder][Threaded]** ends with terminations oriented for field connection, as indicated on Drawings.
 - f. Piping Arrangement: Two pipe **[or four pipe, as indicated on Drawings.]**
 - g. Include coil with manual air vent **[and drain fitting][and drain fitting with valve]**.
 - h. Include coil face with removable lint screen that is easily accessible for inspection and cleaning from room side.
 - i. Include vertical-oriented coil(s) with drain pan constructed of **[galvanized]** steel and sloped at least 1 percent toward a **NPS 1/2 (DN 13)** capped drain connection.

6. Factory Piping: [ASTM B88, Type L (ASTM B88M, Type B)][ASTM B88, Type M (ASTM B88M, Type C)]<Insert type> copper tube with ASME B16.22 wrought-copper fittings.
- F. Finish: [Baked enamel][Powder coat][See Drawings]<Insert finish>.
1. Color: Manufacturer's [standard][custom] paint color, as selected by Architect.
 2. Appearance of Finished Work: Variations in same piece are unacceptable. [Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.]
- G. Accessories:
1. Hoses: NPS 1/2 (DN 13); [18 inches (450 mm)][24 inches (600 mm)][36 inches (900 mm)]<Insert length> long; PTFE-lined flexible hose wrapped in a stainless steel braided jacket and fitted with NPT threaded swivel ends; rated for 300 psig (2069 kPa).
 2. Primary Airflow Automated Dampers: Modulating inlet damper with low-voltage electric actuator for connection to external controls.
 3. Primary Airflow Manual Dampers: Integral damper assembly with locking handle for field adjustment.
 4. Primary Airflow Regulators: Factory set to airflow rate indicated on Drawings; capable of maintaining constant airflow rate within [10]<Insert number> percent of set point.
 5. <Insert accessory>.
- H. Source Quality Control: Comply with ASHRAE 200, AHRI 1240, and AHRI 1241.
1. Rate capacity of coils in accordance with AHRI 410, with capacities established in accordance with ASHRAE 200.
- 2.4 MULTISERVICE CHILLED BEAMS
- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
1. [Halton Company]
 2. [Price Industries Limited]
 3. [Titus; brand of Johnson Controls International plc, Global Products]
 4. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [Halton Company]
 2. [Price Industries Limited]
 3. [Titus; brand of Johnson Controls International plc, Global Products]
 4. <Insert manufacturer's name>
- C. Source Limitations: Obtain chilled beams from single manufacturer.
- D. Description: Sheet metal casing with primary-air, secondary-air, and mixed-air plenums; air nozzles; air inlet grille; supply-air discharge slot(s); cooling[and heating] hydronic coil assembly; [and]mounting-bracket supports [and accessories]suitable for location and mounting arrangement indicated on Drawings.
1. Maximum Overall Height (Exposed Units): [See Drawings]<Insert dimension>.

2. Maximum Overall Height (Recessed Units): **[See Drawings]<Insert dimension>**.

E. Components:

1. Casing:
 - a. Materials, Exposed Units: Minimum **[0.0375-inch- (0.95-mm-)]<Insert thickness>** thick, **[galvanized-]**steel sheet.
 - b. Materials, Recessed Units: Minimum **[0.0375-inch- (0.95-mm-)]<Insert thickness>** thick, **[galvanized-]**steel sheet.
 - c. Mounting Brackets: Factory installed along long side of units, with not less than four supports located near corners of units; field adjustable.
 - d. Commissioning Ports: Equip chilled beams with commissioning ports for field measurement of static pressure differential between primary air plenum and room. Include with commissioning ports an airflow calibration chart attached to each chilled beam.
 - e. Casing Leakage: Factory seal casing joints, seams, and penetrations of casing positive-pressure plenums to be airtight. Leakage in primary-air plenum is not exceed **[5]<Insert number>** percent of airflow rate indicated on Drawings.
 - f. Primary-Air Plenum Duct Connections: Round or oval collar of sufficient length to accommodate a slip-on field-installed duct. Size as indicated on Drawings
 - g. Insulation: Exterior or interior portions of casing capable of forming surface condensation are to be insulated with **[mineral-fiber][or][fiber-free]** insulation to prevent condensation.
 - h. Blank (Filler) Sections: Where indicated on Drawings, chilled-beam manufacturer is to furnish blank (filler) sections to match external appearance of adjoining active portions.
 - i. Multiple Section Mating and Alignment: Where multiple sections are required to join end to end to make a longer contiguous unit, manufacturer to provide means to join multiple sections, so they appear as a single unit with no obvious obstructions or visual cues of multiple sections.
2. Air Nozzles: Quantity, size, and arrangement selected by chilled-beam manufacturer for performance indicated on Drawings. Primary air supplied through nozzles is to induce room (secondary) air across hydronic coil, and two air streams are to mix to supply conditioned air to room.
 - a. Material: **[Metal][or][plastic, complying with NFPA 90A and UL 94 V-0]**.
 - b. Field replaceable **[with different size nozzles to accommodate changes to performance]**.
3. Inlet Air Grille: Mounted on face of chilled beam and arranged for room (secondary) air to enter grille and hydronic coil before mixing with primary air.
 - a. **[Perforated face with 50 percent free area][or][linear bars, extending full length of long dimension, spaced not more than 1/2 inch (13 mm) o.c.][See Drawings for face type]<Insert requirements>**.
 - b. Hinged on **[one][or][two]** sides to open from room side.
 - c. Removable from room side **[without use of tools]**.
4. Supply-Air Discharge Slot(s): Size and arrangement selected by chilled-beam manufacturer for performance indicated on Drawings.
 - a. Material: Extruded aluminum or formed steel.
 - b. Field-Adjustable Discharge-Air Pattern: Include field-adjustable air pattern control to adjust the direction of the discharge air.
5. Hydronic Coil: Copper tube mechanically bonded to aluminum fins and mounted in a galvanized-

steel coil casing; rated for minimum working pressure of [300 psig (2069 kPa)]<Insert pressure>.

- a. Tube Thickness: Minimum [0.016-inch (0.4-mm)]<Insert thickness> thick.
- b. Fluid Tube Velocity (at Chilled-Water Design Flow Rate):
 - 1) Maximum: [4 fps (1.2 m/s)]<Insert velocity>.
 - 2) Minimum: [1 fps (0.3 m/s)]<Insert velocity>.
- c. Fin Thickness: Minimum [0.006-inch (0.15-mm)]<Insert thickness> thick.
- d. Fin Spacing: No closer than [10][12]<Insert spacing> fins per inch.
- e. Field Piping Connections: [Press][Push-on][Solder][Threaded] ends with terminations oriented for field connection, as indicated on Drawings.
- f. Piping Arrangement: Two pipe[or four pipe, as indicated on Drawings.]
- g. Include coil with manual air vent [and drain fitting][and drain fitting with valve].
- h. Include coil face with removable lint screen that is easily accessible for inspection and cleaning from room side.
- i. Include vertical-oriented coil(s) with drain pan constructed of [galvanized]steel and sloped at least 1 percent toward a NPS 1/2 (DN 13) capped drain connection.

6. Factory Piping: [ASTM B88, Type L (ASTM B88M, Type B)][ASTM B88, Type M (ASTM B88M, Type C)]<Insert type> copper tube with ASME B16.22 wrought-copper fittings.

F. Finish: [Baked enamel][Powder coat][See Drawings]<Insert finish>.

1. Color: Manufacturer's [standard][custom] paint color, as selected by Architect.
2. Appearance of Finished Work: Variations in same piece are unacceptable.[Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.]

G. Other Building Services Integrated into Chilled Beams:

1. Fire Alarm System Devices:
 - a. Notification Appliances, Audible: <Insert requirement>.
 - b. Notification Appliances, Visual: <Insert requirement>.
 - c. Heat Detectors: <Insert requirement>.
 - d. Smoke Detectors: <Insert requirement>.
2. Sprinklers: <Insert requirement>.
3. Lighting: <Insert requirement>.
4. Occupancy Sensors: <Insert requirement>.
5. Speakers: <Insert requirement>.
6. Video Cameras: <Insert requirement>.
7. <Insert building service>.

H. Accessories:

1. Hoses: NPS 1/2 (DN 13); [18 inches (450 mm)][24 inches (600 mm)][36 inches (900 mm)]<Insert length> long; PTFE-lined flexible hose wrapped in a stainless steel braided jacket and fitted with NPT threaded swivel ends; rated for 300 psig (2069 kPa).
2. Primary Airflow Automated Dampers: Modulating inlet damper with low-voltage electric actuator for connection to external controls.
3. Primary Airflow Manual Dampers: Integral damper assembly with locking handle for field adjustment.
4. Primary Airflow Regulators: Factory set to airflow rate indicated on Drawings; capable of

- maintaining constant airflow rate within [10]<Insert number> percent of set point.
5. <Insert accessory>.

- I. Source Quality Control: Comply with ASHRAE 200, AHRI 1240, and AHRI 1241.
1. Rate capacity of coils in accordance with AHRI 410, with capacities established in accordance with ASHRAE 200.

2.5 GENERAL PROTECTION REQUIREMENTS

- A. Protect finishes on exposed surfaces from damage by applying a removable, temporary protective covering at the factory before shipping.
- B. Protect coil and piping openings with removable end caps before shipping.
- C. Protect duct connection openings with removable end caps before shipping.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive chilled beams for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for [duct,]piping and wiring to verify actual locations of connections before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF CHILLED BEAMS

- A. Install chilled beams level and plumb.
- B. Coordinate layout and installation of chilled beams and suspension-system components with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, communications system, security system, and partition assemblies.
- C. Seismic Restraints: Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
- D. Comply with requirements for pipe hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- E. Install continuous-thread hanger rods of size required to support chilled-beam weight. Laterally brace chilled beams to prevent movement.

3.3 PIPING CONNECTIONS

- A. Comply with requirements for piping specified in Section 232113 "Hydronic Piping" and Section 232116

"Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

- B. Comply with requirements for general-duty valves specified in Section 230523 "General-Duty Valves for HVAC Piping."
- C. Make piping connections to chilled-beam units at locations indicated on Drawings.
- D. Where installing piping adjacent to chilled beams, allow space for service and maintenance.

3.4 DUCT CONNECTIONS

- A. Comply with requirements for ductwork specified in [Section 233113 "Metal Ducts."][and][Section 233346 "Flexible Ducts."] Drawings indicate general arrangement of ductwork.
- B. Make ductwork connections to chilled-beam units at locations indicated on Drawings.
- C. Where installing ductwork adjacent to chilled beams, allow space for service and maintenance.

3.5 ELECTRICAL CONNECTIONS

- A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Comply with NECA 1.
- D. Wiring Method: Install concealed cables in raceways and cable trays. Do not install cable within consoles, cabinets, desks, and counters. [**In accessible ceiling spaces and in gypsum board partitions, unenclosed wiring method may be used.**][Conceal conductors and cables in accessible ceilings, walls, and floors.] Do not conceal raceways and cables in unfinished spaces.
 - 1. Install plenum cable in environmental air spaces, including plenum ceilings.
 - 2. Comply with requirements for cable trays specified in Section 260536 "Cable Trays for Electrical Systems."
 - 3. Comply with requirements for raceways and boxes specified in Section 260533.13 "Conduits for Electrical Systems" and Section 260533.16 "Boxes and Covers for Electrical Systems."
- E. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

3.6 CONTROLS

- A. Comply with requirements for controls specified in Section 230923 "Direct Digital Control (DDC) System for HVAC[and Section 230993.11 "Sequence of Operations for HVAC DDC]."

3.7 MULTISERVICE CHILLED-BEAM CONNECTIONS

- A. Fire Alarm System Devices: Comply with requirements for fire alarm system installation in [Section 284600 "Fire Detection and Alarm."][Section 284614 "Single- and Multiple-Station Alarms."][Section 284600 "Fire Detection and Alarm" and "Section 284614 "Single- and Multiple-

Station Alarms."]

- B. Sprinklers: Comply with requirements for sprinkler head installation in Section 211000 "Water-Based Fire-Suppression Systems."
- C. Lighting: Comply with requirements for lighting-fixture installation in Section 265119 "LED Interior Lighting."
- D. Occupancy Sensors: Comply with the requirements for occupancy sensor installation in Section 260923 "Lighting Control Devices."
- E. Speakers: Comply with requirements for speaker installation in Section 275116 "Public Address Systems."
- F. Video Cameras: Comply with requirements for video camera installation in Section 282000 "Video Surveillance."

3.8 IDENTIFICATION

- A. Identify electrical system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Identify hydronic piping and valves. Comply with requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.9 CLEANING AND PROTECTION

- A. Protect exposed surfaces of chilled beams from damage with factory-installed protective covering. Maintain covering in place until start of unit testing and balancing.
- B. Protect chilled beam water connections with factory-installed protective covers, and keep them covered until making final field piping connections.
- C. Protect chilled-beam air connections with factory-installed protective covers and keep them covered until making final field duct connections.
- D. Clean chilled beams inside and out to a factory-new condition.
- E. Reject damaged chilled beams and replace with new units.
- F. Only if acceptable to the Owner, minor damage to finishes may be repaired as required to restore beams to factory-new appearance. Any variation in visual appearance between factory and repaired finish is to be rejected.

3.10 FIELD QUALITY CONTROL

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



- C. Perform tests and inspections[**with the assistance of a factory-authorized service representative**].
- D. Tests and Inspections:
 - 1. Leak Test: After installation, fill system with water under [**design**]pressure and test for leaks. Repair leaks and retest until no leaks exist.
- E. Chilled beam will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

3.11 ADJUSTING

- A. Occupancy Adjustments: When requested within [**12**]**<Insert number>** months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to [**two**]**<Insert number>** visits to Project during other-than-normal occupancy hours for this purpose.

3.12 DEMONSTRATION

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

END OF SECTION 23 82 00 00



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23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 82 16 00	23 82 00 00	Chilled Beams



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SECTION 23 82 16 11 - HYDRONIC AIR COILS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Hydronic air coils.
2. Integral face-and-bypass hot-water coils.

B. Related Requirements:

1. Section 238216.12 "Steam Air Coils" for air coils using steam as the heating medium.
2. Section 238216.13 "Refrigerant Air Coils" for air coils using refrigerants as the medium.
3. Section 238216.14 "Electric-Resistance Air Coils" for electric air coils.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each air coil.
2. Include rated capacities, operating characteristics, and pressure drops for each air coil.

B. Sustainable Design Submittals:

1. Product data showing compliance with ASHRAE 62.1.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings:** Floor plans, sections, and other details, or BIM model, drawn to scale, showing the items described in this Section and coordinated with all building trades.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data:** For air coils to include in operation and maintenance manuals.

1.5 FIELD CONDITIONS

- A. Altitude above Mean Sea Level:** <Insert feet (m)>.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. ASHRAE 62.1 Compliance: Comply with applicable requirements in ASHRAE 62.1, Section 5, "Systems and Equipment," and Section 7, "Construction and Startup."
- B. Performance Ratings: Tested and rated in accordance with AHRI 410 and ASHRAE 33.
- C. Minimum Working-Pressure/Temperature Ratings: **[200 psig (1380 kPa)/300 deg F (149 deg C)]<Insert value and temperature>**.
- D. Select cooling coils for no moisture carryover at design conditions. Provide moisture eliminators on discharge face of cooling coil if necessary to eliminate moisture carryover.
- E. Hot-Water Coil Capacities and Characteristics:
 - 1. Coil Face Dimensions:
 - a. Finned Length: **<Insert inches (mm)>**.
 - b. Finned Width: **<Insert inches (mm)>**.
 - 2. Number of Rows: **<Insert number>**.
 - 3. Coating: **<Insert manufacturer; product>**.
 - 4. Serpentine: **[Half][Full]**.
 - 5. Integral Face-and-Bypass Coil: **[Yes][No]**.
 - 6. Air Side:
 - a. Flow Rate: **<Insert cfm (L/s)>**.
 - b. Finned Area Face Velocity: **<Insert fpm (m/s)>**.
 - c. Static Pressure Drop: **<Insert inches wg (Pa)>**.
 - d. Total Capacity: **<Insert Btu/h (kW)>**.
 - e. Entering Temperature: **<Insert deg F (deg C)>**.
 - f. Leaving Temperature: **<Insert deg F (deg C)>**.
 - 7. Water Side:
 - a. Flow Rate: **<Insert gpm (L/s)>**.
 - b. Tube Velocity: **<Insert fpm (m/s)>**.
 - c. Glycol Type: **[Ethylene][Propylene]**.
 - d. Aqueous Glycol Solution Concentration: **[None]<Insert percentage>[by weight][by volume]**.
 - e. Pressure Drop: **<Insert feet (kPa)>**.
 - f. Entering Temperature: **<Insert deg F (deg C)>**.
 - g. Leaving Temperature: **<Insert deg F (deg C)>**.
- F. Chilled-Water Coil Capacities and Characteristics:
 - 1. Coil Face Dimensions:
 - a. Finned Length: **<Insert inches (mm)>**.
 - b. Finned Width: **<Insert inches (mm)>**.

2. Number of Rows: **<Insert number>**.
3. Coating: **<Insert manufacturer; product>**.
4. Serpentine: **[Half][Full][Double]**.
5. Air Side:
 - a. Flow Rate: **<Insert cfm (L/s)>**.
 - b. Finned Area Face Velocity: **<Insert fpm (m/s)>**.
 - c. Static Pressure Drop: **<Insert inches wg (Pa)>**.
 - d. Total Capacity: **<Insert Btu/h (kW)>**.
 - e. Sensible Capacity: **<Insert Btu/h (kW)>**.
 - f. Entering Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
 - g. Entering Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
 - h. Leaving Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
 - i. Leaving Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
6. Water Side:
 - a. Flow Rate: **<Insert gpm (L/s)>**.
 - b. Tube Velocity: **<Insert fpm (m/s)>**.
 - c. Glycol Type: **[Ethylene][Propylene]**.
 - d. Aqueous Glycol Solution Concentration: **[None]<Insert percentage>[by weight][by volume]**.
 - e. Pressure Drop: **<Insert feet (Pa)>**.
 - f. Entering Temperature: **<Insert deg F (deg C)>**.
 - g. Leaving Temperature: **<Insert deg F (deg C)>**.

2.2 HYDRONIC AIR COILS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 1. **[Aerofin]**
 2. **[Carrier Global Corporation]**
 3. **[Coil Company, LLC]**
 4. **[Greenheck Fan Corporation]**
 5. **[Modine Manufacturing Company]**
 6. **[RAE Coils; a division of RAE Corporation]**
 7. **[Super Radiator Coils]**
 8. **[Trane]**
 9. **[USA Coil & Air]**
 10. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 1. **[Aerofin]**
 2. **[Carrier Global Corporation]**
 3. **[Coil Company, LLC]**
 4. **[Greenheck Fan Corporation]**
 5. **[Modine Manufacturing Company]**
 6. **[RAE Coils; a division of RAE Corporation]**
 7. **[Super Radiator Coils]**
 8. **[Trane]**
 9. **[USA Coil & Air]**

10. <Insert manufacturer's name>

- C. Source Limitations: Obtain hydronic coils from single source from single manufacturer.
- D. Description: Coils constructed of staggered tubes mechanically expanded into continuous collars that are die-formed into the coil fins; self-venting; counterflow design of air to fluid.
- E. Tubes:
 - 1. Material: **[Copper][aluminum][carbon steel][90/10 cupronickel alloy][stainless steel]<Insert material>**.
 - 2. Nominal Diameter: Minimum **[1/2 inch (13 mm)][or][5/8 inch (16 mm)]<Insert nominal diameter>** before expanding, selected to provide performance indicated.
 - 3. Nominal Wall Thickness: As required by performance, minimum **[0.020 inch (0.508 mm)][0.025 inch (0.635 mm)][0.035 inch (0.889 mm)][0.049 inch (1.245 mm)]<Insert dimension>** thick.
 - 4. Return Bends: 180-degree bends; material[, **wall thickness**,] and nominal diameter to match tubes.
 - 5. Fluid Velocity at Design Flow Rate:
 - a. Maximum: **[6 fps (1.8 m/s)]<Insert velocity>**.
 - b. Minimum: **[3 fps (0.9 ms)]<Insert velocity>**.
 - 6. Features: **[Cleanable][Individually drainable]**.
- F. Fins:
 - 1. Type: Plate.
 - 2. Materials:
 - a. Aluminum: **[0.0060 inch (0.15 mm)]<Insert dimension>** thick.
 - b. Copper: **[0.0060 inch (0.15 mm)]<Insert dimension>** thick.
 - c. 90/10 Cupronickel: **[0.0060 inch (0.15 mm)]<Insert dimension>** thick.
 - d. **<Insert fin material and thickness>**.
 - 3. Spacing: Maximum **[12 fins per inch (2.1 mm)]<Insert maximum fin spacing>**.
 - 4. Collars: Full collars for accurate fin spacing and maximum tube contact while leaving no surface of tube exposed.
 - 5. Configuration: **[Flat-face fins][Wave-, corrugated-, or waffle-face fins][Fin type as required by performance requirements]<Insert fin type>**.
 - 6. Fin and Tube Joint: **[Mechanical bond][or][silver brazed]**.
- G. Headers:
 - 1. Material: **[Carbon steel][Copper]<Insert material>**[, removable for cleaning and inspection of tubes].
 - 2. Tube-to-Header Connections: Tube-to-header holes to intrude inward, so landed surface area is 3 times the core tube thickness, to provide enhanced-header-to-tube joint integrity. Evenly extend tubes within the ID of the header no more than 0.12 inch (3 mm).
 - 3. Header Top and Bottom Caps: End caps to be die-formed and installed on the ID of header, such that the landed surface area is 3 times the header wall thickness.
 - 4. Drains: Include low point of **[supply][supply and return]** header with a **[NPS 1/2 (DN 13)]<Insert pipe size>** drain connection.
 - 5. Vents: Include high point of **[return][supply and return]** header with a **[NPS 1/2 (DN 13)]<Insert pipe size>** vent connection.
 - 6. Supply and Return Connections: **[Copper][Carbon steel][Red brass]** pipe;

- [threaded][or][flanged], [same end][opposite ends] of coil.
7. Protect opening of supply, return, vent, and drain connections with a threaded cap to prevent entry of dirt into coil.
 8. Fluid Velocity at Design Flow Rate: Maximum of **[6 fps (1.8 m/s)]<Insert velocity>**.
- H. Casings and Tube Sheets:
1. Depth: Extend coil casing and tube sheets a minimum of **[1/2 inch (13 mm)]<Insert dimension>** beyond face of fins on both entering and leaving sides.
 2. Materials:
 - a. Stainless steel, **[Type 304]<Insert type>**, No. 2D finish, ASTM A240/A240M.
 - b. Galvanized steel, ASTM A653/A653M, **G90 (Z275)** coating.
 - c. Copper, ASTM B152/B152M.
- I. Top and Bottom Casings:
1. Flange face minimum of **[1-1/2 inches (68 mm)]<Insert dimension>**; double-flange edge for rigidity and ease of removal with secondary flange face minimum of **[1/2 inch (13 mm)]<Insert dimension>**.
 2. Thickness:
 - a. Coils with Fin Length of Up to **[72 Inches (1800 mm)]<Insert dimension>**: Minimum of **[16 gauge (1.6 mm)][14 gauge (2.0 mm)][12 gauge (2.8 mm)]** thick.
 - b. Coils with Fin Length Exceeding **[72 Inches (1800 mm)]<Insert dimension>**: Minimum of **[16 gauge (1.6 mm)][14 gauge (2.0 mm)][12 gauge (2.8 mm)]** thick.
- J. End Tube Sheets:
1. Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.
 2. Flange face minimum of **[1-1/2 inches (68 mm)]<Insert dimension>**.
 3. Thickness: Minimum of **[16 gauge (1.6 mm)][14 gauge (2.0 mm)][12 gauge (2.8 mm)]** thick.
- K. Intermediate Tube Sheets:
1. Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.
 2. Space intermediate tube sheets a maximum of **[48 inches (1200 mm)]<Insert dimension>** o.c. and locate to provide equal spacing between tube sheet across coil tube length.
 3. Flange face minimum of **[1/2 inch (13 mm)]<Insert dimension>**.
 4. Thickness: Minimum of **[16 gauge (1.6 mm)]<Insert thickness>** thick.
- L. Holes: Include number, size, and location of holes in casing and end tube sheets required for coil installation.
- M. Hardware: Use hex-head bolts, nuts, and washers constructed of **[Type 304][or][Type 316]** stainless steel.
- N. Nameplate: Aluminum or stainless steel nameplate with brass or stainless steel chain for each coil, with the following data engraved or embossed:
1. Manufacturer name, address, telephone number, and website address.
 2. Manufacturer model number.
 3. Serial number.
 4. Manufacturing date.
 5. Coil identification (indicated on Drawings).
 6. Coil fin length.

7. Coil fin height.
8. Coil weight with fluid/without fluid.
9. Coil casing material and thickness.
10. Coil fin material and thickness.
11. Coil tube material and thickness.
12. Coil header material and thickness.
13. **<Insert requirements>**.

O. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating. See Drawings for coils requiring a corrosion-resistant coating.

P. Coating: **[None][Corrosion resistant]<Insert manufacturer; product name>**.

2.3 HOT-WATER HEATING COILS WITH INTEGRAL FACE-AND-BYPASS DAMPERS

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

1. **[LJ Wing; a Mestek Technology, Inc. company]**
2. **[Marlo Heat Transfer Solutions; part of Leonardo DRS, Inc.]**
3. **<Insert manufacturer's name>**

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

1. **[LJ Wing; a Mestek Technology, Inc. company]**
2. **[Marlo Heat Transfer Solutions; part of Leonardo DRS, Inc.]**
3. **<Insert manufacturer's name>**

C. Source Limitations: Obtain integral face-and-bypass coils from single source from single manufacturer.

D. Description: Hydronic coil with **[horizontal][or][vertical]** tube arrangement **[as indicated on Drawings]** with integral face-and-bypass dampers and controls installed to control modulating dampers, to achieve discharge air temperature set point. Design includes alternating arrangement of active coil segments and dampers.

E. Performance:

1. Each coil capable of maintaining constant discharge air temperature, regardless of variations in entering-air temperature with constant water flow through coil.
2. Portioning of air across and around heating element to result in uniform temperature within 5 deg F (3 deg C) of average temperature when measured anywhere across a vertical plane located **[24 inches (600 mm)][36 inches (900 mm)]** downstream of leaving face of coil.

F. Casing: **[Galvanized steel][or][stainless steel]**, minimum of 16 gauge (1.6 mm) thick.

G. Fins: Rectangular shape, constructed of minimum **[0.010-inch- (0.25-mm-)]<Insert dimension>** thick aluminum, with spacing of not closer than **[12 fins per inch (2.1 mm)]<Insert fin spacing>**.

H. Headers: **[Carbon steel][or][copper]**, selected by manufacturer for flow, pressure, and temperature encountered; drain connections at low points, vent connections at high points, and supply and return connections located on discharge face of coil.

1. Insulation: Insulate headers with mineral-fiber insulation covered by a metal jacket.
2. Supply and Return Connections:
 - a. Terminate ends with MNPT.
 - b. Connections **[NPS 2-1/2 (DN 65)]<Insert pipe size>** and larger shall have thread-on flanges. Select flange class, Class 150 or Class 300, for system pressure and temperature encountered.

I. Tubes:

1. Materials: **[Copper][90/10 cupronickel][or][carbon steel]**.
2. Nominal Diameter: **5/8 inch (16 mm)**.
3. Nominal Wall Thickness: As required by performance, minimum of **[0.035 inch (0.9 mm)][0.049 inch (1.2 mm)]** thick.

J. Dampers: Clamshell design arranged to modulate airflow across or around individual heating elements.

1. Material: **[Galvanized steel][or][stainless steel]**, minimum of 16 gauge (1.6 mm) thick.
2. Actuator: **[Face][or side]** mounted; electric motor for proportional control, failing in last position.

K. Brazing: High-temperature brazing alloy with not less than 5 percent silver when brazing like non-ferrous materials together; high-temperature brazing alloy with more than 30 percent silver when brazing ferrous to non-ferrous materials.

L. Hardware: Use hex-head bolts, nuts, and washers constructed of **[zinc-plated carbon steel][or][stainless steel]**.

M. Nameplate: Aluminum or stainless steel nameplate with brass or stainless steel chain for each coil, with the following data engraved or embossed:

1. Manufacturer name, address, telephone number, and website address.
2. Manufacturer model number.
3. Serial number.
4. Manufacturing date.
5. Coil identification (indicated on Drawings).
6. **<Insert requirements>**.

N. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating. See Drawings for coils requiring a corrosion-resistant coating.

O. Coating: **[None][Corrosion resistant]<Insert manufacturer; product name>**.

2.4 MATERIALS

- A. Aluminum: **ASTM B209 (ASTM B209M)**.
- B. Copper Tube: ASTM B75/ASTM 75M annealed temper or ASTM B280 drawn temper.
- C. Copper Sheet: ASTM B152.
- D. 90/10 Cupronickel Alloy: ASTM B122/ASTM B122M.
- E. Steel:

1. Pipe Connections: ASTM A53/A53M.

F. Corrosion-Resistant Coating: Where indicated on Drawings, coat coils with a corrosion-resistant coating capable of withstanding a [3000]<Insert time>-hour salt-spray test in accordance with ASTM B117.

1. Standards:

- a. ASTM B117 for salt spray.
- b. ASTM D2794 for minimum impact resistance of **100 in. lb (11.3 N m)**.
- c. ASTM D3359 for cross-hatch adhesion of 5B.

2. Application: **[Immersion][Spray]**.
3. Thickness: **[1 mil (0.025 mm)]<Insert value>**.
4. Gloss: Minimum gloss of 60 on a 60-degree meter.

2.5 SOURCE QUALITY CONTROL

- A. Hydronic Coils: Factory tested with air while coil is completely submerged underwater to design pressure indicated, but not less than **[300-psig (2070-kPa)]<Insert pressure>** internal pressure.
- B. Coils to display a tag with inspector's identification as proof of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine ducts, plenums, and casings to receive air coils for compliance with requirements for installation tolerances and other conditions affecting coil performance.
- B. Examine roughing-in for piping systems to verify actual locations of piping connections before coil installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install coils level and plumb.
- B. Install coils in metal ducts and casings constructed in accordance with SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."
- C. Install **[galvanized-steel][stainless steel]** drain pan under each cooling coil.
 1. Construct drain pans with connection for drain; insulated and complying with ASHRAE 62.1.
 2. Construct drain pans to extend beyond coil length and width and to connect to condensate trap and drainage.
 3. Extend drain pan upstream and downstream from coil face.
 4. Extend drain pan under coil headers and exposed supply piping.
- D. Install moisture eliminators for cooling coils. Extend drain pan under moisture eliminator.



- E. Straighten bent fins on air coils.
- F. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

3.3 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to coils to allow service and maintenance.
- C. Connect water piping with unions and shutoff valves to allow coils to be disconnected without draining piping. Control valves are specified in Section 230923.11 "Control Valves," and other piping specialties are specified in Section 232116 "Hydronic Piping Specialties."

END OF SECTION 23 82 16 11



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23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 82 16 11	23 82 00 00	Chilled Beams



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SECTION 23 82 16 12 - STEAM AIR COILS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Steam air coils.
2. Integral face-and-bypass steam coils.

B. Related Requirements:

1. Section 238216.11 "Hydronic Air Coils" for air coils using water as the heating or cooling medium.
2. Section 238216.13 "Refrigerant Air Coils" for air coils using refrigerants as the medium.
3. Section 238216.14 "Electric Resistance Air Coils" for electric air coils.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each air coil.
2. Include rated capacities, operating characteristics, and pressure drops for each air coil.

B. Sustainable Design Submittals:

1. Product data showing compliance with ASHRAE 62.1.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings:** Floor plans, sections, and other details, or BIM model, drawn to scale, showing the items described in this Section and coordinated with all building trades.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data:** For air coils to include in operation and maintenance manuals.

1.5 FIELD CONDITIONS

- A. Altitude above Mean Sea Level:** <Insert feet (m)>.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. ASHRAE 62.1 Compliance: Comply with applicable requirements in ASHRAE 62.1, Section 5, "Systems and Equipment," and Section 7, "Construction and Startup."
- B. Performance Ratings: Tested and rated in accordance with AHRI 410 and ASHRAE 33.
- C. Minimum Working-Pressure/Temperature Ratings: **[100 psig (690 kPa)/400 deg F (204 deg C)]<Insert value and temperature>**.
- D. Capacities and Characteristics:
 - 1. Coil Face Dimensions:
 - a. Finned Length: **<Insert inches (mm)>**.
 - b. Finned Width: **<Insert inches (mm)>**.
 - 2. Number of Rows: **<Insert number>**.
 - 3. Coating: **<Insert manufacturer; product>**.
 - 4. Integral Face-and-Bypass Coil: **[Yes][No]**.
 - 5. Air Side:
 - a. Flow Rate: **<Insert cfm (L/s)>**.
 - b. Finned Area Face Velocity: **<Insert fpm (m/s)>**.
 - c. Static Pressure Drop: **<Insert inches wg (Pa)>**.
 - d. Total Capacity: **<Insert Btu/h (kW)>**.
 - e. Entering Temperature: **<Insert deg F (deg C)>**.
 - f. Leaving Temperature: **<Insert deg F (deg C)>**.
 - 6. Steam Side:
 - a. Inlet Pressure: **<Insert psig (kPa)>**.
 - b. Tube Type: **[Single][Distributing]**.
 - c. Condensing Capacity: **<Insert lb/h (g/s)>**.
 - d. Pressure Drop: **<Insert psig (kPa)>**.

2.2 STEAM AIR COILS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Aerofin]**
 - 2. **[Carrier Global Corporation]**
 - 3. **[Coil Company, LLC]**
 - 4. **[Dunham-Bush, Inc]**
 - 5. **[Greenheck Fan Corporation]**
 - 6. **[Heatcraft Refrigeration Products LLC]**
 - 7. **[RAE Coils; a division of RAE Corporation]**
 - 8. **[Super Radiator Coils]**

9. [Trane]
 10. [USA Coil & Air]
 11. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [Aerofin]
 2. [Carrier Global Corporation]
 3. [Coil Company, LLC]
 4. [Dunham-Bush, Inc]
 5. [Greenheck Fan Corporation]
 6. [Heatcraft Refrigeration Products LLC]
 7. [RAE Coils; a division of RAE Corporation]
 8. [Super Radiator Coils]
 9. [Trane]
 10. [USA Coil & Air]
 11. <Insert manufacturer's name>
- C. Source Limitations: Obtain steam air coils from single source from single manufacturer.
- D. Description: Plate fin coils constructed of tubes mechanically expanded into continuous collars that are die-formed into plate fins and specially designed for thermal expansion and contraction of the tubes during coil operation.
1. Distributing-type steam coils of a tube-in-tube design for uniform steam distribution along the entire length of each tube, to ensure a consistent temperature rise across the full coil face and accelerate condensate removal.
 2. Non-distributing-type steam coils of a single tube design for uniform steam distribution across the entire header and each tube
- E. Tubes:
1. Material: [Copper]<Insert material>.
 2. Nominal Diameter: Minimum [5/8 inch (16 mm)][1 inch (25 mm)][outside tube]<Insert nominal diameter> before expanding, selected to provide performance indicated.
 3. Nominal Wall Thickness: As required by performance, minimum of [0.035 inch (0.889 mm)][0.049 inch (1.245 mm)]<Insert dimension> thick.
 4. [Features: Individually drainable.]
- F. Fins:
1. Type: Plate.
 2. Materials:
 - a. Aluminum: [0.0060 inch (0.15 mm)]<Insert dimension> thick.
 - b. Copper: [0.0060 inch (0.15 mm)]<Insert dimension> thick.
 - c. 90/10 Cupronickel: [0.0060 inch (0.15 mm)]<Insert dimension> thick.
 - d. <Insert fin material and thickness>.
 3. Spacing: Maximum [12 fins per inch (2.1 mm)]<Insert maximum fin spacing>.
 4. Collars: Full collars for accurate fin spacing and maximum tube contact while leaving no surface of tube exposed.
 5. Configuration: [Flat-face fins][Wave-, corrugated-, or waffle-face fins][Fin type as required by performance requirements]<Insert fin type>.
 6. Fin and Tube Joint: [Mechanical bond][or][silver brazed].

G. Headers:

1. Material: **[Carbon steel][Copper]<Insert material>[, removable for cleaning and inspection of tubes]**.
2. Tube-to-Header Connections: Tube-to-header holes to intrude inward, so landed surface area is 3 times the core tube thickness, to provide enhanced header-to-tube joint integrity. Evenly extend tubes within the ID of the header no more than 0.12 inch (3 mm).
3. Header Top and Bottom Caps: End caps to be die-formed and installed on the ID of header, such that the landed surface area is 3 times the header wall thickness.
4. Drains: Include low point of **[supply][supply and return]** header with a **[NPS 1/2 (DN 13)]<Insert pipe size>** drain connection.
5. Vents: Include high point of **[return][supply and return]** header with a **[NPS 1/2 (DN 13)]<Insert pipe size>** vent connection.
6. Supply and Condensate Return Connections: **[Copper][Carbon steel][Red brass]** pipe; **[threaded][or][flanged]**, **[same end][opposite ends]** of coil.
7. Protect opening of supply, return, vent, and drain connections with a threaded cap to prevent entry of dirt into coil.

H. Casings and Tube Sheets:

1. Depth: Extend coil casing and tube sheets a minimum of **[1/2 inch (13 mm)]<Insert dimension>** beyond face of fins on both entering and leaving sides.
2. Materials:
 - a. Stainless steel, **[Type 304]<Insert type>**, No. 2D finish.
 - b. Galvanized steel, **G90 (Z275)** coating.
 - c. Copper.

I. Top and Bottom Casings:

1. Flange face minimum of **[1-1/2 inches (68 mm)]<Insert dimension>**; double-flange edge for rigidity and ease of removal with secondary flange face minimum of **[1/2 inch (13 mm)]<Insert dimension>**.
2. Thickness:
 - a. Coils with Fin Length of Up to **[72 Inches (1800 mm)]<Insert dimension>**: Minimum of **[16 gauge (1.6 mm)][14 gauge (2.0 mm)][12 gauge (2.8 mm)]** thick.
 - b. Coils with Fin Length Exceeding **[72 Inches (1800 mm)]<Insert dimension>**: Minimum of **[16 gauge (1.6 mm)][14 gauge (2.0 mm)][12 gauge (2.8 mm)]** thick.

J. End Tube Sheets:

1. Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.
2. Flange face minimum of **[1-1/2 inches (68 mm)]<Insert dimension>**.
3. Thickness: Minimum of **[16 gauge (1.6 mm)][14 gauge (2.0 mm)][12 gauge (2.8 mm)]** thick.

K. Intermediate Tube Sheets:

1. Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.
2. Space intermediate tube sheets a maximum of **[48 inches (1200 mm)]<Insert dimension>** o.c. and locate to provide equal spacing between tube sheet across coil tube length.
3. Flange face minimum of **[1/2 inch (13 mm)]<Insert dimension>**.
4. Thickness: Minimum of **[16 gauge (1.6 mm)]<Insert thickness>** thick.

L. Holes: Include number, size, and location of holes in casing and end tube sheets required for coil

installation.

- M. Hardware: Use hex-head bolts, nuts, and washers constructed of **[Type 304][or][Type 316]** stainless steel.
- N. Nameplate: Aluminum or stainless steel nameplate with brass or stainless steel chain for each coil, with the following data engraved or embossed:
 - 1. Manufacturer name, address, telephone number, and website address.
 - 2. Manufacturer model number.
 - 3. Serial number.
 - 4. Manufacturing date.
 - 5. Coil identification (indicated on Drawings).
 - 6. Coil fin length.
 - 7. Coil fin height.
 - 8. Coil weight with fluid/without fluid.
 - 9. Coil casing material and thickness.
 - 10. Coil fin material and thickness.
 - 11. Coil tube material and thickness.
 - 12. Coil header material and thickness.
 - 13. **<Insert requirements>**.
 - 14. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating. See Drawings for coils requiring a corrosion-resistant coating.
- O. Coating: **[None][Corrosion resistant]<Insert manufacturer; product name>**.

2.3 STEAM HEATING COILS WITH INTEGRAL FACE-AND-BYPASS DAMPERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Armstrong International, Inc]**
 - 2. **[LJ Wing; a Mestek Technology, Inc. company]**
 - 3. **[Marlo Heat Transfer Solutions; part of Leonardo DRS, Inc.]**
 - 4. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Armstrong International, Inc]**
 - 2. **[LJ Wing; a Mestek Technology, Inc. company]**
 - 3. **[Marlo Heat Transfer Solutions; part of Leonardo DRS, Inc.]**
 - 4. **<Insert manufacturer's name>**
- C. Source Limitations: Obtain integral face-and-bypass coils from single source from single manufacturer.
- D. Description: Steam coil with **[horizontal][or][vertical]** tube arrangement **[as indicated on Drawings]** with integral face-and-bypass dampers and controls installed to control modulating dampers to achieve discharge air temperature set point. Design includes alternating arrangement of active coil segments and dampers.
- E. Performance:
 - 1. Each coil capable of maintaining constant discharge air temperature regardless of variations in

- entering-air temperature with constant water flow through coil.
2. Portioning of air across and around heating element to result in uniform temperature within 5 deg F (3 deg C) of average temperature when measured anywhere across a vertical plane located **[24 inches (600 mm)][36 inches (900 mm)]** downstream of leaving face of coil.
- F. Casing: **[Galvanized steel][or][stainless steel]**, minimum of 16 gauge (1.6 mm) thick.
- G. Fins: Rectangular shape, constructed of minimum **[0.010-inch- (0.25-mm-)]<Insert dimension>** thick aluminum, with spacing of not closer than **[12 fins per inch (2.1 mm)]<Insert fin spacing>**.
- H. Headers: **[Carbon steel][or][copper]**, selected by manufacturer for flow, pressure, and temperature encountered; drain connections at low points, vent connections at high points, and supply and return connections located on discharge face of coil.
1. Insulation: Insulate headers with mineral-fiber insulation covered by a metal jacket.
 2. Supply and Return Connections:
 - a. Terminate ends with MNPT.
 - b. Connections **[NPS 2-1/2 (DN 65)]<Insert pipe size>** and larger shall have thread-on flanges. Select flange class, Class 150 or Class 300, for system pressure and temperature encountered.
- I. Tubes:
1. Materials: **[Copper][90/10 cupronickel][or][carbon steel]**.
 2. Nominal Diameter: **5/8 inch (16 mm)**.
 3. Nominal Wall Thickness: As required by performance, minimum of **[0.035 inch (0.9 mm)][0.049 inch (1.2 mm)]** thick.
- J. Dampers: Clamshell design arranged to modulate airflow across or around individual heating elements.
1. Material: **[Galvanized steel][or][stainless steel]**, minimum of 16 gauge (1.6 mm) thick.
 2. Actuator: **[Face][or side]** mounted; electric motor for proportional control, failing in last position.
- K. Brazing: High-temperature brazing alloy with not less than 5 percent silver when brazing like non-ferrous materials together; high-temperature brazing alloy with more than 30 percent silver when brazing ferrous to non-ferrous materials.
- L. Hardware: Use hex-head bolts, nuts, and washers constructed of **[zinc-plated carbon steel][or][stainless steel]**.
- M. Nameplate: Aluminum or stainless steel nameplate with brass or stainless steel chain for each coil, with the following data engraved or embossed:
1. Manufacturer name, address, telephone number, and website address.
 2. Manufacturer model number.
 3. Serial number.
 4. Manufacturing date.
 5. Coil identification (indicated on Drawings).
 6. **<Insert requirements>**.
- N. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating. See Drawings for coils requiring a corrosion-resistant coating.
- O. Coating: **[None][Corrosion resistant]<Insert manufacturer; product name>**.

2.4 MATERIALS

- A. Aluminum: **ASTM B209 (ASTM B209M)**.
- B. Copper Tube: ASTM B75/B75M annealed temper or ASTM B280 drawn temper.
- C. Copper Sheet: ASTM B152.
- D. Galvanized Steel: ASTM A653/A653M.
- E. 90/10 Cupronickel Alloy: ASTM B122/B122M.
- F. Stainless Steel: ASTM A240/A240M.
- G. Steel:
 - 1. Pipe Connections: ASTM A53/A53M.
- H. Corrosion-Resistant Coating: Where indicated on Drawings, coat coils with a corrosion-resistant coating capable of withstanding a [3000]<Insert time>-hour salt-spray test in accordance with ASTM B117.
 - 1. Standards:
 - a. ASTM B117 for salt spray.
 - b. ASTM D2794 for minimum impact resistance of **100 in. lb (11.3 N m)**.
 - c. ASTM D3359 for cross-hatch adhesion of 5B.
 - 2. Application: **[Immersion][Spray]**.
 - 3. Thickness: **[1 mil (0.025 mm)]<Insert value>**.
 - 4. Gloss: Minimum gloss of 60 on a 60-degree meter.

2.5 SOURCE QUALITY CONTROL

- A. Steam Coils: Factory tested to **300 psig (2070 kPa)**.
- B. Coils to display a tag with inspector's identification as proof of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine ducts, plenums, and casings to receive air coils for compliance with requirements for installation tolerances and other conditions affecting coil performance.
- B. Examine roughing-in for piping systems to verify actual locations of piping connections before coil installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.



3.2 INSTALLATION

- A. Install coils level and plumb.
- B. Install coils in metal ducts and casings constructed in accordance with SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."
- C. Straighten bent fins on air coils.
- D. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

3.3 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to coils to allow service and maintenance.
- C. Connect steam piping with gate valve and union and steam condensate piping with union, strainer, trap, and gate valve to allow coils to be disconnected without draining piping. Control valves are specified in Section 230923.11 "Control Valves," and other piping specialties are specified in Section 232213 "Steam and Condensate Heating Piping."

END OF SECTION 23 82 16 12



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 82 16 12	23 82 00 00	Chilled Beams
23 82 16 12	23 82 16 11	Hydronic Air Coils



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SECTION 23 82 16 13 - REFRIGERANT AIR COILS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Refrigerant air coils.

B. Related Requirements:

1. Section 238216.11 "Hydronic Air Coils" for air coils using water as the heating or cooling medium.
2. Section 238216.12 "Steam Air Coils" for air coils using steam as the medium.
3. Section 238216.14 "Electric Resistance Air Coils" for electric air coils.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each air coil.
2. Include rated capacities, operating characteristics, and pressure drops for each air coil.

B. Sustainable Design Submittals:

1. Product data showing compliance with ASHRAE 62.1.
2. Product Data for EA Prerequisite 3, "Fundamental Refrigerant Management": For refrigerants, indicating compliance with refrigerant management practices.
3. Refrigerant: Product Data for refrigerants, indicating compliance with refrigerant management practices.
4. Product Data: For refrigerants, indicating compliance with refrigerant management practices.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings:** Floor plans, sections, and other details, or BIM model, drawn to scale, showing the items described in this Section and coordinated with all building trades.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data:** For air coils to include in operation and maintenance manuals.

1.5 FIELD CONDITIONS

- A. Altitude above Mean Sea Level:** <Insert feet (m)>.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. ASHRAE 62.1 Compliance: Comply with applicable requirements in ASHRAE 62.1, Section 5, "Systems and Equipment," and Section 7, "Construction and Startup."
- B. Performance Ratings: Tested and rated in accordance with AHRI 410 and ASHRAE 33.
- C. Minimum Working-Pressure/Temperature Ratings: **[200 psig (1380 kPa)/300 deg F (149 deg C)]<Insert value and temperature>**.
- D. Select cooling coils for no moisture carryover at design conditions. Provide moisture eliminators on discharge face of cooling coil if necessary to eliminate moisture carryover.
- E. Capacities and Characteristics:
 - 1. Coil Face Dimensions:
 - a. Finned Length: **<Insert inches (mm)>**.
 - b. Finned Width: **<Insert inches (mm)>**.
 - 2. Number of Rows: **<Insert number>**.
 - 3. Coating: **<Insert manufacturer; product>**.
 - 4. Air Side:
 - a. Flow Rate: **<Insert cfm (L/s)>**.
 - b. Finned Area Face Velocity: **<Insert fpm (m/s)>**.
 - c. Static Pressure Drop: **<Insert inches wg (Pa)>**.
 - d. Total Capacity: **<Insert Btu/h (kW)>**.
 - e. Sensible Capacity: **<Insert Btu/h (kW)>**.
 - f. Entering Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
 - g. Entering Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
 - h. Leaving Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
 - i. Leaving Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
 - 5. Refrigerant Side:
 - a. Refrigerant Type: **[R-410A][HFC-134a]<Insert type>**.
 - b. Saturated Suction Temperature: **<Insert deg F (deg C)>**.

2.2 REFRIGERANT AIR COILS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Aerofin]**
 - 2. **[Carrier Global Corporation]**
 - 3. **[Coil Company, LLC]**
 - 4. **[Greenheck Fan Corporation]**
 - 5. **[RAE Coils; a division of RAE Corporation]**

6. **[Super Radiator Coils]**
 7. **[Trane]**
 8. **[USA Coil & Air]**
 9. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Aerofin]**
 2. **[Carrier Global Corporation]**
 3. **[Coil Company, LLC]**
 4. **[Greenheck Fan Corporation]**
 5. **[RAE Coils; a division of RAE Corporation]**
 6. **[Super Radiator Coils]**
 7. **[Trane]**
 8. **[USA Coil & Air]**
 9. **<Insert manufacturer's name>**
- C. Source Limitations: Obtain refrigerant coils from single source from single manufacturer.
- D. Description: Plate fin coils constructed of staggered tubes mechanically expanded into continuous collars that are die-formed into plate fins. Coils are to be counterflow circuited and equipped with pressure-type distributors, and distributor tubes are to be of equal length, to ensure equal distribution of refrigerant to each circuit.
- E. Circuiting: **[Face][Row][Interlaced][Interlaced and face control][Indicated on Drawings]<Insert circuited type>**.
- F. Tubes:
1. Material: **[Copper]<Insert material>**.
 2. Nominal Diameter: Selected for performance indicated.
 3. Nominal Wall Thickness: As required by performance, minimum of **[0.020 inch (0.5 mm)][0.025 inch (0.6 mm)][0.035 inch (0.9 mm)]<Insert dimension>** thick.
 4. Return Bends: 180-degree bends; material, **[wall thickness,]** and nominal diameter to match tubes.
 5. Brazing: High-temperature brazing alloy with not less than 5 percent silver.
- G. Fins:
1. Type: Plate.
 2. Materials:
 - a. Aluminum: **[0.0060 inch (0.15 mm)][0.0075 inch (0.19 mm)][0.0095 inch (0.24 mm)]<Insert dimension>** thick.
 - b. Copper: **[0.0060 inch (0.15 mm)][0.0075 inch (0.19 mm)][0.0095 inch (0.24 mm)]<Insert dimension>** thick.
 - c. 90/10 Cupronickel: **[0.0060 inch (0.15 mm)][0.0075 inch (0.19 mm)][0.0095 inch (0.24 mm)]<Insert dimension>** thick.
 - d. **<Insert material and fin thickness>**.
 3. Spacing: Maximum **[12 fins per inch (2.1 mm)]<Insert maximum fin spacing>**.
 4. Collars: Full collars for accurate fin spacing and maximum tube contact while leaving no surface of tube exposed.
 5. Configuration: **[Flat-face fins][Wave, corrugated, or waffle-face fins][Fin type as required by performance requirements]<Insert fin type>**.

6. Fin and Tube Joint: Silver brazed.

H. Headers:

1. Material: **[Seamless copper]<Insert material>**.
2. Tube-to-Header Connections: Tube-to-header holes to intrude inward, so landed surface area is 3 times the core tube thickness, to provide enhanced header-to-tube joint integrity. Evenly extend tubes within the ID of the header no more than 0.12 inch (3 mm).
3. Header Top and Bottom Caps: End caps to be die-formed and installed on the ID of header, such that the landed surface area is 3 times the header wall thickness.
4. Protect openings to prevent entry of dirt into coil.

I. Casings and Tube Sheets:

1. Depth: Extend coil casing and tube sheets a minimum of **[1/2 inch (13 mm)]<Insert dimension>** beyond face of fins on both entering and leaving sides.
2. Materials:
 - a. Stainless steel, **[Type 304]<Insert type>**, No. 2D finish.
 - b. Galvanized steel, **G90 (Z275)** coating.
 - c. Copper.
 - d. Aluminum.
3. Top and Bottom Casings:
 - a. Flange face minimum of **[1-1/2 inches (68 mm)]<Insert dimension>**; double-flange edge for rigidity and ease of removal with secondary flange face minimum of **[1/2 inch (13 mm)]<Insert dimension>**.
 - b. Thickness: Minimum of **[16 gauge (1.6 mm)][14 gauge (2.0 mm)][12 gauge (2.8 mm)]** thick.
4. End Tube Sheets:
 - a. Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.
 - b. Flange face minimum of **[1-1/2 inches (68 mm)]<Insert dimension>**.
 - c. Thickness: Minimum of **[16 gauge (1.6 mm)][14 gauge (2.0 mm)][12 gauge (2.8 mm)]** thick.
5. Intermediate Tube Sheets:
 - a. Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.
 - b. Space intermediate tube sheets a maximum of **[48 inches (1200 mm)]<Insert dimension>** o.c. and locate to provide equal spacing between tube sheet across coil tube length.
 - c. Flange face minimum of **[1/2 inch (13 mm)]<Insert dimension>**.
 - d. Thickness: Minimum of **[16 gauge (1.6 mm)]<Insert thickness>** thick.

- J. Holes: Include number, size, and location of holes in casing and end tube sheets required for coil installation.

- K. Hardware: Use hex-head bolts, nuts, and washers constructed of **[Type 304][or][Type 316]** stainless steel.

- L. Nameplate: Aluminum or stainless steel nameplate with brass or stainless steel chain for each coil, with the following data engraved or embossed:
 - 1. Manufacturer name, address, telephone number, and website address.
 - 2. Manufacturer model number.
 - 3. Serial number.
 - 4. Manufacturing date.
 - 5. Coil identification (indicated on Drawings).
 - 6. Coil fin length.
 - 7. Coil fin height.
 - 8. Coil weight with fluid/without fluid.
 - 9. Coil casing material and thickness.
 - 10. Coil fin material and thickness.
 - 11. Coil tube material and thickness.
 - 12. Coil header material and thickness.
 - 13. **<Insert requirements>**.
- M. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating. See Drawings for coils requiring a corrosion-resistant coating.
- N. Coating: **[None][Corrosion resistant]<Insert manufacturer; product name>**.

2.3 MATERIALS

- A. Aluminum: **ASTM B209 (ASTM B209M)**.
- B. Copper Sheet: ASTM B152.
- C. Copper Tube: ASTM B75/75M annealed temper or ASTM B280 drawn temper.
- D. Galvanized Steel: ASTM A653/A653M.
- E. Stainless Steel: ASTM A240/A240M.
- F. Steel: ASTM A53/A53M.
- G. Corrosion-Resistant Coating: Coat with a corrosion-resistant coating capable of withstanding a **[3000]<Insert time>**-hour salt-spray test in accordance with ASTM B117.
 - 1. Standards:
 - a. ASTM B117 for salt spray.
 - b. ASTM D2794 for minimum impact resistance of **100 in lb (11.3 N m)**.
 - c. ASTM D3359 for cross-hatch adhesion of 5B.
 - 2. Application: **[Immersion][Spray]**.
 - 3. Thickness: **[1 mil (0.025 mm)]<Insert value>**.
 - 4. Gloss: Minimum gloss of 60 on a 60-degree meter.

2.4 SOURCE QUALITY CONTROL

- A. Refrigerant Coils: Factory tested using dry nitrogen while coil is completely submerged underwater to design pressure indicated, but not less than **[400-psig (2758-kPa)]<Insert pressure>** internal pressure.

- B. Coils to display a tag with inspector's identification as proof of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine ducts, plenums, and casings to receive air coils for compliance with requirements for installation tolerances and other conditions affecting coil performance.
- B. Examine roughing-in for piping systems to verify actual locations of piping connections before coil installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install coils level and plumb.
- B. Install coils in metal ducts and casings constructed in accordance with SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."
- C. Install **[galvanized-steel][stainless steel]** drain pan under each cooling coil.
 - 1. Construct drain pans with connection for drain; insulated and complying with ASHRAE 62.1.
 - 2. Construct drain pans to extend beyond coil length and width and to connect to condensate trap and drainage.
 - 3. Extend drain pan upstream and downstream from coil face.
 - 4. Extend drain pan under coil headers and exposed supply piping.
- D. Install moisture eliminators for cooling coils. Extend drain pan under moisture eliminator.
- E. Straighten bent fins on air coils.
- F. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

3.3 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to coils to allow service and maintenance.
- C. Connect refrigerant piping according to Section 232300 "Refrigerant Piping."

END OF SECTION 23 82 16 13



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 82 16 13	23 82 00 00	Chilled Beams
23 82 16 13	23 82 16 11	Hydronic Air Coils



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SECTION 23 82 16 14 - ELECTRIC-RESISTANCE AIR COILS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Electric-resistance air coils.

B. Related Requirements:

1. Section 238216.11 "Hydronic Air Coils" for air coils using water as the heating or cooling medium.
2. Section 238216.12 "Steam Air Coils" for air coils using steam as the medium.
3. Section 238216.13 "Refrigerant Air Coils" for air coils using refrigerants as the medium.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each air coil.
2. Include rated capacities, operating characteristics, and pressure drops for each air coil.

B. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, sections, and other details, or BIM model, drawn to scale, showing the items described in this Section and coordinated with all building trades.

B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air coils to include in operation and maintenance manuals.

1.5 FIELD CONDITIONS

A. Altitude above Mean Sea Level: <Insert feet (m)>.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Coil Assembly: Comply with UL 1995.



- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- C. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.
- D. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5, "Systems and Equipment," and Section 7, "Construction and Startup."
- E. Equally balance heater electrical load for each step across all electrical phases.
- F. Part-Load Operation: Provide arrangement with operation staged for uninterrupted operation over the full range of airflow down to the minimum airflow indicated.
- G. Capacities and Characteristics:
 - 1. Coil Face Dimensions:
 - a. Length: **<Insert inches (mm)>**.
 - b. Height: **<Insert inches (mm)>**.
 - 2. Mounting: **[Slip in][Flanged]**.
 - 3. Air Side:
 - a. Flow Rate: **<Insert cfm (L/s)>**.
 - b. Face Velocity: **<Insert fpm (m/s)>**.
 - c. Static Pressure Drop: **<Insert inches wg (Pa)>**.
 - d. Total Capacity: **<Insert Btu/h (kW)>**.
 - e. Entering Temperature: **<Insert deg F (deg C)>**.
 - f. Leaving Temperature: **<Insert deg F (deg C)>**.
 - 4. Electrical Characteristics:
 - a. Capacity: **<Insert kilowatts>**.
 - b. Number of Steps: **<Insert number>**.
 - c. Volts: **<Insert value>**.
 - d. Phase: **<Insert value>**.
 - e. Hertz: **<Insert value>**.
 - f. Full-Load Amperes: **<Insert value>**.
 - g. Minimum Circuit Ampacity: **<Insert value>**.
 - h. Maximum Overcurrent Protection: **<Insert amperage>**.

2.2 ELECTRIC-RESISTANCE AIR COILS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Brasch Manufacturing Co., Inc]**
 - 2. **[Chromalox, Inc.]**
 - 3. **[INDEECO]**
 - 4. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Brasch Manufacturing Co., Inc]**
 2. **[Chromalox, Inc.]**
 3. **[INDEECO]**
 4. **<Insert manufacturer's name>**
- C. Source Limitations: Obtain electric-resistance air coils from single source from single manufacturer.
- D. Heating Elements:
1. Open Elements:
 - a. Open-coil resistance wire of 80 percent nickel and 20 percent chromium; supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in a frame.
 - b. Safety Screens: Install safety screens to protect operators from accidentally coming into direct connect with elements.
 2. Finned Tubular Elements:
 - a. Coiled resistance wire of 80 percent nickel and 20 percent chromium; center-mounted and surrounded by compacted magnesium-oxide powder in tubular-steel sheath; with spiral-wound, copper-plated, steel fins continuously brazed to sheath.
 - b. Finish finned tubular elements with a baked-on aluminum paint, and mount in a frame.
 - c. Each element individually removable from terminal box.
 - d. Use threaded stainless steel element terminals and hardware.
- E. Frame: **[Galvanized][stainless][or][aluminized]** steel; minimum **[0.052 inch (1.3 mm)][0.064 inch (1.6 mm)][0.079 inch (2.0 mm)]<Insert thickness>** thick for **[slip-in][flanged]** mounting. Include intermediate element support brackets equally spaced at a maximum of **[36 inches (900 mm)]<Insert distance>** o.c. across electric-resistance air coil.
- F. Terminal Box/Control Panel: **[Unit mounted][Remote mounted][Unit or remote mounting arrangement indicated on Drawings]**; with disconnection means and overcurrent protection.
1. Enclosure: NEMA 250, **[Type 1][or][Type 12]<Insert type>** enclosure complying with UL 50.
 2. Full-face-hinged door **[with lock and key latching device(s)]**.
 3. Factory insulate terminal box to prevent condensation from occurring within box.
 4. Install a laminated elementary wiring diagram on inside face of heater control panel door or in another protected location than visible be service personnel. Wiring diagram to match installation.
- G. Controls:
1. Safety Controls: Each heater is to be provided with the following factory-mounted safety controls:
 - a. Disk-type thermal cutout switch with automatic reset.
 - b. Primary linear thermal limit cutout switch with automatic reset.
 - c. Secondary linear thermal limit cutout switch with local manual reset.
 - d. Airflow Proving Switch: Pressure differential type; with pressure range selected to ensure reliable operation throughout full range of air-handling unit airflow down to minimum airflow indicated.
 2. Staging Control: Magnetic contactors for switching stages of heat.
 3. SCR Control: Silicone-controlled rectifier (SCR) for 100 percent stepless capacity control.

4. Remote Monitoring and Control: Include control devices necessary to interface with remote-control signals, including the following:
 - a. Heater on/off control.
 - b. Monitoring heater on/off status.
 - c. High-temperature alarm.
 - d. Low-airflow alarm.
 - e. Heater capacity control.
 - f. **<Insert requirement>**.

H. Electrical:

1. Single-Point Field Power Connection: Install and wire the heater to accommodate a single field electrical connection for electrical power.
2. Disconnecting Means: Provide each heater with a main electrical power connection, door mounted and interlocking, and disconnecting means to prevent access into panel, unless switched to the off position.
 - a. **[Fused disconnect switch][Nonfused disconnect switch][Circuit breaker]** with lockable handle.
 - b. Minimum Short-Circuit Current Rating: As required by electrical power distribution system, but not less than **[42,000][65,000]<Insert number> A**.
3. Factory install and wire branch circuit fusing or circuit breakers in accordance with NFPA 70.
4. Pilot Lights: Include labeled pilot lights on face of control panel for the following:
 - a. Power on.
 - b. Low-airflow alarm.
 - c. High-temperature alarm.
 - d. One for each stage on.
 - e. **<Insert requirement>**.
5. Terminations: Wire terminations and field interface terminations to labeled terminal strips.
6. Control Transformer: Size control circuit transformer for load.
7. Labeling: Label each electrical device with a laminated phenolic tag.
8. Use only NRTL-labeled electrical components.

I. Nameplate: Include the following data:

1. Manufacturer name, address, telephone number, and website address.
2. Manufacturer model number.
3. Serial number.
4. Manufacturing date.
5. Coil identification (indicated on Drawings).
6. **<Insert requirements>**.

J. See Section 230923.27 "Temperature Instruments" for thermostat.

K. Thermostats: Wall-mounted thermostats, with temperature range from **50 to 90 deg F (10 to 32 deg C)**, and **2.5 deg F (1.4 deg C)** throttling range.



PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine ducts, plenums, and casings to receive air coils for compliance with requirements for installation tolerances and other conditions affecting coil performance.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install coils level and plumb.
- B. Install coils in metal ducts and casings constructed in accordance with SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."
- C. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

3.3 ELECTRICAL CONNECTIONS

- A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least [1/2 inch (13 mm)]<Insert dimension> high.

3.4 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."
- C. Install nameplate for each control connection, indicating field control panel designation and I/O control designation feeding connection.

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: [Owner will engage][Engage] a qualified testing agency to perform tests and inspections.

23 - Heating, Ventilating, and Air-Conditioning (HVAC)



- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections[**with the assistance of a factory-authorized service representative**].
- D. Tests and Inspections:
 - 1. Operational Test: After electrical circuitry has been energized, operate electric coils to confirm proper unit operation.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- E. Prepare test and inspection reports.

END OF SECTION 23 82 16 14



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Task	Specification	Specification Description
23 82 16 14	23 82 00 00	Chilled Beams
23 82 16 14	23 74 16 13b	Unit Ventilators



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SECTION 23 82 19 00 - FAN COIL UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Ductless fan coil units.
2. Ducted fan coil units.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

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

B. Sustainable Design Submittals:

1. Product Data: For ventilation equipment, indicating compliance with ASHRAE 62.1, Section 5 - "Systems and Equipment."
2. Ventilation: Product Data for ventilation equipment, indicating compliance with ASHRAE 62.1, Section 5 - "Systems and Equipment."

C. Shop Drawings:

1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.

D. Samples for Initial Selection: For units with factory-applied color finishes.

E. Samples for Verification: For each type of fan coil unit indicated.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which fan coil units will be attached.
3. Method of attaching hangers to building structure.
4. Size and location of initial access modules for acoustical tile.
5. Items penetrating finished ceiling, including the following:
 - a. Lighting fixtures.
 - b. Air outlets and inlets.
 - c. Speakers.

- d. Sprinklers.
- e. Access panels.
- f. <Insert item>.

6. Perimeter moldings.

B. Seismic Qualification Certificates: For fan coil units, accessories, and components, from manufacturer.

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

C. Field quality-control reports.

D. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fan coil units to include in emergency, operation, and maintenance manuals.

- 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Maintenance schedules and repair part lists for motors, coils, integral controls, and filters.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

- 1. Fan Coil Unit Filters: Furnish <Insert number> spare filters for each filter installed.
- 2. Fan Belts: Furnish <Insert number> spare fan belts for each unit installed.

1.6 QUALITY ASSURANCE

A. Comply with NFPA 70.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.7 COORDINATION

A. Coordinate layout and installation of fan coil units and suspension system components with other

construction that penetrates or is supported by ceilings, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

- B. Coordinate size and location of wall sleeves for outdoor-air intake.

1.8 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of condensing units that fail in materials or workmanship within specified warranty period.
1. Failures include, but are not limited to, the following:
 - a. Compressor failure.
 - b. Condenser coil leak.
 2. Warranty Period: **[Four][Five][10]<Insert number>** years from date of Substantial Completion.
 3. Warranty Period (Compressor Only): **[Five][10]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Factory-packaged and -tested units rated according to AHRI 440, ASHRAE 33, and UL 1995.

2.2 DUCTLESS FAN COIL UNITS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Airtherm; a Mestek company]**
 2. **[Carrier Global Corporation]**
 3. **[Daikin Applied]**
 4. **[Dunham-Bush, Inc]**
 5. **[Engineered Air]**
 6. **[ENVIRO-TEC; brand of Johnson Controls International plc, Building Solutions North America]**
 7. **[First Company Products]**
 8. **[Greenheck Fan Corporation]**
 9. **[IEC (International Environmental Corporation); LSB Industries]**
 10. **[Marlo Heat Transfer Solutions; part of Leonardo DRS, Inc.]**
 11. **[Nailor Industries Inc]**
 12. **[Rosemex Products]**
 13. **[Superior Rex]**
 14. **[Titus; brand of Johnson Controls International plc, Global Products]**
 15. **[Trane Inc.]**
 16. **[USA Coil & Air]**



17. [YORK; brand of Johnson Controls International plc, Building Solutions North America]
 18. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [Airtherm; a Mestek company]
 2. [Carrier Global Corporation]
 3. [Daikin Applied]
 4. [Dunham-Bush, Inc]
 5. [Engineered Air]
 6. [ENVIRO-TEC; brand of Johnson Controls International plc, Building Solutions North America]
 7. [First Company Products]
 8. [Greenheck Fan Corporation]
 9. [IEC (International Environmental Corporation); LSB Industries]
 10. [Marlo Heat Transfer Solutions; part of Leonardo DRS, Inc.]
 11. [Nailor Industries Inc]
 12. [Rosemex Products]
 13. [Superior Rex]
 14. [Titus; brand of Johnson Controls International plc, Global Products]
 15. [Trane Inc.]
 16. [USA Coil & Air]
 17. [YORK; brand of Johnson Controls International plc, Building Solutions North America]
 18. <Insert manufacturer's name>
- C. Fan Coil Unit Configurations: [Row][Face] split.
1. Number of Heating Coils: [One]<Insert number> with two-pipe system.
 2. Number of Cooling Coils: [One][Three] with [two][four]-pipe system.
- D. Coil Section Insulation:
1. [1/2-inch- (13-mm-)][1-inch- (25-mm-)]<Insert dimension> thick, [coated glass fiber][foil-covered, closed-cell foam][matte-finish, closed-cell foam] complying with ASTM C1071 and attached with adhesive complying with ASTM C916.
 2. Insulate coil section according to Section 230716 "HVAC Equipment Insulation."
 3. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E84 by a qualified testing agency.
 4. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- E. Drain Pans: [Main and Auxiliary][Plastic][Stainless steel][Insulated galvanized steel with plastic liner]. Fabricate pans and drain connections to comply with ASHRAE 62.1.[Drain pans shall be removable.]
- F. Chassis: Galvanized steel where exposed to moisture[, with baked-enamel finish and removable access panel][, with powder-coat finish and removable access panel]. Floor-mounting units shall have leveling screws.
- G. Cabinet: Steel with [factory prime coating, ready for field painting][baked-enamel finish in manufacturer's standard paint color as selected by Architect][baked-enamel finish in manufacturer's custom paint color as selected by Architect].

1. Vertical Unit Front Panels: Removable, steel, with [integral stamped][polyethylene][steel] discharge grille and channel-formed edges, cam fasteners, and insulation on back of panel.
 2. Horizontal Unit Bottom Panels: Fastened to unit with cam fasteners and hinge and attached with safety chain; with [integral stamped][cast-aluminum] discharge grilles.
 3. Stack Unit Discharge and Return Grille: Aluminum double-deflection discharge grille, and louvered- or panel-type return grille; color as selected by Architect from manufacturer's [standard][custom] colors. Return grille shall provide maintenance access to fan coil unit.
 4. Steel recessing flanges for recessing fan coil units into ceiling or wall.
- H. Outdoor-Air Wall Box: Minimum **0.1265-inch- (3.2-mm-)** thick, aluminum, rain-resistant louver and box with integral eliminators and bird screen.
1. Louver Configuration: [Horizontal][Vertical], rain-resistant louver.
 2. Louver Material: [Aluminum][Steel].
 3. Bird Screen: **1/2-inch (13-mm)** mesh screen on interior side of louver.
 4. Decorative Grille: On outside of intake.
 5. Finish: [Anodized aluminum][Baked enamel], color as selected by Architect from manufacturer's [standard][custom] colors.
- I. Outdoor-Air Damper: Galvanized-steel blades with edge and end seals and nylon bearings; with [electronic][pneumatic], [two-position][modulating] actuators.
- J. Filters: Minimum arrestance and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2 and all addendums.
1. MERV Rating: [6][13]<Insert number> when tested according to ASHRAE 52.2.
 2. Washable Foam: 70 percent arrestance and MERV[3].
 3. Glass Fiber Treated with Adhesive: 80 percent arrestance and MERV[5].
 4. Pleated Cotton-Polyester Media: 90 percent arrestance and MERV[7].
- K. Hydronic Coils: Copper tube[with corrosion-resistant coating], with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)**, rated for a minimum working pressure of **200 psig (1378 kPa)** and a maximum entering-water temperature of **220 deg F (104 deg C)**. Include manual air vent and drain valve.
- L. Indoor Refrigerant Coils: [Copper][Stainless-steel] tube[with corrosion-resistant coating], with mechanically bonded [aluminum][stainless-steel] fins spaced no closer than **0.1 inch (2.5 mm)** and brazed joints at fittings. Comply with AHRI 210/240, and leak test to minimum **450 psig (3105 kPa)** for a minimum **300-psig (2070-kPa)** working pressure. Include thermal expansion valve.
- M. Steam Coils: Copper[distributing] tube[with corrosion-resistant coating], with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)**, rated for a minimum working pressure of **75 psig (517 kPa)**.
- N. Corrosion-Resistant Coating: Coat coils with a corrosion-resistant coating capable of withstanding a [3,000]<Insert time>-hour salt-spray test according to ASTM B117.
1. Standards:
 - a. ASTM B117 for salt spray.
 - b. ASTM D2794 for minimum impact resistance of **100 in-lb (11.3 N-m)**.
 - c. ASTM D3359 for cross hatch adhesion of 5B.
 2. Application: [Immersion][Spray].
 3. Thickness: [1 mil]<Insert measurement>.
 4. Gloss: Minimum gloss of 50 gloss units on a single angle 60 degree meter.

- 5. UV Protection: Spray applied topcoat.
- O. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with fuses in terminal box for overcurrent protection and limit controls for high-temperature protection. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.
- P. Fan and Motor Board: Removable.
 - 1. Fan: Forward curved, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.
 - 2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Section 230500 "Common Work Results for HVAC."
 - 3. Wiring Termination: Connect motor to chassis wiring with plug connection.
- Q. Factory, Hydronic Piping Package: **[ASTM B88, Type L (ASTM B88M, Type B)][ASTM B88, Type M (ASTM B88MType C)]** copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet.
 - 1. **[Two][Three]-way, [two-position][modulating]** control valve for dual-temperature coil.
 - 2. **[Two][Three]-way, [two-position][modulating]** control valve for chilled-water coil.
 - 3. **[Two][Three]-way, [two-position][modulating]** control valve for hot-water heating coil.
 - 4. **[Two][Three]-way [two-position][modulating]** control valve for hot-water reheat coil.
 - 5. Hose Kits: Minimum **400-psig (2758-kPa)** working pressure and operating temperatures from **33 to 211 deg F (0.5 to 99 deg C)**. Tag hose kits to equipment designations.
 - a. Length: **[24 inches (600 mm)][36 inches (900 mm)]<Insert dimension>**.
 - b. Minimum Diameter: Equal to fan coil unit connection size.
 - 6. Two-Piece Ball Valves: Bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and **600-psig (4140-kPa)** minimum CWP rating and blowout-proof stem.
 - 7. Calibrated-Orifice Balancing Valves: Bronze body, ball type; **125-psig (860-kPa)** working pressure, **250 deg F (121 deg C)** maximum operating temperature; with calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, threaded ends, and a memory stop to retain set position.
 - 8. Automatic Flow-Control Valve: Brass or ferrous-metal body; **300-psig (2070-kPa)** working pressure at **250 deg F (121 deg C)**; with removable, corrosion-resistant, tamperproof, self-cleaning piston spring; factory set to maintain constant indicated flow with plus or minus 10 percent over differential pressure range of **2 to 80 psig (13.8 to 552 kPa)**.
 - 9. Y-Pattern Hydronic Strainers: Cast-iron body (ASTM A126, Class B); **125-psig (860-kPa)** working pressure; with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum **NPS 1/2 (DN 15)** hose-end, full-port, ball-type blowdown valve in drain connection.
 - 10. Wrought-Copper Unions: ASME B16.22.
 - 11. Risers: **[ASTM B88, Type L (ASTM B88M, Type B)][ASTM B88, Type M (ASTM B88MType C)]** copper pipe with hose and ball valve for system flushing.
- R. Control devices and operational sequences are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."
- S. Basic Unit Controls:
 - 1. Control voltage transformer.
 - 2. **[Wall-mounting][Unit-mounted]** thermostat with the following features:

- a. Heat-cool-off switch.
 - b. Fan on-auto switch.
 - c. Fan-speed switch.
 - d. **[Manual][Automatic]** changeover.
 - e. Adjustable deadband.
 - f. **[Concealed][Exposed]** set point.
 - g. **[Concealed][Exposed]** indication.
 - h. **[Degree F][Degree C]** indication.
3. **[Wall-mounting][Unit-mounted]** humidistat.
- a. **[Concealed][Exposed]** set point.
 - b. **[Concealed][Exposed]** indication.
4. **[Wall-mounting][Unit-mounted]** temperature sensor.
5. Unoccupied-period-override push button.
6. Data entry and access port.
- a. Input data includes room temperature, and humidity set points and occupied and unoccupied periods.
 - b. Output data includes room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.

T. Terminal Controller: **[DDC.]**

- 1. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.
- 2. Unoccupied-Period-Override Operation: **[Two]<Insert number>** hours.
- 3. Unit Supply-Air Fan Operation:
 - a. Occupied Periods: Fan runs continuously.
 - b. Unoccupied Periods: Fan cycles to maintain room setback temperature.
- 4. Hydronic-Cooling-Coil Operation:
 - a. Occupied Periods: **[Open][Modulate]** control valve to maintain room temperature.
 - b. Unoccupied Periods: Close control valve.
- 5. Refrigerant-Coil Operation:
 - a. Occupied Periods: Start compressor to maintain room temperature or humidistat set point.
 - b. Unoccupied Periods: Stop compressor cooling and cycle compressor for heating to maintain setback temperature.
- 6. Heating-Coil Operation: **[Supplemental.]**
 - a. Occupied Periods: **[Open control valve][Modulate control valve][Energize electric-resistance coil]** to provide heating if room temperature falls below thermostat set point.
 - b. Unoccupied Periods: Start fan and **[open control valve][modulate control valve][energize electric-resistance coil]** if room temperature falls below setback temperature.
 - c. Switch refrigerant-reversing valve to operate supplemental coil for heating when outdoor temperature is below **[25 deg F (4 deg C)]<Insert temperature>**.
- 7. Dual-Temperature Hydronic-Coil Operation:



- a. Occupied Periods: When chilled water is available, **[open][modulate]** control valve if room temperature exceeds thermostat set point. When hot water is available, open control valve if temperature falls below thermostat set point.
 - b. Unoccupied Periods: When chilled water is available, close control valve. When hot water is available, **[open][modulate]** control valve if room temperature falls below thermostat setback temperature.
8. Reheat-Coil Operation:
 - a. Humidity Control for Occupied Periods:
 - 1) Humidistat **[opens control valve][modulates control valve][energizes electric-resistance coil]** to provide heating. As space temperature rises above set point, cooling-coil valve **[opens][modulates]** to maintain room temperature.
 - b. Humidity Control for Unoccupied Periods: **[Close control valve][De-energize]**.
 - c. Occupied Periods:
 - 1) Heating Operations: **[Open control valve][Modulate control valve][Energize electric-resistance coil]** to provide heating if room temperature falls below thermostat set point.
 - 2) Humidity-Control Operations: Humidistat **[opens control valve][modulates control valve][energizes electric-resistance coil]** to provide heating. As space temperature rises above set point, cooling-coil valve **[opens][modulates]** to maintain room temperature.
 - d. Unoccupied Periods: Start fan and **[open control valve][modulate control valve][energize electric-resistance coil]** if room temperature falls below setback temperature. Humidity control is not available.
9. Outdoor-Air Damper Operation, Fixed, Minimum Outdoor-Air Intake:
 - a. Occupied Periods: Open damper to fixed position for **[25]<Insert number>** percent outdoor air.
 - b. Unoccupied periods: Close damper.
10. Outdoor-Air Damper Operation, Outdoor-Air Economizer Cycle:
 - a. Occupied Periods:
 - 1) Outdoor-Air Temperature below Room Temperature: If room temperature is above thermostat set point, modulate outdoor-air damper to maintain room temperature (outdoor-air economizer). If room temperature is below thermostat set point, position damper to fixed minimum position.
 - 2) Outdoor-Air Temperature above Room Temperature: Position damper to fixed minimum position for **[25]<Insert number>** percent outdoor air.
 - b. Unoccupied Periods: Close damper.
11. Outdoor-Air Damper Operation (Enthalpy Based):
 - a. Occupied Periods:
 - 1) Outdoor-Air Enthalpy below Room Enthalpy: If room temperature is above room-temperature set point, modulate outdoor-air damper to maintain room temperature

- (outdoor-air economizer). If room temperature is below set point, position damper to fixed minimum position for [25]<Insert number> percent outdoor air.
- 2) Outdoor-Air Enthalpy above Room Enthalpy: Position damper to fixed minimum position for [25]<Insert number> percent outdoor air.
 - b. Unoccupied Periods: Close outdoor-air damper and open return-air damper.
12. Controller shall have volatile-memory backup.
- U. Interface with DDC System for HVAC Requirements:
1. Interface relay for scheduled operation.
 2. Interface relay to provide indication of fault at the central workstation.
 3. Provide [BACnet][or][LonWorks] interface for central DDC system for HVAC workstation for the following functions:
 - a. Adjust set points.
 - b. Fan coil unit start, stop, and operating status.
 - c. Data inquiry, including [outdoor-air damper position,]supply- and room-air temperature[and humidity].
 - d. Occupied and unoccupied schedules.
- V. Electrical Connection: Factory wire motors and controls for a single electrical connection.
- W. Capacities and Characteristics:
1. Fan:
 - a. Airflow: <Insert cfm (L/s)>.
 - b. External Static Pressure: <Insert inches wg (kPa)>.
 - c. Fan Speed: <Insert rpm>.
 - d. Motor Speed: <Insert rpm>.
 - e. Motor Horsepower: <Insert horsepower>.
 - f. Drive: [Direct][Belt].
 2. Cooling Capacity:
 - a. Total: <Insert Btu/h (kW)>.
 - b. Sensible: <Insert Btu/h (kW)>.
 - c. Entering-Air Dry-Bulb Temperature: <Insert deg F (deg C)>.
 - d. Entering-Air Wet-Bulb Temperature: <Insert deg F (deg C)>.
 3. Chilled-Water Coil:
 - a. Water Flow: <Insert gpm (L/s)>.
 - b. Water-Side Pressure Loss: <Insert feet wg (kPa)>.
 - c. Entering-Water Temperature: <Insert deg F (deg C)>.
 - d. Air-Side Pressure Drop: <Insert inches wg (kPa)>.
 4. Refrigerant Coil:
 - a. Air-Side Pressure Loss: <Insert inches wg (kPa)>.
 - b. Suction Temperature: <Insert deg F (deg C)>.
 5. Heating Capacity:

- a. Output: **<Insert Btu/h (kW)>**.
 - b. Entering-Air Temperature: **<Insert deg F (deg C)>**.
 - c. Air-Temperature Rise: **<Insert deg F (deg C)>**.
6. Hot-Water Heating Coil:
 - a. Water Flow: **<Insert gpm (L/s)>**.
 - b. Water-Side Pressure Loss: **<Insert feet wg (kPa)>**.
 - c. Air-Side Pressure Drop: **<Insert inches wg (kPa)>**.
 - d. Entering-Water Temperature: **<Insert deg F (deg C)>**.
7. Steam Heating Coil:
 - a. Inlet Steam Pressure: **<Insert psig (kPa)>**.
 - b. Condensing Capacity: **<Insert lb/h (g/s)>**.
 - c. Air-Side Pressure Drop: **<Insert inches wg (kPa)>**.
8. Electric-Resistance Heating Coil:
 - a. Capacity: **<Insert kilowatts>**.
 - b. Number of Steps: **<Indicate number>**.
 - c. Air-Side Pressure Drop: **<Insert inches wg (kPa)>**.
9. Reheat Capacity:
 - a. Output: **<Insert Btu/h (kW)>**.
 - b. Entering-Air Temperature: **<Insert deg F (deg C)>**.
 - c. Air-Temperature Rise: **<Insert deg F (deg C)>**.
10. Filters:
 - a. Face Area: **<Insert sq. ft. (sq. m)>**.
 - b. Thickness: **[1 inch (25 mm)][2 inches (50 mm)]<Insert dimension>**.
11. Electrical Characteristics for Single-Point Connection:
 - a. Voltage/Phase/Hertz: **<Insert values>**.
 - b. Full-Load Amperes: **<Insert value>**.
 - c. Maximum Circuit Amperes: **<Insert value>**.
 - d. Maximum Overcurrent Protection: **<Insert amperage>**.

2.3 DUCTED FAN COIL UNITS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Carrier Global Corporation]**
 2. **[Daikin Applied]**
 3. **[Dunham-Bush, Inc]**
 4. **[Engineered Air]**
 5. **[ENVIRO-TEC; brand of Johnson Controls International plc, Building Solutions North America]**

6. [First Company Products]
 7. [Greenheck Fan Corporation]
 8. [IEC (International Environmental Corporation); LSB Industries]
 9. [Marlo Heat Transfer Solutions; part of Leonardo DRS, Inc.]
 10. [Nailor Industries Inc]
 11. [Rosemex Products]
 12. [Superior Rex]
 13. [Titus; brand of Johnson Controls International plc, Global Products]
 14. [Trane Inc.]
 15. [USA Coil & Air]
 16. [Williams Comfort Products]
 17. [YORK; brand of Johnson Controls International plc, Building Solutions North America]
 18. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [Carrier Global Corporation]
 2. [Daikin Applied]
 3. [Dunham-Bush, Inc]
 4. [Engineered Air]
 5. [ENVIRO-TEC; brand of Johnson Controls International plc, Building Solutions North America]
 6. [First Company Products]
 7. [Greenheck Fan Corporation]
 8. [IEC (International Environmental Corporation); LSB Industries]
 9. [Marlo Heat Transfer Solutions; part of Leonardo DRS, Inc.]
 10. [Nailor Industries Inc]
 11. [Rosemex Products]
 12. [Superior Rex]
 13. [Titus; brand of Johnson Controls International plc, Global Products]
 14. [Trane Inc.]
 15. [USA Coil & Air]
 16. [Williams Comfort Products]
 17. [YORK; brand of Johnson Controls International plc, Building Solutions North America]
 18. <Insert manufacturer's name>
- C. Fan Coil Unit Configurations: [Row][Face] split.
1. Number of Heating Coils: [One] with two-pipe system.
 2. Number of Cooling Coils: [One][Three] with [two][four]-pipe system.
- D. Coil Section Insulation:
1. [1/2-inch- (13-mm-)][1-inch- (25-mm-)]<Insert dimension> thick, [coated][foil-faced] glass fiber complying with ASTM C1071 and attached with adhesive complying with ASTM C916.
 2. Insulate coil section according to Section 230716 "HVAC Equipment Insulation."
 3. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E84 by a qualified testing agency.
 4. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- E. Drain Pans: [Main and Auxiliary][Plastic][Stainless steel][Insulated galvanized steel with plastic liner]. Fabricate pans and drain connections to comply with ASHRAE 62.1.

- F. Chassis: Galvanized steel where exposed to moisture[, **with baked-enamel finish and removable access panel**][, **with powder-coat finish and removable access panel**]. Floor-mounting units shall have leveling screws.
- G. Cabinets: Steel with baked-enamel finish in manufacturer's standard paint color.
1. Supply-Air Plenum: Sheet metal plenum finished and insulated to match the chassis[**with mill-finish, aluminum, double-deflection grille**].
 2. Return-Air Plenum: Sheet metal plenum finished to match the chassis.
 3. Mixing Plenum: Sheet metal plenum finished and insulated to match the chassis with outdoor- and return-air, formed-steel dampers.
 4. Dampers: Galvanized steel with extruded-vinyl blade seals, flexible-metal jamb seals, and interlocking linkage.
- H. Filters: Minimum arrestance and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2 and all addendums.
- I. MERV Rating: **[6][13]<Insert number>** when tested according to ASHRAE 52.2.
1. Washable Foam: 70 percent arrestance and MERV[**3**].
 2. Glass Fiber Treated with Adhesive: 80 percent arrestance and MERV[**5**].
 3. Pleated Cotton-Polyester Media: 90 percent arrestance and MERV[**7**].
- J. Hydronic Coils: Copper tube[**with corrosion-resistant coating**], with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)**, rated for a minimum working pressure of **200 psig (1378 kPa)** and a maximum entering-water temperature of **220 deg F (104 deg C)**. Include manual air vent and drain.
- K. Indoor Refrigerant Coils: Copper tube[**with corrosion-resistant coating**], with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)** and brazed joints at fittings. Comply with AHRI 210/240, and leak test to minimum **450 psig (3105 kPa)** for a minimum **300-psig (2070-kPa)** working pressure. Include thermal expansion valve.
- L. Steam Coils: Copper tube[**with corrosion-resistant coating**], with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)**, rated for a minimum working pressure of **75 psig (517 kPa)**.
- M. Corrosion-Resistant Coating: Coat [**coils**][**and**][**fan guards**] with a corrosion-resistant coating capable of withstanding a **[3,000]<Insert time>**-hour salt-spray test according to ASTM B117.
1. Standards:
 - a. ASTM B117 for salt spray.
 - b. ASTM D2794 for minimum impact resistance of **100 in-lb (11.3 N-m)**
 - c. ASTM D3359 for cross hatch adhesion of 5B.
 2. Application: [**Immersion**][**Spray**].
 3. Thickness: [**1 mil**]**<Insert measurement>**.
 4. Gloss: Minimum gloss of 50 gloss units on a single angle 60 degree meter.
 5. UV Protection: Spray applied topcoat.
- N. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with fuses in terminal box for overcurrent protection and limit controls for high-temperature protection of heaters. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.

- O. Direct-Driven Fans: Double width, forward curved, centrifugal; with permanently lubricated, multispeed motor resiliently mounted in the fan inlet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.
 - 1. Motors: Comply with requirements in Section 230500 "Common Work Results for HVAC."
- P. Belt-Driven Fans: Double width, forward curved, centrifugal; with permanently lubricated, single-speed motor installed on an adjustable fan base resiliently mounted in the cabinet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.
 - 1. Motors: Comply with requirements in Section 230500 "Common Work Results for HVAC."
- Q. Factory, Hydronic Piping Package: **[ASTM B88, Type L (ASTM B88M, Type B)][ASTM B88, Type M (ASTM B88M Type C)]** copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet.
 - 1. **[Two][Three]-way, [two-position][modulating]** control valve for chilled-water coil.
 - 2. **[Two][Three]-way, [two-position][modulating]** control valve for heating coil.
 - 3. **[Two][Three]-way, [two-position][modulating]** control valve for dual-temperature coil.
 - 4. **[Two][Three]-way, [two-position][modulating]** control valve for reheat coil.
 - 5. Hose Kits: Minimum **400-psig (2758-kPa)** working pressure and operating temperatures from **33 to 211 deg F (0.5 to 99 deg C)**. Tag hose kits to equipment designations.
 - a. Length: **[24 inches (600 mm)][36 inches (900 mm)]<Insert dimension>**.
 - b. Minimum Diameter: Equal to fan coil unit connection size.
 - 6. Two-Piece Ball Valves: Bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and **600-psig (4140-kPa)** minimum CWP rating and blowout-proof stem.
 - 7. Calibrated-Orifice Balancing Valves: Bronze body, ball type; **125-psig (860-kPa)** working pressure, **250 deg F (121 deg C)** maximum operating temperature; with calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, threaded ends, and a memory stop to retain set position.
 - 8. Automatic Flow-Control Valve: Brass or ferrous-metal body; **300-psig (2070-kPa)** working pressure at **250 deg F (121 deg C)**; with removable, corrosion-resistant, tamperproof, self-cleaning piston spring; factory set to maintain constant indicated flow with plus or minus 10 percent over differential pressure range of **2 to 80 psig (13.8 to 552 kPa)**.
 - 9. Y-Pattern Hydronic Strainers: Cast-iron body (ASTM A126, Class B); **125-psig (860-kPa)** working pressure; with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum **NPS 1/2 (DN 15)** hose-end, full-port, ball-type blowdown valve in drain connection.
 - 10. Wrought-Copper Unions: ASME B16.22.
- R. Remote condensing units are specified in Section 236200 "Packaged Compressor and Condenser Units."
- S. Control devices and operational sequence are specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."
- T. Basic Unit Controls:
 - 1. Control voltage transformer.
 - 2. **[Wall-mounting][Unit-mounted]** thermostat with the following features.
 - a. Heat-cool-off switch.
 - b. Fan on-auto switch.
 - c. Fan-speed switch.

- d. **[Manual][Automatic]** changeover.
 - e. Adjustable deadband.
 - f. **[Concealed][Exposed]** set point.
 - g. **[Concealed][Exposed]** indication.
 - h. **[Degree F][Degree C]** indication.
3. **[Wall-mounting][Unit-mounted]** humidistat.
- a. **[Concealed][Exposed]** set point.
 - b. **[Concealed][Exposed]** indication.
4. **[Wall-mounting][Unit-mounted]** temperature sensor.
5. Unoccupied-period-override push button.
6. Data entry and access port.
- a. Input data includes room temperature, and humidity set points and occupied and unoccupied periods.
 - b. Output data includes room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.

U. Terminal Controller:**[DDC.]**

- 1. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.
- 2. Unoccupied-Period-Override Operation: **[Two]<Insert number>** hours.
- 3. Unit Supply-Air Fan Operation:
 - a. Occupied Periods: Fan runs continuously.
 - b. Unoccupied Periods: Fan cycles to maintain room setback temperature.
- 4. Hydronic-Cooling-Coil Operation:
 - a. Occupied Periods: **[Open][Modulate]** control valve to maintain room temperature.
 - b. Unoccupied Periods: Close control valve.
- 5. Refrigerant-Coil Operation:
 - a. Occupied Periods: Start compressor to maintain room temperature or humidistat set point.
 - b. Unoccupied Periods: Stop compressor cooling and cycle compressor for heating to maintain setback temperature.
- 6. Heating-Coil Operation:**[Supplemental.]**
 - a. Occupied Periods: **[Open control valve][Modulate control valve][Energize electric-resistance coil]** to provide heating if room temperature falls below thermostat set point.
 - b. Unoccupied Periods: Start fan and **[open control valve][modulate control valve][energize electric-resistance coil]** if room temperature falls below setback temperature.
 - c. Switch refrigerant-reversing valve to operate supplemental coil for heating when outdoor temperature is below **[25 deg F (4 deg C)]<Insert temperature>**.
- 7. Dual-Temperature Hydronic-Coil Operation:
 - a. Occupied Periods: When chilled water is available, **[open][modulate]** control valve if room temperature exceeds thermostat set point. When hot water is available, **[open][modulate]**

- control valve if temperature falls below thermostat set point.
 - b. Unoccupied Periods: When chilled water is available, close valve. When hot water is available, **[open][modulate]** control valve if room temperature falls below thermostat setback temperature.
8. Reheat-Coil Operation:
 - a. Humidity Control for Occupied Periods:
 - 1) Humidistat **[opens control valve][modulates control valve][energizes electric-resistance coil]** to provide heating. As room temperature rises above set point, cooling-coil valve **[opens][modulates]** to maintain room temperature.
 - b. Humidity Control for Unoccupied Periods: **[Close control valve][De-energize]**.
 - c. Occupied Periods:
 - 1) Heating Operations: **[Open control valve][Modulate control valve][Energize electric-resistance coil]** to provide heating if room temperature falls below thermostat set point.
 - 2) Humidity-Control Operations: Humidistat **[opens control valve][modulates control valve][energizes electric-resistance coil]** to provide heating. As room temperature rises above set point, cooling-coil valve **[opens][modulates]** to maintain room temperature.
 - d. Unoccupied Periods: Start fan and **[open control valve][modulate control valve][energize electric-resistance coil]** if room temperature falls below setback temperature. Humidity control is not available.
9. Outdoor-Air Damper Operation, Fixed, Minimum Outdoor-Air Intake:
 - a. Occupied Periods: Open damper to fixed position for **[25]<Insert number>** percent outdoor air.
 - b. Unoccupied Periods: Close damper.
10. Outdoor-Air Damper Operation, Outdoor-Air Economizer Cycle:
 - a. Occupied Periods:
 - 1) Outdoor-Air Temperature below Room Temperature: If room temperature is above room-temperature set point, modulate outdoor- and return-air dampers to maintain room temperature set point (outdoor-air economizer). If room temperature is below set point, position damper to fixed minimum setting.
 - 2) Outdoor-Air Temperature above Room Temperature: Position damper to fixed minimum position for **[25]<Insert number>** percent outdoor air.
 - b. Unoccupied Periods: Close outdoor-air damper and open return-air damper.
11. Outdoor-Air Damper Operation (Enthalpy Based):
 - a. Occupied Periods:
 - 1) Outdoor-Air Enthalpy below Room Enthalpy: If room temperature is above room-temperature set point, modulate outdoor-air damper to maintain room temperature (outdoor-air economizer). If room temperature is below set point, position damper to fixed minimum position for **[25]<Insert number>** percent outdoor air.
 - 2) Outdoor-Air Enthalpy above Room Enthalpy: Position damper to fixed minimum

position for [25]<Insert number> percent outdoor air.

b. Unoccupied Periods: Close outdoor-air damper and open return-air damper.

12. Controller shall have volatile-memory backup.

V. Interface with DDC System for HVAC Requirements:

1. Interface relay for scheduled operation.
2. Interface relay to provide indication of fault at the central workstation.
3. Provide **[BACnet][or][LonWorks]** interface for central DDC system for HVAC workstation for the following functions:
 - a. Adjust set points.
 - b. Fan coil unit start, stop, and operating status.
 - c. Data inquiry, including **[outdoor-air damper position]**, supply- and room-air temperature **[and humidity]**.
 - d. Occupied and unoccupied schedules.

W. Electrical Connection: Factory wire motors and controls for a single electrical connection.

X. Capacities and Characteristics:

1. Fan:
 - a. Airflow: **<Insert cfm (L/s)>**.
 - b. Static Pressure: **<Insert inches wg (kPa)>**.
 - c. Fan Speed: **<Insert rpm>**.
 - d. Motor Speed: **<Insert rpm>**.
 - e. Motor Horsepower: **<Insert horsepower>**.
 - f. Drive: **[Direct][Belt]**.
2. Cooling Capacity:
 - a. Total: **<Insert Btu/h (kW)>**.
 - b. Sensible: **<Insert Btu/h (kW)>**.
 - c. Entering-Air Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
 - d. Entering-Air Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
3. Chilled-Water Coil:
 - a. Water Flow: **<Insert gpm (L/s)>**.
 - b. Water-Side Pressure Loss: **<Insert feet wg (kPa)>**.
 - c. Air-Side Pressure Drop: **<Insert inches wg (kPa)>**.
 - d. Entering-Water Temperature: **<Insert deg F (deg C)>**.
4. Refrigerant Coil:
 - a. Air-Side Pressure Loss: **<Insert inches wg (kPa)>**.
 - b. Suction Temperature: **<Insert deg F (deg C)>**.
5. Heating Capacity:
 - a. Output: **<Insert Btu/h (kW)>**.

- b. Entering-Air Temperature: **<Insert deg F (deg C)>**.
 - c. Air-Temperature Rise: **<Insert deg F (deg C)>**.
- 6. Hot-Water Heating Coil:
 - a. Water Flow: **<Insert gpm (L/s)>**.
 - b. Water-Side Pressure Loss: **<Insert feet wg (kPa)>**.
 - c. Air-Side Pressure Drop: **<Insert inches wg (kPa)>**.
 - d. Entering-Water Temperature: **<Insert deg F (deg C)>**.
- 7. Steam Heating Coil:
 - a. Inlet Steam Pressure: **<Insert psig (kPa)>**.
 - b. Condensing Capacity: **<Insert lb/h (g/s)>**.
 - c. Air-Side Pressure Drop: **<Insert inches wg (kPa)>**.
- 8. Electric-Resistance Heating Coil:
 - a. Capacity: **<Insert kilowatts>**.
 - b. Number of Steps: **<Insert number>**.
 - c. Air-Side Pressure Drop: **<Insert inches wg (kPa)>**.
- 9. Reheat Capacity:
 - a. Output: **<Insert Btu/h (kW)>**.
 - b. Entering-Air Temperature: **<Insert deg F (deg C)>**.
 - c. Air-Temperature Rise: **<Insert deg F (deg C)>**.
- 10. Filters:
 - a. Face Area: **<Insert sq. ft. (sq. m)>**.
 - b. Thickness: **[1 inch (25 mm)][2 inches (50 mm)]<Insert dimension>**.
- 11. Electrical Characteristics for Single-Point Connection:
 - a. Voltage/Phase/Hertz: **<Insert values>**.
 - b. Full-Load Amperes: **<Insert values>**.
 - c. Maximum Circuit Amperes: **<Insert values>**.
 - d. Maximum Overcurrent Protection: **<Insert amperage>**.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas, with Installer present, to receive fan coil units for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping and electrical connections to verify actual locations before fan coil unit installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF FAN COIL UNITS

- A. Install fan coil units level and plumb.
- B. Install fan coil units to comply with NFPA 90A.
- C. Suspend fan coil units from structure with elastomeric hangers. Vibration isolators are specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."
- D. Verify locations of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices **[48 inches (1220 mm)][60 inches (1525 mm)]<Insert dimension>** above finished floor.
- E. Install new filters in each fan coil unit within two weeks after Substantial Completion.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
 - 1. Install piping adjacent to machine to allow service and maintenance.
 - 2. Connect piping to fan coil unit factory hydronic piping package. Install piping package if shipped loose.
 - 3. Connect condensate drain to indirect waste.
 - a. Install condensate trap of adequate depth to seal against fan pressure. Install cleanouts in piping at changes of direction.
- B. Connect supply-air and return-air ducts to fan coil units with flexible duct connectors specified in Section 233300 "Air Duct Accessories." Comply with safety requirements in UL 1995 for duct connections.
- C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections **[with the assistance of a factory-authorized service representative]**:
 - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
 - 3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.



- D. Remove and replace malfunctioning units and retest as specified above.
- E. Prepare test and inspection reports.

3.5 ADJUSTING

- A. Adjust initial temperature and humidity set points.
- B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to **[two]<Insert number>** visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain fan coil units.

END OF SECTION 23 82 19 00



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23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 82 19 00	23 82 00 00	Chilled Beams



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SECTION 23 82 29 00 - RADIATORS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes flat-pipe steel radiators.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings:
 - 1. Include plans, elevations, sections, and details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Indicate location and size of each field connection.
 - 4. Indicate location and arrangement of piping valves and specialties.
 - 5. Indicate location and arrangement of integral controls and other accessories.
- C. Samples: For each exposed product and for each color and texture specified.
- D. Color Samples for Initial Selection: For radiators with factory-applied color finishes.
- E. Color Samples for Verification: For each type of exposed finish.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Structural members, including wall construction, to which radiators will be attached.
 - 2. Method of attaching radiators to building structure.
 - 3. Penetrations of fire-rated wall and floor assemblies.
- B. Field quality-control reports.

PART 2 - PRODUCTS

2.1 FLAT-PIPE STEEL RADIATORS

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

1. [Quincy Hydronic Technology Inc]
 2. [Runtal North America, Inc.]
 3. [Zehnder Group, Inc.]
 4. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [Quincy Hydronic Technology Inc]
 2. [Runtal North America, Inc.]
 3. [Zehnder Group, Inc.]
 4. <Insert manufacturer's name>
- C. Heating Elements: Steel, welded and formed into flat, square, steel header with minimum thickness of **0.109 inch (2.76 mm)**. Include threaded piping and air-vent connections.
1. Working Pressure:
 - a. **56 psig (386 kPa); 0.048 inch (1.22 mm).**
 - b. **85 psig (585 kPa); 0.058 inch (1.47 mm).**
 - c. **128 psig (881 kPa); 0.078 inch (1.98 mm).**
 2. Tube Height: <Insert inches (mm)>.
 3. Tube Depth: <Insert inches (mm)>.
 4. Tube Length: <Insert inches (mm)>.
 5. Number of Tubes High: <Insert number>.
 6. Number of Tubes Deep: <Insert number>.
 7. Room Air Temperature: [65 deg F (18 deg C)]<Insert temperature>.
 8. Heat Output: <Insert Btu/h (W)>.
 9. Average Water Temperature: [180 deg F (82 deg C)]<Insert temperature>.
 10. Temperature Drop: [10 deg F (5.56 deg C)][20 deg F (11.1 deg C)][30 deg F (16.6 deg C)]<Insert temperature>.
 11. Pressure Loss: <Insert feet wg (kPa)>.
- D. Mounting: [Wall brackets][Floor pedestals] with maximum spacing of **36 inches (914 mm)**.
- E. Finish: Baked-enamel finish in manufacturer's [standard][custom] color as selected by Architect.
- F. Accessories:
1. Steel piping covers finished to match radiator finish.
 2. Flexible Expansion Compensation Hoses: Minimum **400-psig (2758-kPa)** working pressure, and operating temperatures from **33 to 211 deg F (0.5 to 99.5 deg C)**.
 - a. Length: [24 inches (600 mm)][36 inches (900 mm)]<Insert dimension>.
 - b. Minimum Diameter: Equal to connection size.

PART 3 - EXECUTION**3.1 EXAMINATION**

- A. Examine areas to receive radiators for compliance with requirements for installation tolerances and

other conditions affecting performance of the Work.

- B. Examine roughing-in for hydronic-piping connections to verify actual locations before installation of radiators.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install units level and plumb.
- B. Install expansion compensation hoses.
- C. Install piping covers.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect radiators and components to piping according to Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties."
 - 1. Install shutoff valves on inlet and outlet, and balancing valve on outlet.
- C. Install control valves as required by Section 230923.11 "Control Valves."
- D. Install piping adjacent to radiators to allow service and maintenance.

3.4 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections:
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
- B. Units will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

END OF SECTION 23 82 29 00



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23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 82 29 00	23 82 00 00	Chilled Beams
23 82 29 00	23 82 33 00	Convectors



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SECTION 23 82 33 00 - CONVECTORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Convectors - electric.
2. Convectors - hot water.
3. Convectors - steam.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

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

B. Shop Drawings:

1. Include plans, elevations, sections, and details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include details and dimensions of custom-fabricated enclosures.
4. Indicate location and size of each field connection.
5. Indicate location and arrangement of piping valves and specialties.
6. Indicate location and arrangement of integral controls.
7. Include enclosure joints, corner pieces, access doors, and other accessories.
8. Include diagrams for power, signal, and control wiring.

C. Samples: For each exposed product and for each color and texture specified.

D. Color Samples for Initial Selection: For units with factory-applied color finishes.

E. Color Samples for Verification: For each type of exposed finish.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

B. Field quality control reports.

PART 2 - PRODUCTS**2.1 CONVECTORS****A. Convectors - Electric :**

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Chromalox, Inc.]**
 - b. **[INDEECO]**
 - c. **[Markel Products Company; a subsidiary of TPI Corporation]**
 - d. **[Marley Engineered Products]**
 - e. **[Ouellet Canada Inc]**
 - f. **[STELPRO DESIGN INC]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Chromalox, Inc.]**
 - b. **[INDEECO]**
 - c. **[Markel Products Company; a subsidiary of TPI Corporation]**
 - d. **[Marley Engineered Products]**
 - e. **[Ouellet Canada Inc]**
 - f. **[STELPRO DESIGN INC]**
 - g. **<Insert manufacturer's name>**
3. Description: Factory-packaged units constructed in accordance with UL 499, UL 1030, and UL 2021.
4. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
5. Heating Elements: Nickel-chromium-wire heating element enclosed in metallic sheath mechanically bonded to fins, with high-temperature cutout and sensor running the full length of element. Element supports to eliminate thermal expansion noise.
 - a. Volts: **<Insert value>**.
 - b. Phase: **<Insert value>**.
 - c. Hertz: **<Insert value>**.
 - d. Heat Output: **[300][500][750][1000][1250][1500][1750][2000][2250][2500]<Insert number> W.**
6. Front and Top Panel: Minimum **[0.0528-inch- (1.35-mm-)][0.0677-inch- (1.7-mm-)]<Insert dimension>** thick steel with exposed corners rounded; removable front panels with tamper-resistant fasteners braced and reinforced for stiffness.
7. Wall-Mounted Back and End Panels: Minimum **0.0428-inch- (1.1-mm-)** thick steel.
8. Floor-Mounted Pedestals: Conceal conduit for power and control wiring at maximum **36-inch (914-mm)** spacing. Pedestal-mounted back panel to be solid panel matching front panel.
9. Support Brackets: Locate at maximum **36-inch (914-mm)** spacing to support front panel and element.
10. Insulation: **1/2-inch- (13-mm-)** thick, fibrous glass on inside of the back of the enclosure.

11. Finish: Baked-enamel finish in manufacturer's **[standard][custom]** color as selected by Architect.
12. Damper: Knob-operated internal damper.
13. Access Doors: Factory made, permanently hinged with tamper-resistant fastener, minimum size **6 by 7 inches (150 by 175 mm)**, integral with enclosure.
14. Enclosure Style: **[Sloped][Flat]** top.
 - a. Front Inlet Grille:
 - 1) Punched louver; painted to match enclosure.
 - 2) Extruded-aluminum linear bar grille; pencil-proof bar spacing.
 - a) Mill-finish aluminum.
 - b) Anodized finish, color as selected by Architect from manufacturer's **[standard][custom]** colors.
 - c) Painted to match enclosure.
 - b. Outlet Grille:
 - 1) Location: **[Top][Front]**.
 - 2) Punched louver; painted to match enclosure.
 - 3) Extruded-aluminum linear bar grille; pencil-proof bar spacing.
 - a) Mill-finish aluminum.
 - b) Anodized finish, color as selected by Architect from manufacturer's **[standard][custom]** colors.
 - c) Painted to match enclosure.
 - c. Enclosure Height: **<Insert inches (mm)>**.
 - d. Enclosure Depth: **<Insert inches (mm)>**.
 - e. Enclosure Length: **<Insert inches (mm)>**.
15. Unit Controls: Integral **[line-voltage thermostat with minimum range of 60 to 90 deg F (15 to 32 deg C)][low-voltage relay and control transformer for remote thermostat]**.
16. Accessories: Integral disconnect switch, recessing flanges finished to match enclosure or overlapping front cover for fully recessed units, and rubber gaskets to seal cabinet at wall.

B. Convectors - Hot Water :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Engineered Air]**
 - b. **[Slant/Fin Corp]**
 - c. **[Sterling HVAC Products; a Mestek company]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Engineered Air]**
 - b. **[Slant/Fin Corp]**
 - c. **[Sterling HVAC Products; a Mestek company]**
 - d. **<Insert manufacturer's name>**

3. Heating Elements: Seamless copper tubing mechanically expanded into evenly spaced aluminum fins and rolled into cast-[iron][or][brass] headers with inlet/outlet and air vent; steel side plates and supports. Factory-pressure-test element at minimum **100 psig (690 kPa)**.
 - a. Element Height: **<Insert inches (mm)>**.
 - b. Element Depth: **<Insert inches (mm)>**.
 - c. Element Length: **<Insert inches (mm)>**.
 - d. Entering-Air Temperature: **[65 deg F (18 deg C)]<Insert temperature>**.
 - e. Heat Output: **<Insert Btu/h per ft. (W/m)>**.
 - f. Average Water Temperature: **[180 deg F (82 deg C)]<Insert temperature>**.
 - g. Temperature Drop: **[10 deg F (5.56 deg C)][20 deg F (11.1 deg C)][30 deg F (16.6 deg C)]<Insert temperature>**.
 - h. Pressure Loss: **<Insert ft. wg (kPa)>**.
4. Front and Top Panel: Minimum **[0.0528-inch- (1.35-mm-)][0.0677-inch- (1.7-mm-)]<Insert dimension>** thick steel with exposed corners rounded; removable front panels with tamper-resistant fasteners braced and reinforced for stiffness.
5. Wall-Mounted Back and End Panels: Minimum **0.0428-inch- (1.1-mm-)** thick steel.
6. Floor-Mounted Pedestals: Conceal conduit for power and control wiring at maximum **36-inch (914-mm)** spacing. Pedestal-mounted back panel to be solid panel matching front panel.
7. Support Brackets: Locate at maximum **36-inch (914-mm)** spacing to support front panel and element.
8. Insulation: **1/2-inch- (13-mm-)** thick, fibrous glass on inside of the back of the enclosure.
9. Finish: Baked-enamel finish in manufacturer's **[standard][custom]** color as selected by Architect.
10. Damper: Knob-operated internal damper.
11. Access Doors: Factory made, permanently hinged with tamper-resistant fastener, minimum size **6 by 7 inches (150 by 175 mm)**, integral with enclosure.
12. Enclosure Style: **[Sloped][Flat]** top.
 - a. Front Inlet Grille:
 - 1) Punched louver; painted to match enclosure.
 - 2) Extruded-aluminum linear bar grille; pencil-proof bar spacing.
 - a) Mill-finish aluminum.
 - b) Anodized finish, color as selected by Architect from manufacturer's **[standard][custom]** colors.
 - c) Painted to match enclosure.
 - b. Outlet Grille:
 - 1) Location: **[Top][Front]**.
 - 2) Punched louver; painted to match enclosure.
 - 3) Extruded-aluminum linear bar grille; pencil-proof bar spacing.
 - a) Mill-finish aluminum.
 - b) Anodized finish, color as selected by Architect from manufacturer's **[standard][custom]** colors.
 - c) Painted to match enclosure.
 - c. Enclosure Height: **<Insert inches (mm)>**.
 - d. Enclosure Depth: **<Insert inches (mm)>**.
 - e. Enclosure Length: **<Insert inches (mm)>**.

C. Convectors - Steam :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Engineered Air]
 - b. [Slant/Fin Corp]
 - c. [Sterling HVAC Products; a Mestek company]
 - d. [Trane]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Engineered Air]
 - b. [Slant/Fin Corp]
 - c. [Sterling HVAC Products; a Mestek company]
 - d. [Trane]
 - e. <Insert manufacturer's name>
3. Heating Elements: Seamless copper tubing mechanically expanded into evenly spaced aluminum fins and rolled into cast-[iron][or][brass] headers with inlet/outlet and air vent; steel side plates and supports. Factory-pressure-test element at minimum **100 psig (690 kPa)**.
 - a. Element Height: <Insert inches (mm)>.
 - b. Element Depth: <Insert inches (mm)>.
 - c. Element Length: <Insert inches (mm)>.
 - d. Entering-Air Temperature: [65 deg F (18 deg C)]<Insert temperature>.
 - e. Heat Output: <Insert sq. ft. EDR (W)>.
 - f. Entering Steam Pressure: [1 psig (6.9 kPa)]<Insert value>.
4. Front and Top Panel: Minimum [0.0528-inch- (1.35-mm-)][0.0677-inch- (1.7-mm-)]<Insert dimension> thick steel with exposed corners rounded; removable front panels with tamper-resistant fasteners braced and reinforced for stiffness.
5. Wall-Mounted Back and End Panels: Minimum **0.0428-inch- (1.1-mm-)** thick steel.
6. Floor-Mounted Pedestals: Conceal conduit for power and control wiring at maximum **36-inch (914-mm)** spacing. Pedestal-mounted back panel to be solid panel matching front panel.
7. Support Brackets: Locate at maximum **36-inch (914-mm)** spacing to support front panel and element.
8. Insulation: **1/2-inch- (13-mm-)** thick, fibrous glass on inside of the back of the enclosure.
9. Finish: Baked-enamel finish in manufacturer's [standard][custom] color as selected by Architect.
10. Damper: Knob-operated internal damper.
11. Access Doors: Factory made, permanently hinged with tamper-resistant fastener, minimum size **6 by 7 inches (150 by 175 mm)**, integral with enclosure.
12. Enclosure Style: [Sloped][Flat] top.
13. Front Inlet Grille:
 - a. Punched louver; painted to match enclosure.
 - b. Extruded-aluminum linear bar grille; pencil-proof bar spacing.
 - 1) Mill-finish aluminum.
 - 2) Anodized finish, color as selected by Architect from manufacturer's [standard][custom] colors.
 - 3) Painted to match enclosure.

14. Outlet Grille:
 - a. Location: **[Top][Front]**.
 - b. Punched louver; painted to match enclosure.
 - c. Extruded-aluminum linear bar grille; pencil-proof bar spacing.
 - 1) Mill-finish aluminum.
 - 2) Anodized finish, color as selected by Architect from manufacturer's **[standard][custom]** colors.
 - 3) Painted to match enclosure.
15. Enclosure Height: **<Insert inches (mm)>**.
16. Enclosure Depth: **<Insert inches (mm)>**.
17. Enclosure Length: **<Insert inches (mm)>**.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive convectors for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for **[hydronic-piping][steam-piping][electrical]** connections to verify actual locations before installation of convector.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF CONVECTORS

- A. Install convectors level and plumb.
- B. Install valves within reach of access door provided in enclosure.
- C. Install air-seal gasket between wall and recessed flanges or front cover of fully recessed unit.
- D. Install piping within pedestals for freestanding units.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in **[Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."][Section 232213 "Steam and Condensate Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties.]** Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect hot-water convectors and components to piping in accordance with Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
 1. Install shutoff valves on inlet and outlet, and balancing valve on outlet.
- C. Connect steam convectors and components to piping in accordance with Section 232213 "Steam and



Condensate Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties."

1. Install shutoff valve on inlet; install strainer, steam trap, and shutoff valve on outlet.
- D. Install control valves as required by Section 230923.11 "Control Valves."
- E. Install piping adjacent to convectors to allow service and maintenance.
- F. Ground electric convectors in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- G. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections:
 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 2. Operational Test: After electrical circuitry has been energized, start convectors to confirm proper operation.
 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Convectors will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

END OF SECTION 23 82 33 00



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23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 82 33 00	23 82 00 00	Chilled Beams



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SECTION 23 82 36 00 - FINNED-TUBE RADIATION HEATERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Baseboard radiation heaters - electric.
2. Baseboard radiation heaters - hot water.
3. Finned-tube radiation heaters - electric.
4. Finned-tube radiation heaters - hot water.
5. Finned-tube radiation heaters - steam.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

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

B. Shop Drawings:

1. Include plans, elevations, sections, and details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include details and dimensions of custom-fabricated enclosures.
4. Indicate location and size of each field connection.
5. Indicate location and arrangement of piping valves and specialties.
6. Indicate location and arrangement of integral controls.
7. Include enclosure joints, corner pieces, access doors, and other accessories.
8. Include diagrams for power, signal, and control wiring.

C. Samples: For each exposed product and for each color and texture specified.

D. Color Samples for Initial Selection: For baseboard and finned-tube radiation heaters with factory-applied color finishes.

E. Color Samples for Verification: For each type of exposed finish.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Structural members, including wall construction, to which baseboard and finned-tube radiation heaters will be attached.
2. Method of attaching baseboard and finned-tube radiation heaters to building structure.
3. Penetrations of fire-rated wall and floor assemblies.

- B. Field quality control reports.

PART 2 - PRODUCTS

2.1 BASEBOARD RADIATION HEATERS

- A. Baseboard Radiation Heaters - Electric: **<Insert drawing designation>**

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Source Limitations: Obtain electric baseboard radiation heaters from single manufacturer.
3. Description: Factory-packaged units constructed in accordance with UL 499, UL 1030, and UL 2021.
4. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
5. Heating Elements: Nickel-chromium-wire heating element enclosed in metallic sheath mechanically bonded to fins, with high-temperature cutout and sensor running the full length of the element. Element supports are to eliminate thermal expansion noise.
 - a. Volts: **<Insert value>**.
 - b. Phase: **<Insert value>**.
 - c. Hertz: **<Insert value>**.
 - d. Heat Output: **<Insert W/ft. (W/m)>**.
6. Enclosures:
 - a. Minimum **[18 gauge] [20 gauge] <Insert gauge> [steel] [galvanized steel] <Insert material>** with removable front cover.
 - b. Full-height back.
 - c. Full-length damper.
 - d. End panel.
 - e. **[Plastic end] [End]** caps.
 - f. Inside and outside corners.
 - g. Joiner pieces to snap together.
 - h. Enclosure Height: **<Insert inches (mm)>**.
 - i. Enclosure Depth: **<Insert inches (mm)>**.
 - j. Finish: Powder-coated finish in manufacturer's **[standard] [custom]** color as selected by Architect.
 - k. Element Brackets: Primed and painted steel to support front panel and element.
7. Unit Controls: **[Integral line-voltage thermostat] [Integral electronic thermostat] [Remote electronic thermostat] [Remote line-voltage thermostat] <Insert thermostat type>**.
8. Accessories:
 - a. Blank filler sections without a heating element matching the adjacent enclosure.
 - b. Straight-Blade-Type Receptacles: Comply with FED W-C-596H, NEMA WD 1, NEMA WD 6, and UL 498; in color selected by Architect.

- B. Baseboard Radiation Heaters - Hot Water: **<Insert drawing designation>**

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Source Limitations: Obtain hot water baseboard radiation heaters from single manufacturer.
3. Performance Ratings: Rate baseboard radiation heaters in accordance with Hydronics Institute's "I=B=R Testing and Rating Standard for Baseboard Radiation."

4. Heating Elements, Copper Tubing: Mechanically expanded into flanged collars of evenly spaced aluminum fins resting on polypropylene element glides. One end of tube will be belled.
 - a. Tube Diameter: **[NPS 1/2 (DN 15)] [NPS 3/4 (DN 20)] [NPS 1 (DN 25)] [NPS 1-1/4 (DN 32)]** **<Insert pipe size>**.
 - b. Fin Size: **[2-1/2 by 2-1/2 inches (63 by 63 mm)] [3 by 3 inches (76 by 76 mm)]** **<Insert dimensions>**.
 - c. Fin Spacing: **[40 per ft. (131 per m)] [50 per ft. (164 per m)] [58 per ft. (190 per m)]** **<Insert value>**.
 - d. Number of Tiers: **<Insert number>**.
 - e. Heat Output: **<Insert Btu/h per ft. (W/m)>**.
 - f. Entering-Air Temperature: **[65 deg F (18 deg C)]** **<Insert temperature>**.
 - g. Average Water Temperature: **[180 deg F (82 deg C)]** **<Insert temperature>**.
 - h. Minimum Water Velocity: **[1/2 fps (0.15 m/s)]** **<Insert value>**.

5. Heating Elements, Steel Tubing: Mechanically expanded into flanged collars of evenly spaced steel fins resting on polypropylene element glides. Tube ends will be threaded.
 - a. Tube Diameter: **[NPS 1-1/4 (DN 32)]** **<Insert pipe size>**.
 - b. Fin Size: Nominal **[2-1/2 by 2-1/2 inches (64 by 64 mm)] [3 by 3 inches (76 by 76 mm)]** **<Insert dimensions>**.
 - c. Fin Spacing: **[52 per ft. (171 per m)] [52 per ft. (171 per m)]** **<Insert value>**.
 - d. Number of Tiers: **<Insert number>**.
 - e. Heat Output: **<Insert Btu/h per ft. (W/m)>**.
 - f. Entering-Air Temperature: **[65 deg F (18 deg C)]** **<Insert temperature>**.
 - g. Average Water Temperature: **[180 deg F (82 deg C)]** **<Insert temperature>**.
 - h. Minimum Water Velocity: **[1/2 fps (0.15 m/s)]** **<Insert value>**.

6. Enclosure: Minimum **[18 gauge] [20 gauge]** **<Insert gauge>** **[steel] [galvanized steel]** **<Insert material>** with removable front cover.
 - a. Full-height back.
 - b. Full-length damper.
 - c. End panel.
 - d. End caps.
 - e. Inside and outside corners.
 - f. Valve access door.
 - g. Joiner pieces to snap together.
 - h. Enclosure Height: **<Insert inches (mm)>**.
 - i. Enclosure Depth: **<Insert inches (mm)>**.
 - j. Finish: **[Baked-enamel] [or] [powder-coated]** finish in manufacturer's **[standard] [custom]** color as selected by Architect.
 - k. Element Brackets: Primed and painted steel to support front panel and element.

2.2 FINNED-TUBE RADIATION HEATERS

A. Finned-Tube Radiation Heaters - Electric: **<Insert drawing designation>**

1. **<Double click here to find, evaluate, and insert list of manufacturers and products.>**
2. Source Limitations: Obtain electric finned-tube radiation heaters from single manufacturer.
3. Description: Factory-packaged units constructed in accordance with UL 499, UL 1030, and UL 2021.
4. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

5. Heating Elements: Nickel-chromium-wire heating element enclosed in metallic sheath mechanically bonded to fins, with high-temperature cutout and sensor running the full length of the element. Element supports will eliminate thermal expansion noise.
 - a. Volts: **<Insert value>**.
 - b. Phase: **<Insert value>**.
 - c. Hertz: **<Insert value>**.
 - d. Heat Output: **<Insert W/ft. (W/m)>**.
6. Front Panel: Minimum **[18 gauge] [20 gauge] <Insert gauge> [steel] [ASTM A653/A653M, G60 (Z180) galvanized steel] <Insert material>** with removable front cover.
7. Wall-Mounted Back Panel: Minimum **[18 gauge] [20 gauge] <Insert gauge>** thick steel, full height, with full-length channel support for front panel without exposed fasteners.
8. Floor-Mounted Pedestals: Conceal conduit for power and control wiring at maximum 36-inch (914-mm) spacing. Pedestal-mounted back panel is to be solid panel matching front panel.
9. Support Brackets: Locate at maximum 36-inch (914-mm) spacing to support front panel and element.
10. Finish: **[Baked-enamel] [Baked-epoxy] [Powder-coated]** finish in manufacturer's **[standard] [custom]** color as selected by Architect.
11. Damper: Knob-operated internal damper at enclosure outlet.
12. Access Doors: Factory made, permanently hinged with tamper-resistant fastener, minimum size 6 by 7 inches (150 by 175 mm), integral with enclosure.
13. Enclosure Style: **[Sloped] [Flat]** top.
 - a. Front Inlet Grille:
 - 1) Punched louver; painted to match enclosure.
 - 2) Extruded-aluminum linear bar grille; pencil-proof bar spacing.
 - a) Mill-finish aluminum.
 - b) Anodized finish, color as selected by Architect from manufacturer's **[standard] [custom]** colors.
 - c) Painted to match enclosure.
 - b. Outlet Grille:
 - 1) Location: **[Top] [Front]**.
 - 2) Punched louver; painted to match enclosure.
 - 3) Extruded-aluminum linear bar grille; pencil-proof bar spacing.
 - a) Mill-finish aluminum.
 - b) Anodized finish, color as selected by Architect from manufacturer's **[standard] [custom]** colors.
 - c) Painted to match enclosure.
 - c. Enclosure Height: **<Insert inches (mm)>**.
 - d. Enclosure Depth: **<Insert inches (mm)>**.
14. Unit Controls: Integral **[line-voltage thermostat with minimum range of 60 to 90 deg F (15 to 32 deg C)] [low-voltage relay and control transformer for remote thermostat]**.
15. Accessories: Integral disconnect switch, blank filler sections, corners, relay sections, and splice plates all matching the enclosure and grille finishes.

B. Finned-Tube Radiation Heaters - Hot Water:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Source Limitations: Obtain hot water finned tube radiation heaters from single manufacturer.
3. Performance Ratings: Rate finned-tube radiation heaters in accordance with Hydronics Institute's "I=B=R Testing and Rating Standard for Finned-Tube (Commercial) Radiation."
4. Heating Elements, Copper Tubing: Mechanically expanded into flanged collars of evenly spaced aluminum fins resting on element supports. One end of tube will be belled.
 - a. Tube Diameter: **[NPS 3/4 (DN 20)] [NPS 1 (DN 25)] [NPS 1-1/4 (DN 32)]** **<Insert pipe size>**.
 - b. Fin Size: **[3 by 3 inches (76 by 76 mm)] [4 by 4 inches (102 by 102 mm)]** **<Insert dimensions>**.
 - c. Fin Spacing: **[40 per ft. (131 per m)] [50 per ft. (164 per m)] [58 per ft. (190 per m)]** **<Insert value>**.
 - d. Number of Tiers: **<Insert number>**.
 - e. Heat Output: **<Insert Btu/h per ft. (W/m)>**.
 - f. Entering-Air Temperature: **[65 deg F (18 deg C)]** **<Insert temperature>**.
 - g. Average Water Temperature: **[180 deg F (82 deg C)]** **<Insert temperature>**.
 - h. Minimum Water Velocity: **[1/2 fps (0.15 m/s)]** **<Insert value>**.
5. Heating Elements, Steel Tubing: Mechanically expanded into flanged collars of evenly spaced steel fins resting on element supports. Tube ends will be threaded.
 - a. Tube Diameter: **[NPS 1-1/4 (DN 32)]** **<Insert pipe size>**.
 - b. Fin Size: **[4 by 4 inches (102 by 102 mm)]** **<Insert dimensions>**.
 - c. Fin Spacing: **[52 per ft. (171 per m)]** **<Insert value>**.
 - d. Number of Tiers: **<Insert number>**.
 - e. Heat Output: **<Insert Btu/h per ft. (W/m)>**.
 - f. Entering-Air Temperature: **[65 deg F (18 deg C)]** **<Insert temperature>**.
 - g. Average Water Temperature: **[180 deg F (82 deg C)]** **<Insert temperature>**.
 - h. Minimum Water Velocity: **[1/2 fps (0.15 m/s)]** **<Insert value>**.
6. Element Supports: Ball-bearing cradle type to permit longitudinal movement on enclosure brackets.
 - a. Front Inlet Grille:
 - 1) Punched louver; painted to match enclosure.
 - 2) Extruded-aluminum linear bar grille; pencil-proof bar spacing.
 - a) Mill-finish aluminum.
 - b) Anodized finish, color as selected by Architect from manufacturer's **[standard]** **[custom]** colors.
 - c) Painted to match enclosure.
 - b. Outlet Grille:
 - 1) Location: **[Top] [Front]**.
 - 2) Punched louver; painted to match enclosure.
 - 3) Extruded-aluminum linear bar grille; pencil-proof bar spacing.
 - a) Mill-finish aluminum.
 - b) Anodized finish, color as selected by Architect from manufacturer's **[standard]** **[custom]** colors.
 - c) Painted to match enclosure.
 - c. Enclosure Height: **<Insert inches (mm)>**.

d. Enclosure Depth: **<Insert inches (mm)>**.

7. Accessories: Blank filler sections, corners, relay sections, and splice plates all matching the enclosure and grille finishes.

C. Finned-Tube Radiation Heaters - Steam:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Source Limitations: Obtain steam finned-tube radiation heaters from single manufacturer.
3. Performance Ratings: Rate finned-tube radiation heaters in accordance with Hydronics Institute's "I=B=R Testing and Rating Standard for Finned-Tube (Commercial) Radiation."
4. Heating Elements, Copper Tubing: Mechanically expanded into flanged collars of evenly spaced aluminum fins resting on element supports. One end of tube is to be belled.
 - a. Tube Diameter: **[NPS 1-1/4 (DN 32)] <Insert pipe size>**.
 - b. Fin Size: **[3 by 3 inches (76 by 76 mm)] <Insert dimensions>**.
 - c. Fin Spacing: **[40 per ft. (131 per m)] [48 per ft. (157 per m)] [50 per ft. (164 per m)] [58 per ft. (190 per m)] <Insert value>**.
 - d. Number of Tiers: **<Insert number>**.
 - e. Heat Output: **<Insert Btu/h per ft. (W/m)>**.
 - f. Entering-Air Temperature: **[65 deg F (18 deg C)] <Insert temperature>**.
 - g. Entering Steam Pressure: **[1 psig (6.9 kPa)] <Insert value>**.
5. Heating Elements, Steel Tubing: Mechanically expanded into flanged collars of evenly spaced steel fins resting on element supports. Tube ends are to be threaded.
 - a. Tube Diameter: **[NPS 1-1/4 (DN 32)] <Insert pipe size>**.
 - b. Fin Size: **[3 by 3 inches (76 by 76 mm)] <Insert dimensions>**.
 - c. Fin Spacing: **[52 per ft. (171 per m)] <Insert value>**.
 - d. Number of Tiers: **<Insert number>**.
 - e. Heat Output: **<Insert Btu/h per ft. (W/m)>**.
 - f. Entering-Air Temperature: **[65 deg F (18 deg C)] <Insert temperature>**.
 - g. Entering Steam Pressure: **[1 psig (6.9 kPa)] <Insert value>**.
6. Element Supports: Ball-bearing cradle type to permit longitudinal movement on enclosure brackets.
7. Front Panel: Minimum **[16 gauge] [18 gauge] [20 gauge] <Insert gauge> [steel] [ASTM A653/A653M, G60 (Z180) galvanized steel] <Insert material>** with removable front cover.
8. Wall-Mounted Back Panel: Minimum 20 gauge steel, full height, with full-length channel support for front panel without exposed fasteners.
9. Floor-Mounted Pedestals: Conceal insulated piping at maximum 36-inch (914-mm) spacing. Pedestal-mounted back panel is to be solid panel matching front panel. Provide stainless steel escutcheon for floor openings at pedestals.
10. Support Brackets: Locate at maximum 36-inch (914-mm) spacing to support front panel and element.
11. Finish: **[Baked-enamel] [Baked-epoxy] [Powder-coated]** finish in manufacturer's **[standard] [custom]** color as selected by Architect.
12. Damper: Knob-operated internal damper at enclosure outlet.
13. Access Doors: Factory made, permanently hinged with tamper-resistant fastener, minimum size 6 by 7 inches (150 by 175 mm), integral with enclosure.
14. Enclosure Style: **[Sloped] [Flat]** top.
 - a. Front Inlet Grille:

- 1) Punched louver; painted to match enclosure.
 - 2) Extruded-aluminum linear bar grille; pencil-proof bar spacing.
 - a) Mill-finish aluminum.
 - b) Anodized finish, color as selected by Architect from manufacturer's **[standard]** **[custom]** colors.
 - c) Painted to match enclosure.
 - b. Outlet Grille:
 - 1) Location: **[Top]** **[Front]**.
 - 2) Punched louver; painted to match enclosure.
 - 3) Extruded-aluminum linear bar grille; pencil-proof bar spacing.
 - a) Mill-finish aluminum.
 - b) Anodized finish, color as selected by Architect from manufacturer's **[standard]** **[custom]** colors.
 - c) Painted to match enclosure.
 - c. Enclosure Height: **<Insert inches (mm)>**.
 - d. Enclosure Depth: **<Insert inches (mm)>**.
15. Accessories: Blank filler sections, corners, relay sections, and splice plates all matching the enclosure and grille finishes.

PART 3 - EXECUTION

3.1 INSTALLATION OF BASEBOARD RADIATION HEATERS - ELECTRIC

- A. Examine areas to receive electric baseboard radiation heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for electrical connections to verify actual locations before installation of electric baseboard radiation heaters.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.
- D. Install units level and plumb.
- E. Install enclosure continuously around corners, using outside and inside corner fittings.
- F. Join sections with splice plates and blank filler pieces to provide continuous enclosure.
- G. Install enclosure continuously from wall to wall.
- H. Terminate enclosures with manufacturer's end caps except where enclosures are indicated to extend to adjoining walls.
- I. Install air-seal gasket between wall and recessed flanges or front cover of fully recessed unit.

3.2 INSTALLATION OF BASEBOARD RADIATION HEATERS - HOT WATER

- A. Examine areas to receive hot water baseboard radiation heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for hot water connections to verify actual locations before installation of hot water baseboard radiation heaters.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.
- D. Install units level and plumb.
- E. Install enclosure continuously around corners, using outside and inside corner fittings.
- F. Join sections with splice plates and blank filler pieces to provide continuous enclosure.
- G. Install access doors for access to valves.
- H. Install enclosure continuously from wall to wall.
- I. Terminate enclosures with manufacturer's end caps except where enclosures are indicated to extend to adjoining walls.
- J. Install valves within reach of access door provided in enclosure.
- K. Install air-seal gasket between wall and recessed flanges or front cover of fully recessed unit.
- L. Install piping within pedestals for freestanding units.

3.3 INSTALLATION OF FINNED-TUBE RADIATION HEATERS - ELECTRIC

- A. Examine areas to receive electric finned-tube radiation heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for electric connections to verify actual locations before installation of electric finned-tube radiation heaters.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.
- D. Install units level and plumb.
- E. Install enclosure continuously around corners, using outside and inside corner fittings.
- F. Join sections with splice plates and blank filler pieces to provide continuous enclosure.
- G. Install enclosure continuously from wall to wall.
- H. Terminate enclosures with manufacturer's end caps except where enclosures are indicated to extend to adjoining walls.
- I. Install air-seal gasket between wall and recessed flanges or front cover of fully recessed unit.

3.4 INSTALLATION OF FINNED-TUBE RADIATION HEATERS - HOT WATER

- A. Examine areas to receive hot water finned-tube radiation heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for hot water finned-tube radiation heaters for compliance with requirements for installation tolerances of hot water finned-tube radiation heaters.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.
- D. Install units level and plumb.
- E. Install enclosure continuously around corners, using outside and inside corner fittings.
- F. Join sections with splice plates and blank filler pieces to provide continuous enclosure.
- G. Install access doors for access to valves.
- H. Install enclosure continuously from wall to wall.
- I. Terminate enclosures with manufacturer's end caps except where enclosures are indicated to extend to adjoining walls.
- J. Install valves within reach of access door provided in enclosure.
- K. Install air-seal gasket between wall and recessed flanges or front cover of fully recessed unit.
- L. Install piping within pedestals for freestanding units.

3.5 INSTALLATION OF FINNED-TUBE RADIATION HEATERS - STEAM

- A. Examine areas to receive steam finned-tube radiation heaters for compliance with requirements for installation tolerance and other conditions affecting performance of the Work.
- B. Examine roughing-in for steam finned-tube radiation heaters for compliance with requirements for installation tolerances of steam finned-tube radiation heaters.
- C. Install units level and plumb.
- D. Install enclosure continuously around corners, using outside and inside corner fittings.
- E. Join sections with splice plates and blank filler pieces to provide continuous enclosure.
- F. Install access doors for access to valves.
- G. Install enclosure continuously from wall to wall.
- H. Terminate enclosures with manufacturer's end caps except where enclosures are indicated to extend to adjoining walls.
- I. Install valves within reach of access door provided in enclosure.
- J. Install air-seal gasket between wall and recessed flanges or front cover of fully recessed unit.

- K. Install piping within pedestals for freestanding units.

3.6 PIPING CONNECTIONS

- A. Piping installation requirements are specified in [Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."] [Section 232213 "Steam and Condensate Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties."] Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect hot water [baseboard] [and] [finned-tube] radiation heaters and components to piping in accordance with Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
 - 1. Install shutoff valves on inlet and outlet, and balancing valve on outlet.
- C. Connect steam finned-tube radiation heaters and components to piping in accordance with Section 232213 "Steam and Condensate Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties."
 - 1. Install shutoff valve on inlet; install strainer, steam trap, and shutoff valve on outlet.
- D. Install control valves as required by Section 230923.11 "Control Valves."
- E. Install piping adjacent to finned-tube radiation heaters to allow service and maintenance.

3.7 ELECTRICAL CONNECTIONS

- A. Ground electric finned-tube radiation heaters in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.8 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections:
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Units will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

END OF SECTION 23 82 36 00



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 82 36 00	23 82 00 00	Chilled Beams
23 82 36 00	23 82 33 00	Convectors
23 82 39 00	23 82 00 00	Chilled Beams



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SECTION 23 82 39 13 - CABINET UNIT HEATERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: Cabinet unit heaters with centrifugal fans and hot-water, steam, or electric-resistance heating coils.

1.2 DEFINITIONS

- A. CWP: Cold working pressure.
- B. DDC: Direct digital control.
- C. PTFE: Polytetrafluoroethylene plastic.
- D. TFE: Tetrafluoroethylene plastic.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Sustainable Design Submittals:
 - 1. Product data showing compliance with ASHRAE 62.1.
- C. Shop Drawings:
 - 1. Include plans, elevations, sections, and details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include location and size of each field connection.
 - 4. Include details of anchorages and attachments to structure and to supported equipment.
 - 5. Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories.
 - 6. Indicate location and arrangement of piping valves and specialties.
 - 7. Indicate location and arrangement of integral controls.
 - 8. Wiring Diagrams: Power, signal, and control wiring.
- D. Samples: For each exposed product and for each color and texture specified.
- E. Samples for Initial Selection: Finish colors for units with factory-applied color finishes.
- F. Samples for Verification: Finish colors for each type of cabinet unit heater indicated with factory-applied color finishes.



1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Suspended ceiling components.
 - 2. Structural members to which cabinet unit heaters will be attached.
 - 3. Method of attaching hangers to building structure.
 - 4. Size and location of initial access modules for acoustical tile.
 - 5. Items penetrating finished ceiling, including the following:
 - a. Lighting fixtures.
 - b. Air outlets and inlets.
 - c. Speakers.
 - d. Sprinklers.
 - e. Access panels.
 - f. <Insert item>.
 - 6. Perimeter moldings for exposed or partially exposed cabinets.
- B. Seismic Qualification Data: Submit certification that cabinet unit heaters, accessories, and components will withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC." Include the following:
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Include detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For cabinet unit heaters to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Cabinet Unit-Heater Filters: Furnish [one]<Insert number> spare filter(s) for each filter installed.

PART 2 - PRODUCTS

2.1 CABINET UNIT HEATERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Airtherm; a Mestek company]**
 2. **[Berko; Marley Engineered Products]**
 3. **[Carrier Global Corporation]**
 4. **[Chromalox, Inc.]**
 5. **[Dunham-Bush, Inc]**
 6. **[Engineered Air]**
 7. **[IEC (International Environmental Corporation); LSB Industries]**
 8. **[INDEECO]**
 9. **[Markel Products Company; a subsidiary of TPI Corporation]**
 10. **[Marley Engineered Products]**
 11. **[Ouellet Canada Inc]**
 12. **[QMark; Marley Engineered Products]**
 13. **[Rosemex Products]**
 14. **[Trane]**
 15. **[USA Coil & Air]**
 16. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Airtherm; a Mestek company]**
 2. **[Berko; Marley Engineered Products]**
 3. **[Carrier Global Corporation]**
 4. **[Chromalox, Inc.]**
 5. **[Dunham-Bush, Inc]**
 6. **[Engineered Air]**
 7. **[IEC (International Environmental Corporation); LSB Industries]**
 8. **[INDEECO]**
 9. **[Markel Products Company; a subsidiary of TPI Corporation]**
 10. **[Marley Engineered Products]**
 11. **[Ouellet Canada Inc]**
 12. **[QMark; Marley Engineered Products]**
 13. **[Rosemex Products]**
 14. **[Trane]**
 15. **[USA Coil & Air]**
 16. **<Insert manufacturer's name>**
- C. Heaters: Factory-assembled and -tested unit complying with AHRI 440.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- E. Comply with UL 2021.

2.2 PERFORMANCE REQUIREMENTS

- A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- B. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- C. Seismic Performance: Cabinet unit heaters are to withstand the effects of earthquake motions determined in accordance with **[ASCE/SEI 7]<Insert requirement>**.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified **[and the unit will be fully operational after the seismic event]**."

2.3 COIL SECTION INSULATION

- A. Insulation Materials:
 - 1. Duct-Liner-Type, Glass-Fiber Insulation: ASTM C1071; surfaces exposed to airstream are to have **[aluminum-foil facing][erosion-resistant coating]** to prevent erosion of glass fibers.
 - a. Thickness: **[1/2 inch (13 mm)][1 inch (25 mm)][1-1/2 inches (38 mm)]**.
 - b. Thermal Conductivity (k-Value): **0.26 Btu x in./h x sq. ft. at 75 deg F (0.037 W/m x K at 24 deg C)** mean temperature.
 - c. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested in accordance with ASTM E84.
 - d. Adhesive: Comply with ASTM C916 and with NFPA 90A or NFPA 90B.
 - e. Airstream Surfaces: Surfaces in contact with the airstream comply with requirements in ASHRAE 62.1.
 - 2. Flexible Elastomeric Insulation: Comply with NFPA 90A or NFPA 90B. Unicellular polyethylene thermal plastic, preformed sheet insulation complying with ASTM C534, Type II, except for density.
 - a. Thickness: **[3/8 inch (9 mm)][1/2 inch (13 mm)][3/4 inch (19 mm)][1 inch (25 mm)]**.
 - b. Thermal Conductivity (k-Value): **0.24 Btu x in./h x sq. ft. at 75 deg F (0.034 W/m x K at 24 deg C)** mean temperature.
 - c. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested in accordance with ASTM C411.
 - d. Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
 - e. Airstream Surfaces: Surfaces in contact with the airstream comply with requirements in ASHRAE 62.1.

2.4 CABINETS

- A. Material: Steel with **[factory prime coating, ready for field painting][baked-enamel finish with manufacturer's standard paint, in color selected by Architect][baked-enamel finish with manufacturer's custom paint, in color selected by Architect]**.
 - 1. Vertical Unit, Exposed Front Panels: Minimum **[0.0528-inch- (1.35-mm-)][0.0677-inch- (1.7-mm-)]** thick **[galvanized]** sheet steel, removable panels with channel-formed edges secured with

- tamperproof cam fasteners.
- 2. Horizontal Unit, Exposed Bottom Panels: Minimum **[0.0528-inch- (1.35-mm-)] [0.0677-inch- (1.7-mm-)]** thick **[galvanized]** sheet steel, removable panels secured with tamperproof cam fasteners and safety chain.
- 3. Recessed Flanges: Steel, finished to match cabinet.
- 4. Control Access Door: Key operated.
- 5. Base: Minimum **0.0528-inch- (1.35-mm-)** thick steel, finished to match cabinet, **[4 inches (100 mm)] [6 inches (150 mm)] <Insert dimension>** high with leveling bolts.
- 6. Extended Piping Compartment: **[8-inch- (200-mm-)] <Insert dimension>** wide piping end pocket.
- 7. False Back: Minimum **0.0428-inch- (1.1-mm-)** thick steel, finished to match cabinet.
- 8. Outdoor-Air Wall Box: Minimum **0.1265-inch- (3.2-mm-)** thick, aluminum, rain-resistant louver and box with integral eliminators and bird screen; aluminum louver with **[anodized] [baked-enamel]** finish in color selected by Architect from manufacturer's **[standard] [custom]** colors.
 - a. Outdoor-Air Damper: Galvanized-steel blades with edge and end seals and nylon bearings; with **[manual] [electronic] [pneumatic]**, two-position actuators.

2.5 FILTERS

- A. Minimum Efficiency Reporting Value and Average Arrestance: In accordance with ASHRAE 52.2.
- B. Minimum Efficiency Reporting Value: In accordance with ASHRAE 52.2.
- C. Material:
 - 1. Washable Foam, **[MERV 3] <Insert value>**.
 - 2. Glass fiber treated with adhesive, **[MERV 5] <Insert value>**.
 - 3. Pleated cotton-polyester media, **[MERV 7] <Insert value>**.

2.6 COILS

- A. Hot-Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)** and rated for a minimum working pressure of **200 psig (1378 kPa)** and a maximum entering-water temperature of **220 deg F (104 deg C)**. Include manual air vent and drain.
- B. Steam Coil: Copper **[distributing]** tube, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)** and rated for a minimum working pressure of **75 psig (517 kPa)**.
- C. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and hum, mounted in ceramic inserts in galvanized-steel housing; with fuses in terminal box for overcurrent protection and limit controls for high-temperature protection. Terminate elements in stainless steel machine-staked terminals secured with stainless steel hardware.

2.7 CONTROLS

- A. Fan and Motor Board: Removable.
 - 1. Fan: Forward curved, **[high static,]** double width, centrifugal, directly connected to motor; thermoplastic or painted-steel wheels and aluminum, painted-steel, or galvanized-steel fan scrolls.
 - 2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Section 230500 "Common Work Results for HVAC."
 - 3. Wiring Terminations: Connect motor to chassis wiring with plug connection.

- B. Factory, Hot-Water Piping Package: [ASTM B88, Type L (ASTM B88M, Type B)][ASTM B88, Type M (ASTM B88M Type C)] copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet.
1. [Two][Three]-way, [two-position][modulating] control valve. [Three-way valve packages include bypass line with manually adjustable balance device.]
 2. Hose Kits: Minimum **400-psig (2758-kPa)** working pressure, and operating temperatures from **33 to 211 deg F (0.5 to 99 deg C)**. Tag hose kits to equipment designations.
 - a. Length: [24 inches (600 mm)][36 inches (900 mm)]<Insert dimension>.
 - b. Minimum Diameter: Equal to cabinet unit-heater connection size.
 3. Two-Piece, Ball Valves: Bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and **600-psig (4140-kPa)** minimum CWP rating and blowout-proof stem.
 4. Calibrated-Orifice Balancing Valves: Bronze body, ball type, **125-psig (860-kPa)** working pressure, **250 deg F (121 deg C)** maximum operating temperature; with calibrated orifice or venture, connection for portable differential pressure meter with integral seals, threaded ends, and equipped with a memory stop to retain set position.
 5. Automatic Flow-Control Valve: Brass or ferrous-metal body, **300-psig (2068-kPa)** working pressure at **250 deg F (121 deg C)**, with removable, corrosion-resistant, tamperproof, self-cleaning piston spring; factory set to maintain constant indicated flow within plus or minus 10 percent of differential pressure range of **2 to 80 psig (13.8 to 552 kPa)**.
 6. Y-Pattern, Hot-Water Strainers: Cast-iron body (ASTM A126, Class B); **125-psig (860-kPa)** minimum working pressure; with threaded connections, bolted cover, perforated stainless steel basket, and bottom drain connection. Include minimum **NPS 1/2 (DN 15)** threaded pipe and full-port ball valve in strainer drain connection.
 7. Wrought-Copper Unions: ASME B16.22.
- C. Control devices and operational sequences are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."
- D. Basic Unit Controls:
1. Control voltage transformer.
 2. [Wall][Unit]-mounted thermostat with the following features:
 - a. Heat-off switch.
 - b. Fan on-auto switch.
 - c. Manual fan-speed switch.
 - d. Adjustable deadband.
 - e. [Concealed][Exposed] set point.
 - f. [Concealed][Exposed] indication.
 - g. **Deg F (Deg C)** indication.
 3. [Wall][Unit]-mounted temperature sensor.
 4. Unoccupied period override push button.
 5. Data entry and access port.
 - a. Input data includes room temperature and occupied and unoccupied periods.
 - b. Output data includes room temperature, supply-air temperature, entering-water temperature, operating mode, and status.
- E. Terminal Controller: [DDC.]
1. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of

- four programmable periods per day.
 2. Unoccupied Period Override: **[Two]<Insert number>** hours.
 3. Unit Supply-Air Fan Operations:
 - a. Occupied Periods: Fan runs continuously.
 - b. Unoccupied Periods: Fan cycles to maintain setback room temperature.
 4. Heating-Coil Operations:
 - a. Occupied Periods: **[Open control valve][Modulate control valve][Energize electric-resistance coil]** to provide heating if room temperature falls below thermostat set point.
 - b. Unoccupied Periods: Start fan and **[open control valve][modulate control valve][energize electric-resistance coil]** if room temperature falls below setback temperature.
 5. Outdoor-Air Damper Operation:
 - a. Occupied Periods: Open dampers. Delay damper opening if room temperature is more than three degrees below set point.
 - b. Unoccupied Periods: Close damper.
 6. Controller is to have volatile-memory backup.
- F. Interface with DDC System for HVAC Requirements:
1. Interface relay for scheduled operation.
 2. Interface relay to provide indication of fault at central workstation.
 3. Interface is to be **[BAC-net][or][LonWorks]** compatible for central DDC system for HVAC workstation and include the following functions:
 - a. Adjust set points.
 - b. Cabinet unit-heater start, stop, and operating status.
 - c. Data inquiry, including **[outdoor-air damper position and]**supply-air and room-air temperature.
 - d. Occupied and unoccupied schedules.
- G. Electrical Connection: Factory-wired motors and controls for a single field connection.

2.8 CAPACITIES AND CHARACTERISTICS

- A. Cabinet:
1. Vertical, Surface Mounted, Upflow:
 - a. Top: **[Flat][Sloped][Flat or sloped]**.
 - b. Air Inlet: **[Open bottom][Front, punched louver][Front, extruded-aluminum bar grille]**.
 - c. Air Outlet: **[Front][Top][Front or top], [quad louver][punched louver][extruded-aluminum bar grille]**.
 2. Vertical, Surface Mounted, Downflow:
 - a. Top: **[Flat][Sloped][Flat or sloped]**.
 - b. Air Inlet: **[Front][Top][Front or top], [punched louver][extruded-aluminum bar grille]**.
 - c. Air Outlet: **Front, [quad louver][punched louver][extruded-aluminum bar grille]**.



3. Vertical, Semirecessed, Upflow:
 - a. Air Inlet: **[Open bottom][Front, punched louver][Front, extruded-aluminum bar grille]**.
 - b. Air Outlet: **[Front][Top][Front or top], [quad louver][punched louver][extruded-aluminum bar grille]**.
4. Vertical, Semirecessed, Downflow:
 - a. Air Inlet: **[Front][Top][Front or top], [punched louver][extruded-aluminum bar grille]**.
 - b. Air Outlet: **Front, [quad louver][punched louver][extruded-aluminum bar grille]**.
5. Vertical, Fully Recessed: **[Upflow][Downflow]**.
 - a. Air Inlet: **[Front][Duct connection], [punched louver][extruded-aluminum bar grille]**.
 - b. Air Outlet: **[Front][Duct connection], [quad louver][punched louver][extruded-aluminum bar grille]**.
6. Horizontal, Surface Mounted:
 - a. Air Inlet: **[Bottom][Front][Bottom or front], [punched louver][extruded-aluminum bar grille]**.
 - b. Air Outlet: **[Front][Top][Front or top], [quad louver][punched louver][extruded-aluminum bar grille]**.
7. Horizontal, Semirecessed:
 - a. Air Inlet: **[Bottom][Front][Bottom or front], [punched louver][extruded-aluminum bar grille]**.
 - b. Air Outlet: **[Front][Top][Front or top], [quad louver][punched louver][extruded-aluminum bar grille]**.
8. Horizontal, Fully Recessed:
 - a. Air Inlet: **[Front][Duct connection], [punched louver][extruded-aluminum bar grille]**.
 - b. Air Outlet: **[Front][Duct connection], [quad louver][punched louver][extruded-aluminum bar grille]**.

B. Concealed Unit Heater:

1. Vertical: **[Upflow][Downflow]**.
 - a. Air Inlet: **[Open bottom][Front, punched louver][Front, extruded-aluminum bar grille]**.
 - b. Air Outlet: **[Front][Top][Front or top], [quad louver][punched louver][extruded-aluminum bar grille]**.
2. Horizontal: Upflow.
 - a. Air Inlet: **[Open bottom][Front, punched louver][Front, extruded-aluminum bar grille]**.
 - b. Air Outlet: **[Front][Top][Front or top], [quad louver][punched louver][extruded-aluminum bar grille]**.

C. Fan:

1. Airflow: **<Insert cfm (L/s)>**.

2. External Static Pressure: **<Insert inches wg (Pa)>**.
 3. Fan Speed: **<Insert rpm>**.
 4. Motor Horsepower: **<Insert value>**.
- D. Heating Capacity:
1. Output: **<Insert Btu/h (kW)>**.
 2. Entering-Air Temperature: **<Insert deg F (deg C)>**.
 3. Air-Temperature Rise: **<Insert deg F (deg C)>**.
- E. Hot-Water Heating Coil:
1. Water Flow: **<Insert gpm (L/s)>**.
 2. Water-Side Pressure Loss: **<Insert feet wg (kPa)>**.
 3. Entering-Water Temperature: **<Insert deg F (deg C)>**.
- F. Steam Heating Coil:
1. Inlet Steam Pressure: **<Insert psig (kPa)>**.
 2. Condensing Capacity: **<Insert lb/h (g/s)>**.
- G. Electric-Resistance Heating Coil:
1. Capacity: **<Insert kilowatts>**.
 2. Number of Steps: **<Insert number>**.
- H. Filters:
1. Face Area: **<Insert sq. ft. (sq. m)>**.
 2. Thickness: **[1/2 inch (13 mm)][1 inch (25 mm)]<Insert dimension>**.
- I. Electrical Characteristics for Single-Point Connection:
1. Volts: **<Insert value>**.
 2. Phase: **<Insert value>**.
 3. Hertz: **<Insert value>**.
 4. Full-Load Amperes: **<Insert value>**.
 5. Minimum Circuit Ampacity: **<Insert value>**.
 6. Maximum Overcurrent Protection: **<Insert amperage>**.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive cabinet unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for **[piping and]**electrical connections to verify actual locations before unit-heater installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF CABINET UNIT HEATERS

- A. Install wall boxes in finished wall assembly; seal and weatherproof. Joint-sealant materials and applications are specified in Section 079200 "Joint Sealants."
- B. Install cabinet unit heaters to comply with NFPA 90A.
- C. Suspend cabinet unit heaters from structure with elastomeric hangers[**and seismic restraints**]. Vibration isolators[**and seismic restraints**] are specified in [**Section 230548 "Vibration and Seismic Controls for HVAC."**][**Section 230548.13 "Vibration Controls for HVAC."**]
- D. Install wall-mounted thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.
- E. Install new filters in each fan-coil unit within two weeks of Substantial Completion.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in Section 232113 "Hydronic Piping," Section 232116 "Hydronic Piping Specialties," Section 232213 "Steam and Condensate Heating Piping," and Section 232216 "Steam and Condensate Heating Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to machine to allow service and maintenance.
- C. Connect piping to cabinet unit heater's factory, hot-water piping package. Install the piping package if shipped loose.
- D. Connect supply and return ducts to cabinet unit heaters with flexible duct connectors specified in Section 233300 "Air Duct Accessories."
- E. Comply with safety requirements in UL 1995.
- F. Unless otherwise indicated, install union and gate or ball valve on supply-water connection and union and calibrated balancing valve on return-water connection of cabinet unit heater. Hydronic specialties are specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
- G. Unless otherwise indicated, install union and gate or ball valve on steam-supply connection and union, strainer, steam trap, and gate or ball valve on condensate-return connection of cabinet unit heater. Steam specialties are specified in Section 232216 "Steam and Condensate Heating Piping Specialties."
- H. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- I. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

B. Units will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust initial temperature set points.

B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to **[two]<Insert number>** visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain cabinet unit heaters.

END OF SECTION 23 82 39 13



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SECTION 23 82 39 16 - PROPELLER UNIT HEATERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: Propeller unit heaters with hot-water, steam, or electric-resistance heating coils.

1.2 DEFINITIONS

- A. CWP: Cold working pressure.
- B. PTFE: Polytetrafluoroethylene plastic.
- C. TFE: Tetrafluoroethylene plastic.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Sustainable Design Submittals:
 - 1. Product Data: For ventilation equipment, indicating compliance with ASHRAE 62.1, Section 5 - "Systems and Equipment."
 - 2. Ventilation: Product Data for ventilation equipment, indicating compliance with ASHRAE 62.1, Section 5 - "Systems and Equipment."
- C. Shop Drawings:
 - 1. Include plans, elevations, sections, and details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include location and size of each field connection.
 - 4. Include details of anchorages and attachments to structure and to supported equipment.
 - 5. Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories.
 - 6. Indicate location and arrangement of piping valves and specialties.
 - 7. Indicate location and arrangement of integral controls.
 - 8. Wiring Diagrams: Power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which propeller unit heaters will be attached.
3. Method of attaching hangers to building structure.
4. Size and location of initial access modules for acoustical tile.
5. Items penetrating finished ceiling, including the following:
 - a. Lighting fixtures.
 - b. Air outlets and inlets.
 - c. Speakers.
 - d. Sprinklers.
 - e. Access panels.
 - f. <Insert item>.

- B. Seismic Qualification Data: Submit certification that propeller unit heaters, accessories, and components will withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC." Include the following:

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

- C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For propeller unit heaters to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 PROPELLER UNIT HEATERS

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

1. **[Airtherm; a Mestek company]**
2. **[CCI Thermal Technologies, Inc]**
3. **[Engineered Air]**
4. **[Rosemex Products]**
5. **[Trane]**
6. **<Insert manufacturer's name>**

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

1. **[Airtherm; a Mestek company]**
2. **[CCI Thermal Technologies, Inc]**
3. **[Engineered Air]**

4. [Rosemex Products]
5. [Trane]
6. <Insert manufacturer's name>

- C. Heaters: Assembly including casing, coil, fan, and motor in [vertical][and][horizontal] discharge configuration with adjustable discharge louvers.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- E. Comply with UL 2021.
- F. Comply with UL 823.

2.2 PERFORMANCE REQUIREMENTS

- A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- B. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- C. Seismic Performance: Propeller unit heaters are to withstand the effects of earthquake motions determined in accordance with [ASCE/SEI 7]<Insert requirement>.
 1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified[and the unit will be fully operational after the seismic event]."

2.3 HOUSINGS

- A. Finish: Manufacturer's [standard][custom] baked enamel applied to factory-assembled and -tested propeller unit heaters before shipping.
- B. Airstream Surfaces: Surfaces in contact with the airstream comply with requirements in ASHRAE 62.1.
- C. Discharge Louver: Adjustable fin diffuser for horizontal units and conical diffuser for vertical units.

2.4 COILS

- A. General Coil Requirements: Test and rate [hot-water][steam] propeller unit-heater coils in accordance with ASHRAE 33.
- B. Hot-Water Coil:
 1. Copper tube, minimum **0.025-inch (0.635-mm)** wall thickness, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)** and rated for a minimum working pressure of **200 psig (1380 kPa)** and a maximum entering-water temperature of **325 deg F (163 deg C)**, with manual air vent. Test for leaks to **350 psig (2413 kPa)** underwater.
 2. Cupronickel tube, minimum **0.031-inch (0.78-mm)** wall thickness, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)** and rated for a minimum working pressure of **400 psig (2760 kPa)** and a maximum entering-water temperature of **450 deg F (232**

- deg C), with manual air vent. Test for leaks to **600 psig (4137 kPa)** underwater.
3. Red-brass tube, minimum **0.049-inch (1.24-mm)** wall thickness, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)** and rated for a minimum working pressure of **260 psig (1793 kPa)** and a maximum entering-water temperature of **390 deg F (199 deg C)**, with manual air vent. Test for leaks to **390 psig (2689 kPa)** underwater.
4. Steel tube, minimum **0.049-inch (1.24-mm)** wall thickness, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)** and rated for a minimum working pressure of **400 psig (2760 kPa)** and a maximum entering-water temperature of **450 deg F (232 deg C)**, with manual air vent. Test for leaks to **600 psig (4137 kPa)** underwater.
5. Vertical steel tube, minimum **0.065-inch (1.65-mm)** wall thickness, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)** and rated for a minimum working pressure of **400 psig (2760 kPa)** and a maximum entering-water temperature of **450 deg F (232 deg C)**, with steel headers at top and bottom. Test for leaks to **600 psig (4137 kPa)** underwater.

C. Steam Coil:

1. Copper tube, minimum **0.025-inch (0.635-mm)** wall thickness, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)** and rated for a minimum working pressure of **75 psig (520 kPa)**.
2. Red-brass tube, minimum **0.049-inch (1.24-mm)** wall thickness, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)** and rated for a minimum working pressure of **75 psig (520 kPa)**.
3. Vertical steel tube, minimum **0.065-inch (1.65-mm)** wall thickness, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)** and rated for a minimum working pressure of **[100 psig (690 kPa)][200 psig (1380 kPa)]**, with steel headers at top and bottom.

D. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and 60-Hz hum, embedded in magnesium oxide refractory and sealed in steel or corrosion-resistant metallic sheath with fins no closer than **0.16 inch (4 mm)**. Element ends are to be enclosed in terminal box. Fin surface temperature is not to exceed **550 deg F (288 deg C)** at any point during normal operation.

1. Circuit Protection: One-time fuses in terminal box for overcurrent protection and limit controls for high-temperature protection of heaters.
2. Wiring Terminations: Stainless steel or corrosion-resistant material.

2.5 FAN AND MOTOR

- A. Fan: Propeller type with aluminum wheel directly mounted on motor shaft in the fan venturi.
- B. Motor: Permanently lubricated, **[explosion proof][multispeed][variable speed]**. Comply with requirements in Section 230500 "Common Work Results for HVAC."

2.6 CONTROLS

- A. Control Devices:
 1. **[Unit][Wall]**-mounted, **[variable]** fan-speed switch.
 2. **[Unit][Wall]**-mounted thermostat.

2.7 CAPACITIES AND CHARACTERISTICS

- A. Heating Capacity:

1. Heat Output: **<Insert Btu/h (kW)>**.
 2. Length of Throw: **<Insert feet (m)>**.
 3. Mounting Height: **<Insert feet (m)>**.
- B. Water Coil:
1. Entering-Water Temperature: **<Insert deg F (deg C)>**.
 2. Temperature Difference: **<Insert deg F (deg C)>**.
 3. Water Flow: **<Insert gpm (L/s)>**.
 4. Water-Side Pressure Drop: **<Insert feet (kPa)>**.
- C. Steam Coil:
1. Inlet Pressure: **<Insert psig (kPa)>**.
 2. Condensing Capacity: **<Insert lb/h (g/s)>**.
- D. Electric Coil:
1. Heating Capacity: **<Insert kilowatts>**.
 2. Number of Steps: **<Insert number>**.
- E. Supply Air:
1. Airflow: **<Insert cfm (L/s)>**.
 2. Leaving-Air Temperature: **<Insert deg F (deg C)>**.
 3. Entering-Air Temperature: **<Insert deg F (deg C)>**.
- F. Fan Motor:
1. High Speed: **<Insert rpm>**.
 2. Motor Size: **<Insert horsepower>**.
- G. Electrical Characteristics for Single-Point Connection:
1. Volts: **<Insert value>**.
 2. Phase: **<Insert value>**.
 3. Hertz: **<Insert value>**.
 4. Full-Load Amperes: **<Insert value>**.
 5. Minimum Circuit Amperes: **<Insert value>**.
 6. Maximum Overcurrent Protection: **<Insert amperage>**.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive propeller unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for **[piping and]**electrical connections to verify actual locations before unit-heater installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF PROPELLER UNIT HEATERS

- A. Install propeller unit heaters to comply with NFPA 90A.
- B. Install propeller unit heaters level and plumb.
- C. Suspend propeller unit heaters from structure with all-thread hanger rods and **[elastomeric hangers][spring hangers][spring hangers with vertical-limit stop]**. Hanger rods and attachments to structure are specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment." Vibration hangers are specified in **[Section 230548 "Vibration and Seismic Controls for HVAC."][Section 230548.13 "Vibration Controls for HVAC."]**
- D. Install wall-mounted thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.

3.3 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties. Piping installation requirements are specified in the following Sections:
 - 1. Section 232113 "Hydronic Piping."
 - 2. Section 232116 "Hydronic Piping Specialties."
 - 3. Section 232213 "Steam and Condensate Heating Piping."
 - 4. Section 232216 "Steam and Condensate Heating Piping Specialties."
- B. Install piping adjacent to machine to allow service and maintenance.
- C. Connect piping to propeller unit heater's factory, hot-water piping package. Install the piping package if shipped loose.
- D. Comply with safety requirements in UL 1995.
- E. Unless otherwise indicated, install union and gate or ball valve on supply-water connection and union and calibrated balancing valve on return-water connection of propeller unit heater. Hydronic specialties are specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
- F. Unless otherwise indicated, install union and gate or ball valve on steam-supply connection and union, strainer, steam trap, and gate or ball valve on condensate-return connection of propeller unit heater. Steam specialties are specified in Section 232216 "Steam and Condensate Piping Specialties."
- G. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- H. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections **[with the assistance of a factory-authorized service representative]**:
 - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor

- rotation and unit operation.
 - 2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
 - 3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
- B. Units will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

3.5 ADJUSTING

- A. Adjust initial temperature set points.
- B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to **[two]<Insert number>** visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain propeller unit heaters.

END OF SECTION 23 82 39 16



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SECTION 23 82 39 19 - WALL AND CEILING UNIT HEATERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: Wall and ceiling unit heaters with propeller fans and electric-resistance heating coils.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
1. Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Sustainable Design Submittals:
1. Product Data: For ventilation equipment, indicating compliance with ASHRAE 62.1, Section 5 - "Systems and Equipment."
 2. Ventilation: Product Data for ventilation equipment, indicating compliance with ASHRAE 62.1, Section 5 - "Systems and Equipment."
- C. Shop Drawings:
1. Include plans, elevations, sections, and details.
 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 3. Include details of anchorages and attachments to structure and to supported equipment.
 4. Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories.
 5. Wiring Diagrams: Power, signal, and control wiring.
- D. Samples: For each exposed product and for each color and texture specified.

1.3 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For wall and ceiling unit heaters to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 WALL AND CEILING UNIT HEATERS

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

2. [Chromalox, Inc.]
3. [Glen Dimplex Americas]
4. [INDEECO]
5. [Markel Products Company; a subsidiary of TPI Corporation]
6. [Marley Engineered Products]
7. [Ouellet Canada Inc]
8. [QMark; Marley Engineered Products]
9. [Trane]
10. <Insert manufacturer's name>

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

1. [Berko; Marley Engineered Products]
2. [Chromalox, Inc.]
3. [Glen Dimplex Americas]
4. [INDEECO]
5. [Markel Products Company; a subsidiary of TPI Corporation]
6. [Marley Engineered Products]
7. [Ouellet Canada Inc]
8. [QMark; Marley Engineered Products]
9. [Trane]
10. <Insert manufacturer's name>

C. Heaters: Assembly including chassis, electric heating coil, fan, motor, and controls. Comply with UL 2021.

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

2.2 CABINET

- A. Front Panel: [Stamped-steel louver][Extruded-aluminum bar grille], with removable panels fastened with tamperproof fasteners.
- B. Finish: Baked enamel over baked-on primer with manufacturer's [standard][custom] color selected by Architect, applied to factory-assembled and -tested wall and ceiling heaters before shipping.
- C. Airstream Surfaces: Surfaces in contact with the airstream comply with requirements in ASHRAE 62.1.
- D. Surface-Mounted Cabinet Enclosure: Steel with finish to match cabinet.

2.3 COIL

- A. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and 60-Hz hum, embedded in magnesium oxide refractory and sealed in corrosion-resistant metallic sheath. Terminate elements in stainless steel, machine-staked terminals secured with stainless steel hardware, and limit controls for high-temperature protection. [Provide integral circuit breaker for overcurrent protection.]

2.4 FAN AND MOTOR

- A. Fan: Aluminum propeller directly connected to motor.
- B. Motor: Permanently lubricated[, **multispeed**]. Comply with requirements in Section 230500 "Common Work Results for HVAC."

2.5 CONTROLS

- A. Controls: Unit-mounted thermostat.[**Low-voltage relay with transformer kit.**]
- B. Electrical Connection: Factory wire motors and controls for a single field connection[**with disconnect switch**].

2.6 CAPACITIES AND CHARACTERISTICS

- A. Airflow: <**Insert cfm (L/s)**>.
- B. Fan Speed: <**Insert rpm**>.
- C. Heating Coil: <**Insert kilowatts**>.
- D. Electrical Characteristics for Single-Point Connection:
 - 1. Volts: <**Insert value**>.
 - 2. Phase: <**Insert value**>.
 - 3. Hertz: <**Insert value**>.
 - 4. Full-Load Amperes: <**Insert value**>.
 - 5. Minimum Circuit Ampacity: <**Insert value**>.
 - 6. Maximum Overcurrent Protection: <**Insert amperage**>.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive wall and ceiling unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for electrical connections to verify actual locations before unit-heater installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF WALL AND CEILING UNIT HEATERS

- A. Install wall and ceiling unit heaters to comply with NFPA 90A.
- B. Install wall and ceiling unit heaters level and plumb.
- C. Install wall-mounted thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and

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room details before installation.

- D. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- E. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

END OF SECTION 23 82 39 19



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SECTION 23 83 13 00 - RADIANT-HEATING ELECTRIC CABLES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes electric heating cables for ceiling or floor radiant heating, snow and ice melting on pavement, and freezer-floor frost-heave prevention with the following electric heating cables:
 - 1. Mineral insulated, series resistance.
 - 2. Plastic insulated, series resistance.
 - 3. Self-regulating, parallel resistance.
- B. Related Requirements:
 - 1. Section 210533 "Heat Tracing for Fire-Suppression Piping."
 - 2. Section 220533 "Heat Tracing for Plumbing Piping."
 - 3. Section 230533 "Heat Tracing for HVAC Piping."
 - 4. Section 238213 "Valance Heating and Cooling Units" for factory-fabricated electric heating panels for ceiling and wall applications.
 - 5. Section 238323 "Radiant-Heating Electric Panels."

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, operating characteristics, and furnished specialties and accessories.
 - 2. Schedule heating capacity, length of cable, spacing, and electrical power requirement for each electric heating cable required.
- B. Shop Drawings: For electric heating cable.
 - 1. Include plans, sections, details, and attachments to other work.
 - 2. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Ceiling suspension assembly members.
 - 2. Method of attaching hangers to building structure.
 - 3. Items installed in finished ceiling, including the following:
 - a. Lighting fixtures.
 - b. Air outlets and inlets.
 - c. Speakers.
 - d. Sprinklers.
 - e. Access panels.
 - f. Perimeter moldings.

g. <Insert item>.

B. Field quality-control reports.

C. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For electric heating cables to include in operation and maintenance manuals.

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace electric heating cable that fails in materials or workmanship within specified warranty period.

1. Warranty Period: [10][15]<Insert number> years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR ELECTRIC HEATING CABLES

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

2.2 MINERAL-INSULATED, SERIES-RESISTANCE HEATING CABLES

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

1. [Chromalox, Inc.]
2. [Delta-Therm Corporation]
3. [EasyHeat; Emerson Electric Co., Commercial and Residential Solutions]
4. [Nelson; Emerson Electric Co., Automation Solutions]
5. [RAYCHEM; brand of nVent Electrical plc]
6. [Trasor Corp.]
7. <Insert manufacturer's name>

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

1. [Chromalox, Inc.]
2. [Delta-Therm Corporation]
3. [EasyHeat; Emerson Electric Co., Commercial and Residential Solutions]
4. [Nelson; Emerson Electric Co., Automation Solutions]
5. [RAYCHEM; brand of nVent Electrical plc]
6. [Trasor Corp.]
7. <Insert manufacturer's name>

- C. Comply with UL 1673.
- D. Heating Element: Single- or dual-conductor resistor wire. Terminate with waterproof, factory-assembled, nonheating leads with connectors at both ends.
- E. Electrical Insulating Mineral: Magnesium oxide.
- F. Cable Cover: Copper-nickel alloy[**and high-density polyethylene outer jacket**].
- G. Maximum Operating Temperature: **[300 deg F (150 deg C)]<Insert temperature>**.
- H. Capacities and Characteristics:
 - 1. Maximum Heat Output: **[6 W/ft. (19.7 W/m)][7.5 W/ft. (24.6 W/m)]<Insert value>**.
 - 2. Spacing: **<Insert inches (mm)>**.
 - 3. Electrical Characteristics for Single-Circuit Connection:
 - a. Volts: **[120][208][240][277][480]<Insert value>**.
 - b. Phase: **<Insert value>**.
 - c. Hertz: **<Insert value>**.
 - d. Full-Load Amperes: **<Insert value>**.
 - e. Minimum Circuit Ampacity: **<Insert value>**.
 - f. Maximum Overcurrent Protection: **<Insert amperage>**.

2.3 PLASTIC-INSULATED, SERIES-RESISTANCE HEATING CABLES

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Delta-Therm Corporation]**
 - 2. **[EasyHeat; Emerson Electric Co., Commercial and Residential Solutions]**
 - 3. **[NUHEAT; brand of nVent Electrical plc]**
 - 4. **[Orbit Manufacturing]**
 - 5. **[RAYCHEM; brand of nVent Electrical plc]**
 - 6. **[SunTouch; A Watts Water Technologies Company]**
 - 7. **[WarmlyYours Radiant, Inc.]**
 - 8. **[Warmup Inc.]**
 - 9. **[Warmzone Premier Radiant Heating]**
 - 10. **[WATTS; A Watts Water Technologies Company]**
 - 11. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Delta-Therm Corporation]**
 - 2. **[EasyHeat; Emerson Electric Co., Commercial and Residential Solutions]**
 - 3. **[NUHEAT; brand of nVent Electrical plc]**
 - 4. **[Orbit Manufacturing]**
 - 5. **[RAYCHEM; brand of nVent Electrical plc]**
 - 6. **[SunTouch; A Watts Water Technologies Company]**
 - 7. **[WarmlyYours Radiant, Inc.]**
 - 8. **[Warmup Inc.]**
 - 9. **[Warmzone Premier Radiant Heating]**
 - 10. **[WATTS; A Watts Water Technologies Company]**

11. <Insert manufacturer's name>

- C. Comply with UL 1673.
- D. Heating Element: Single resistor wire. Terminate with waterproof, factory-assembled, nonheating leads with connectors at both ends.
- E. Electrical Insulating Jacket: Minimum **4.0-mil (0.10-mm)** Kapton with silicone or Tefzel.
- F. Cable Cover: [**Aluminum**][**Stainless-steel**][**Nickel**] braid[**with silicone or Hylar outer jacket**].
- G. Maximum Operating Temperature: [**300 deg F (150 deg C)**]<Insert temperature>.
- H. Cable-Heated Mats: Factory-fabricated cable and fiberglass or plastic mesh with uniform [**1-1/2-inch (38-mm)**][**3-inch (76-mm)**]<Insert dimension> cable spacing, in [**18-inch (457-mm)**][**36-inch (914-mm)**]<Insert dimension> widths.
- I. Capacities and Characteristics:
 - 1. Maximum Heat Output (Cable): [**6 W/ft. (19.7 W/m)**][**7.5 W/ft. (24.6 W/m)**]<Insert value>.
 - 2. Maximum Heat Output (Mat): [**12 W/sq. ft. (129 W/sq. m)**][**16 W/sq. ft. (172 W/sq. m)**]<Insert value>.
 - 3. Spacing: <Insert inches (mm)>.
 - 4. Electrical Characteristics for Single-Circuit Connection:
 - a. Volts: [**120**][**208**][**240**][**277**][**480**]<Insert value>.
 - b. Phase: <Insert value>.
 - c. Hertz: <Insert value>.
 - d. Full-Load Amperes: <Insert value>.
 - e. Minimum Circuit Ampacity: <Insert value>.
 - f. Maximum Overcurrent Protection: <Insert amperage>.

2.4 SELF-REGULATING, PARALLEL-RESISTANCE HEATING CABLES

- A. Manufacturers: Subject to compliance with requirements, [**provide products by the following**][**provide products by one of the following**][**available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following**]:
 - 1. [**BriskHeat**]
 - 2. [**Chromalox, Inc.**]
 - 3. [**Delta-Therm Corporation**]
 - 4. [**EasyHeat; Emerson Electric Co., Commercial and Residential Solutions**]
 - 5. [**Nelson; Emerson Electric Co., Automation Solutions**]
 - 6. [**RAYCHEM; brand of nVent Electrical plc**]
 - 7. [**Thermon, Inc.**]
 - 8. [**Trasor Corp.**]
 - 9. [**Warmup Inc.**]
 - 10. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1. [**BriskHeat**]
 - 2. [**Chromalox, Inc.**]

3. [Delta-Therm Corporation]
 4. [EasyHeat; Emerson Electric Co., Commercial and Residential Solutions]
 5. [Nelson; Emerson Electric Co., Automation Solutions]
 6. [RAYCHEM; brand of nVent Electrical plc]
 7. [Thermon, Inc.]
 8. [Trasor Corp.]
 9. [Warmup Inc.]
 10. <Insert manufacturer's name>
- C. Comply with UL 1673.
- D. Heating Element: Pair of parallel [No. 16][No. 18] AWG, [tinned][nickel-coated], stranded copper bus wires embedded in crosslinked conductive polymer core, which varies heat output in response to temperature along its length. Terminate with waterproof, factory-assembled, nonheating leads with connectors at one end, and seal the opposite end watertight. Cable shall be capable of crossing over itself once without overheating.
- E. Electrical Insulating Jacket: Flame-retardant polyolefin.
- F. Cable Cover: [Tinned-copper][Stainless-steel] braid[with polyolefin outer jacket with ultraviolet inhibitor].
- G. Maximum Operating Temperature: [300 deg F (150 deg C)]<Insert temperature>.
- H. Cable-Heated Mats: Factory-fabricated cable and fiberglass or plastic mesh with uniform [1-1/2-inch (38-mm)][3-inch (76-mm)]<Insert dimension> cable spacing, in [18-inch (457-mm)][36-inch (914-mm)]<Insert dimension> widths.
- I. Capacities and Characteristics:
1. Maximum Heat Output (Cable): [3 W/ft. (9.8 W/m)][5 W/ft. (16.4 W/m)][8 W/ft. (26 W/m)][10 W/ft. (32.8 W/m)][12 W/ft. (39.4 W/m)]<Insert value>.
 2. Maximum Heat Output (Mat): [6 W/sq. ft. (65 W/sq. m)][12 W/sq. ft. (129 W/sq. m)][16 W/sq. ft. (172 W/sq. m)][24 W/sq. ft. (260 W/sq. m)]<Insert value>.
 3. Spacing: <Insert inches (mm)>.
 4. Electrical Characteristics for Single-Circuit Connection:
 - a. Volts: [120][208][240][277][480]<Insert value>.
 - b. Phase: <Insert value>.
 - c. Hertz: <Insert value>.
 - d. Full-Load Amperes: <Insert value>.
 - e. Minimum Circuit Ampacity: <Insert value>.
 - f. Maximum Overcurrent Protection: <Insert amperage>.

2.5 CONTROLS

- A. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC" for control devices and sequence of operations for radiant-heating electric cables.
- B. Wall-Mounted Thermostats for Ceiling and Floor Heating Cables:
1. Minimum temperature range from [50 to 90 deg F (10 to 32 deg C)]<Insert temperature range>.
 2. Manually operated with on-off switch.

C. Precipitation and Temperature Sensor for Snow Melting on Pavement:

1. **[Microprocessor-based][Automatic]** control with manual on, automatic, and standby/reset switch.
2. Precipitation and temperature sensors shall sense the surface conditions of pavement and shall be programmed to energize the cable as follows:
 - a. Temperature Span: **[34 to 44 deg F (1 to 7 deg C)]<Insert temperature range>**.
 - b. Adjustable Delay-Off Span: **[30 to 90]<Insert time>** minutes.
 - c. Energize Cables: Following **[two]<Insert time>**-minute delay if ambient temperature is below set point and precipitation is detected.
 - d. De-Energize Cables: On detection of a dry surface plus time delay.
3. Corrosion-proof and waterproof enclosure suitable for outdoor mounting, for controls and precipitation and temperature sensors.
4. Minimum 30-A contactor to energize cable or close other contactors.
5. Provide relay with contacts to indicate operational status, on or off, for interface with central HVAC control-system workstation.

2.6 ACCESSORIES

- A. Cable Installation Accessories: Fiberglass tape, heat-conductive putty, cable ties, silicone end seals and splice kits, and installation clips all furnished by manufacturer, or as recommended in writing by manufacturer.
- B. Embedded Heating-Cable Identification:
1. Flush-mounted cast-iron boxes with identification on lid according to NFPA 70.
 2. Mechanically fastened **[metal][plastic]** signage with identification according to NFPA 70 and complying with requirements in **[Section 101416 "Plaques."][Section 101419 "Dimensional Letter Signage."][Section 101423 "Panel Signage."]**
 3. Mechanically fastened **[metal][plastic][concrete]** post-mounted signage with identification according to NFPA 70 and complying with requirements in **[Section 101416 "Plaques."][Section 101419 "Dimensional Letter Signage."][Section 101423 "Panel Signage."]**

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine surfaces and substrates to receive electric heating cables or cable-heated mats for compliance with requirements for installation tolerances and other conditions affecting performance.
1. Ensure surfaces in contact with electric heating cables or cable-heated mats are free of burrs and sharp protrusions.
 2. Ensure surfaces and substrates are level and plumb.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

- A. Install the following types of electric heating cable for the applications described:
1. Ceiling Radiant Heating: **[Plastic-insulated, series-resistance][Self-regulating, parallel-resistance]** heating cable.
 2. Floor Radiant Heating: **[Plastic-insulated, series-resistance][Self-regulating, parallel-resistance]** heating cable.
 3. Snow and Ice Melting on Pavement: **[Mineral-insulated, series-resistance][Plastic-insulated, series-resistance][Self-regulating, parallel-resistance]** heating cable.
 4. Freezer-Floor Frost-Heave Prevention: **[Plastic-insulated, series-resistance][Self-regulating, parallel-resistance]** heating cable.

3.3 INSTALLATION

- A. Install electric heating cable or cable-heated mats across expansion, construction, and control joints according to manufacturer's written instructions; use cable-protection conduit and slack cable to allow movement without damage to cable.
- B. Do not energize cables embedded in concrete or plaster until those assemblies are cured.
- C. Electric Heating-Cable Installation for Ceiling Radiant Heating: Install heating cable or cable-heated mat with heat-conductive fill materials such as plaster to ensure direct contact with finished radiant surfaces.
- D. Electric Heating-Cable Installation for Floor Radiant Heating: Install heating cable or cable-heated mat with heat-conductive fill materials such as concrete to ensure direct contact with finished radiant surfaces.
- E. Electric Heating-Cable or Cable-Heated-Mat Installation for Snow and Ice Melting in Pavement:
1. Install heating cable or cable-heated mat with heat-conductive fill materials such as asphalt or concrete to ensure direct contact with finished radiant surfaces.
 2. Install cables or cable-heated mats after applying bituminous binder course to lower base; ensure that second bituminous binder course is applied to cables or mats before pouring finish topping.
 3. Install embedded electric heating-cable or cable-heated-mat identification box where indicated in pavement before pavement work is completed.
 4. Stamp concrete with embedded electric heating-cable or cable-heated-mat identification according to NFPA 70 and complying with requirements in Section 033000 "Cast-in-Place Concrete."
 5. Mount precipitation sensor in pavement.
- F. Electric Heating-Cable Installation for Freezer-Floor Frost-Heave Prevention: Install electric heating cable or cable-heated mat below insulation in subsoil.
1. Install embedded electric heating-cable or cable-heated-mat identification box where indicated.
 2. Install embedded electric heating-cable or cable-heated-mat identification according to NFPA 70 on adjacent structure and complying with requirements in **[Section 101416 "Plaques."][Section 101419 "Dimensional Letter Signage."][Section 101423 "Panel Signage.]**
 3. Install embedded electric heating-cable or cable-heated-mat identification according to NFPA 70 on **[metal][wood][concrete]** post and complying with requirements in **[Section 101416 "Plaques."][Section 101419 "Dimensional Letter Signage."][Section 101423 "Panel Signage.]**
 4. Stamp concrete with embedded electric heating-cable or cable-heated-mat identification according to NFPA 70 and complying with requirements in Section 033000 "Cast-in-Place Concrete."

- G. Set field-adjustable switches and circuit-breaker trip ranges.

3.4 CONNECTIONS

- A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
 - 1. Perform tests after cable installation but before application of coverings such as insulation, wall or ceiling construction, or concrete.
 - 2. Test cables for electrical continuity and insulation integrity before energizing.
 - 3. Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.
- D. Repeat tests for continuity, insulation resistance, and input power after applying finished surface on heating cables.
- E. Radiant-heating electric cables will be considered defective if they do not pass tests and inspections.
- F. Prepare test and inspection reports.

3.6 PROTECTION

- A. Protect installed heating cables, including nonheating leads, from damage during construction.
- B. Remove and replace damaged radiant-heating electric cables and cable-heated mats.

END OF SECTION 23 83 13 00



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 83 13 13	21 05 33 00	Heat Tracing for Fire-Suppression Piping
23 83 13 13	22 05 33 00	Heat Tracing for Plumbing Piping
23 83 13 13	23 05 33 00	Heat Tracing for HVAC Piping
23 83 13 13	23 83 13 00	Radiant-Heating Electric Cables



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SECTION 23 84 13 00 - HEAT EXCHANGER HUMIDIFIERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Heat-exchanger humidifiers.
 - 2. Condensate drain coolers.

1.2 DEFINITIONS

- A. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Sustainable Design Submittals:
 - 1. Product data showing compliance with ASHRAE 62.1.
 - 2. Product Data: For adhesives, indicating VOC content.
 - 3. Laboratory Test Reports: For adhesives, indicating compliance with requirements for low-emitting materials.
 - 4. Laboratory Test Reports: For Insulation, indicating compliance with requirements for low-emitting materials.
 - 5. Laboratory Test Reports: For insulation, indicating compliance with requirements for low-emitting materials.
 - 6. Laboratory Test Reports: For insulation, indicating compliance with requirements for low-emitting materials.
 - 7. Laboratory Test Reports: For insulation, indicating compliance with requirements for low-emitting materials.
- C. Shop Drawings: Detail fabrication and installation of humidifiers. Include piping details, plans, elevations, sections, details of components, manifolds, and attachments to other work.
 - 1. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Detail humidifiers and adjacent equipment. Show support locations, type of support, weight on each support, required clearances, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
 - 1. Structural members to which humidifiers will be attached.

2. Size and location of initial access modules for acoustical tile.

- B. Seismic Qualification Data: Certificates, for humidifiers, accessories, and components from manufacturer.
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Product Test Reports: For each humidifier, for tests performed by a qualified testing agency.
- D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For humidifiers to include in operation and maintenance manuals.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An NRTL.

1.7 COORDINATION

- A. Coordinate location and installation of humidifiers with distributor tubes/manifolds in ducts and plenums or occupied space. Revise locations and elevations to suit field conditions and to ensure proper humidifier operation.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with AHRI 640.
- C. Listed and labeled by an NRTL for intended location and use.
- D. Listed and labeled by [ETL]<Insert option>.
- E. Seismic Performance: Heat-exchanger humidifiers shall withstand the effects of earthquake motions determined according to [ASCE/SEI 7]<Insert requirement>.
 1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified[and the unit will be fully operational after the seismic event]."

2. Component Importance Factor: **[1.5][1.0]**.
3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.

F. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: **[25]<Insert value>** or less.
2. Smoke-Developed Index: **[50]<Insert value>** or less.

2.2 HEAT-EXCHANGER HUMIDIFIERS

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

1. **[Armstrong International, Inc]**
2. **[DriSteem]**
3. **[Herrmidifier; a brand of Trion]**
4. **[Neptronic; National Environmental Products, Inc.]**
5. **[Nortec Industries Inc.]**
6. **[Pure Humidifier Company]**
7. **<Insert manufacturer's name>**

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

1. **[Armstrong International, Inc]**
2. **[DriSteem]**
3. **[Herrmidifier; a brand of Trion]**
4. **[Neptronic; National Environmental Products, Inc.]**
5. **[Nortec Industries Inc.]**
6. **[Pure Humidifier Company]**
7. **<Insert manufacturer's name>**

C. Capacities and Characteristics:

1. Humidification Rate: **<Insert lb/h (g/s)>**.
2. Dry-Bulb Air Temperature at Discharge: **<Insert deg F (deg C)>**.
3. Wet-Bulb Air Temperature at Discharge: **<Insert deg F (deg C)>**.
4. Distributer Tube/Manifold Steam Supply Pressure: **<Insert psig (kPa)>**.
5. Maximum Absorption Distance: **<Insert inches (mm)>**.
6. Minimum Makeup Water Supply Pressure: **<Insert psig (kPa)>**.
7. Steam to Heat Exchanger:
 - a. Supply Pressure at Control Valve Inlet: **<Insert psig (kPa)>**.
 - b. Condensing Rate: **<Insert lb/h (g/s)>**.
8. Steam Distribution Method - Atmospheric Steam Distributer Tube:
 - a. Number of Distributer Tubes: **<Insert number>**.
9. Steam Distribution Method - Atmospheric Steam Panel Distribution Manifold:
 - a. Number of Distribution Manifolds: **<Insert number>**.

10. Steam Distribution Method -Area Dispersion:

- a. Number of Distributer Tubes: **<Insert number>**.
- b. Fan Airflow: **<Insert cfm (L/s)>**.
- c. Fan Motor Horsepower: **<Insert HP (KW)>**.
- d. Fan Electrical Characteristics:
 - 1) Volts: **<Insert number> V**.
 - 2) Phase: **[Single][Three]** Phase.
 - 3) Hertz: **[60]<Insert number> Hz**.
 - 4) Full-Load Amperes: **<Insert number> A**.
 - 5) Minimum Circuit Ampacity: **<Insert number> A**.
 - 6) Maximum Overcurrent Protection: **<Insert number> A**.

D. Water Type: Suitable for use with **[tap][softened][reverse osmosis][deionized]** water.

1. Evaporation Chamber:

- a. Designed for atmospheric steam output.
- b. Chamber and lid constructed of **[stainless steel][stainless steel, Type 304][or][stainless steel, Type 316][, factory insulated for safe operating surface temperature]**.
- c. Removable lid for access to clean.
- d. Provide overflow and drain fittings.

2. Heat Exchanger:

- a. Material: **[Stainless steel][Stainless steel, Type 304][Stainless steel, Type 316][Copper][Nickel-plated copper]<Insert material>**.
- b. Pressure: Designed for maximum incoming steam pressure of **15 psig (103 kPa)**.

3. Hinged or removable cover, keyed to restrict unauthorized access.
4. Weatherproof Outdoor Enclosure: **[Insulated and with automatically controlled heating and ventilating system to maintain minimum operating conditions within the enclosure.]**

E. Control Panel:

1. **[Shipped loose][Factory mounted]**.
2. Microprocessor-based control system for **[modulating][cycling]** control.
3. Liquid-crystal display.
4. Programmable keypad.
5. Low-voltage control circuit, with fused transformer.
6. Diagnostic, maintenance, alarm, and status features.
7. Key-locked access doors to prevent unauthorized access.
8. Electrical terminals for connection to each controlling device and alarm.
9. NEMA 250, **[Type 3R][Type 4][Type 4X][Type 12]<Insert type>**, to comply with environmental conditions at installed locations.
10. Material: **[Galvanized][Powder-coated][Stainless]** steel **<Insert material>**.

F. Building Automation System Interface:

1. Full Communication Interface: **[BACnet]<Insert interface option>**.
2. **[Web-based remote factory online monitoring with same functionality as local keypad/display.]**

G. Controls:

1. Solenoid Fill Valve to Maintain Water Level: **[Stainless-steel][Bronze]**, including fill tee with built-in air gap to prevent back siphoning.
 2. Inlet Strainer, Y-Pattern: **[Stainless-steel][bronze]** body with **[20]<Insert number>-mesh** stainless-steel screen.
 3. Field-adjustable **[timer][conductivity controller]** to control drain cycle for flush duration and interval. **[Automatic flush is not required for reverse osmosis or deionized water applications.]**
 4. Controls shall drain tanks if no demand for humidification for more than 72 hours.
 5. Set-point adjustment.
 6. **[Tri-conductivity sensor probes][Stainless-steel float switches]** for water-level control and to shutdown heat exchanger upon low water condition.
 7. Aquastat maintains minimum water temperature in tank during short periods of no demand.
 8. Foaming detection and correction.
- H. Area Dispersion Accessory: Stainless-steel tube, with integral fan that discharges vapor directly into occupied space. Designed for remote mounting from humidifier.
- I. Atmospheric Steam Distributer Tube(s): Single or multiple, atmospheric steam distributer tube extending across entire width of duct or plenum and equipped with mounting brackets on ends. Nozzles/metered orifices are spaced evenly along distributer tubes and provide dry and uniform steam distribution.
1. Material: **[Stainless steel][Stainless steel, Type 304][Stainless steel, Type 316]**.
 2. Insulation: **[Uninsulated][Insulated][Insulated, minimum R-0.5]**.
- J. Atmospheric Steam Panel Distribution Manifold:
1. Prefabricated steam dispersion grid assembly.
 2. Designed for short absorption distance.
 3. Suitable for atmospheric steam applications.
 4. Extending the full width and height of duct or plenum.
 5. **[Horizontal][or][vertical]** header with multiple **[vertical][or][horizontal]** tubes designed for dry steam injection within short absorption distance.
 6. Nozzles/metered orifices, spaced evenly along distribution tubes, provide dry and uniform steam distribution.
 7. Distribution panel extending the full width and height of duct or plenum.
 8. Headers and Distribution Tubes:
 - a. Material: **[Stainless steel][Stainless steel, Type 304][Stainless steel, Type 316]**.
 - b. Insulation: **[Uninsulated][Insulated][Insulated, minimum R-0.5]**.
 9. Steam Separator: Separators/baffles, integral to the header, to provide condensate-free steam to the distribution tubes.
- K. Humidifier Control Valve:
1. Actuator:
 - a. **[Pneumatic][Electric]** modulating with spring return.
 - b. As specified in Section 230923.11 "Control Valves."
 2. Body: **[Bronze][Stainless steel][Stainless steel, Type 304][Stainless steel, Type 316]**.
- L. Steam Trap:
1. Material: **[Cast iron][Stainless steel][Stainless steel, Type 304][Stainless steel, Type 316]**.
 2. Type: **[Inverted-bucket type][or][float and thermostatic type]**.

3. Sized for a minimum of [3]<Insert number> times the maximum rated condensate flow of humidifier at [1/2-psig (3.4-kPa)]<Insert value> differential pressure.

M. Accessories:

1. [Humidistat][Humidity Sensor]: [Wall][Return-duct] mounted.
2. Duct-mounted, high-limit [humidistat][humidity sensor].
3. In-Line Strainer, Y-Pattern: [Cast-iron][Stainless-steel][Stainless-steel, Type 304][Stainless-steel, Type 316] body with [20]<Insert number>-mesh [Type 304][Type 316] stainless-steel screen.
4. Airflow switch for preventing humidifier operation without airflow.
5. Steam and Condensate Hoses: For interconnection of humidifier to distributor tube(s)/manifold.

2.3 CONDENSATE DRAIN COOLERS

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

1. [Armstrong International, Inc]
2. [DriSteem]
3. [Neptronic; National Environmental Products, Inc.]
4. [Nortec Industries Inc.]
5. [Pure Humidifier Company]
6. <Insert manufacturer's name>

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

1. [Armstrong International, Inc]
2. [DriSteem]
3. [Neptronic; National Environmental Products, Inc.]
4. [Nortec Industries Inc.]
5. [Pure Humidifier Company]
6. <Insert manufacturer's name>

- C. Capacities and Characteristics:

1. Hot Condensate in: <Insert gpm (L/s)>.
2. Hot Condensate Temperature: <Insert deg F (deg C)>.
3. Cold Water in <Insert gpm (L/s)>.
4. Cold Water Temperature: <Insert de F (deg C)>.
5. Tempered Water out <Insert gpm (L/s)>.
6. Tempered Water Temperature: <Insert deg F (deg C)>.

- D. Description: Mixes hot condensate with a cold water supply to reduce the drain temperature as required by state and local codes.

- E. Cold Water Tempering Valve: Bronze body, [thermostatic self-actuated with aquastat][24-VAC electric-actuated with temperature sensor].

- F. Drain Temperature Set-Point Range: Field adjustable between 115 deg F (46 deg C) and 140 deg F (60 deg C). Drain sensor to control cold water tempering valve to limit drain discharge temperature to set point.

- G. Reservoir Body Material: **[Cast iron or carbon steel][Stainless steel][stainless steel, Type 304][stainless steel, Type 316]**.
- H. Mounting: Suitable for **[wall][floor][suspended]** mounting.
- I. Vacuum breaker or air vent connection.
- J. Condensate drain cooler built into the humidifier cabinet and offered as the humidifier manufacturer's standard product is acceptable in lieu of a separate product by the listed manufacturers.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine ducts, air-handling units, and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Examine roughing-in for piping systems to verify actual locations of piping connections before humidifier installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install humidifiers with required clearance for service and maintenance. **[Maintain path, downstream from humidifiers, clear of obstructions as required by ASHRAE 62.1.]**
- B. Seal all penetrations of duct or plenum with flange.
- C. Install humidifier assemblies in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."
- D. Install **[galvanized][stainless]**-steel drain pan under each manifold mounted in duct.
 - 1. Construct drain pans with connection for drain; insulated **[and complying with ASHRAE 62.1]**.
 - 2. Connect to condensate trap and drainage piping.
 - 3. Extend drain pan upstream and downstream from humidifier tube(s)/manifold a minimum distance recommended by manufacturer but not less than required by ASHRAE 62.1.
- E. Install drip leg upstream from steam trap a minimum of **[12 inches (300 mm)]<Insert height>** tall for proper operation of trap.
- F. Equipment Mounting:
 - 1. Install floor-mounted humidifiers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

- G. Install all manufacturer-provided accessories in accordance with manufacturer's written installation instructions.

3.3 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
 - 1. Install piping adjacent to humidifiers to allow service and maintenance.
 - 2. Install shutoff valve, strainer, backflow preventer, and union in humidifier makeup line.
- B. Install piping specialties furnished by manufacturer but not factory mounted.

3.4 ELECTRICAL CONNECTIONS

- A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer but not factory mounted.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch (13 mm)** high.

3.5 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring between humidity sensors, high-limit humidity sensors, condensate temperature sensors, and **[DDC control system]<Insert system description>**.
- C. Connect control wiring between humidistats, thermostats, and controlled devices.
- D. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.6 FIELD QUALITY CONTROL

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



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

D. Humidifier will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.7 DEMONSTRATION

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

END OF SECTION 23 84 13 00



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SECTION 23 84 13 16 - WETTED-ELEMENT HUMIDIFIERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Wetted-element humidifiers.

1.2 DEFINITIONS

- A. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Sustainable Design Submittals:
 - 1. Product data showing compliance with ASHRAE 62.1.
- C. Shop Drawings: Detail fabrication and installation of humidifiers. Include piping details, plans, elevations, sections, details of components, manifolds, and attachments to other work.
 - 1. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Detail humidifiers and adjacent equipment. Show support locations, type of support, weight on each support, required clearances, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
 - 1. Structural members to which humidifiers will be attached.
 - 2. Size and location of initial access modules.
- B. Seismic Qualification Data: Certificates, for humidifiers, accessories, and components from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

- C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For humidifiers to include in operation and maintenance manuals.

1.6 COORDINATION

- A. Coordinate location and installation of humidifiers with manifolds in ducts and air-handling units or occupied space. Revise locations and elevations to suit field conditions and to ensure proper humidifier operation.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with AHRI 640.
- C. Comply with UL 900, **[Class I][or][Class II]**.
- D. Comply with **<Insert standard>**.
- E. Seismic Performance: Wetted-element humidifiers shall withstand the effects of earthquake motions determined according to **[ASCE/SEI 7]<Insert requirement>**.
 - 1. The term "withstand" means the "unit will remain in place without separation of any parts when subjected to the seismic forces specified **[and the unit will be fully operational after the seismic event]**."
 - 2. Component Importance Factor: **[1.5][1.0]**.
 - 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.
- F. Capacities and Characteristics:
 - 1. Humidification Rate: **<Insert lb/h (g/s)>**.
 - 2. Entering Dry-Bulb Air Temperature: **<Insert deg F (deg C)>**.
 - 3. Entering Wet-Bulb Air Temperature: **<Insert deg F (deg C)>**.
 - 4. Leaving Dry-Bulb Air Temperature: **<Insert deg F (deg C)>**.
 - 5. Leaving Wet-Bulb Air Temperature: **<Insert deg F (deg C)>**.
 - 6. Duct/Plenum Height: **<Insert inches (mm)>**.
 - 7. Duct/Plenum Width: **<Insert inches (mm)>**.
 - 8. Number of Media Control Stages: **<Insert number>**.
 - 9. Maximum Absorption Distance: **<Insert inches (mm)>**.
 - 10. Cooling Efficiency Required: **<Insert number>** percent.
 - 11. Media Water Pump:
 - a. Number of Pumps: **<Insert number>**.

- b. Motor Horsepower (Each): **<Insert hp (W)>**.
 - 12. Drain Pump:
 - a. Number of Pumps: **<Insert number>**.
 - b. Motor Horsepower: **<Insert hp (W)>**.
 - 13. Electrical Characteristics: Single point of connection.
 - a. Volts: **<Insert number>** V.
 - b. Phase: **[Single][Three]** phase.
 - c. Hertz: **<Insert number>** Hz.
 - d. Full-Load Amperes: **<Insert number>** A.
 - e. Minimum Circuit Ampacity: **<Insert number>** A
 - f. Maximum Overcurrent Protection: **<Insert number>** A.
 - G. Water Type: Suitable for use with **[tap][softened][reverse osmosis][deionized]** water.
- 2.2 WETTED-ELEMENT HUMIDIFIERS
- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[DriSteem]**
 - 2. **[Neptronic; National Environmental Products, Inc.]**
 - 3. **[Nortec Industries Inc.]**
 - 4. **<Insert manufacturer's name>**
 - B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[DriSteem]**
 - 2. **[Neptronic; National Environmental Products, Inc.]**
 - 3. **[Nortec Industries Inc.]**
 - 4. **<Insert manufacturer's name>**
 - C. Piping and Fittings, **ASTM A269 (ASTM A269M):** **[Stainless-steel][Stainless-steel, type 304][Stainless-steel, type 316]** pipe and fittings.
 - D. Piping and Fittings, **ASTM B88 (ASTM B88M):** type L copper pipe and wrought-copper fittings with brazed joints.
 - E. Media Water Pump:
 - 1. **[Stainless-steel][Bronze]** pump body and **[single][variable]**-speed motor.
 - 2. **[One pump][One solenoid valve][One pump or solenoid valve]** for each media stage.
 - F. Drain Pump: **[Stainless-steel][Bronze]** pump body and single-speed motor.
 - G. Media:
 - 1. Inorganic and inflammable.

- H. Reservoir, Header, and Frame:
 - 1. Stainless steel.
 - 2. Reservoir designed, so it drains and dries completely.
- I. Mist Eliminator: Mounted to a stainless-steel frame with removable panels.
- J. Water Treatment:
 - 1. Ultraviolet disinfection system.
 - 2. Silver-ion antibacterial cartridge.
 - 3. **[5-micron]<Insert value>** pre-filter.
- K. Control Panel:
 - 1. NEMA 250, **[type 3R][type 4X]<Insert type>**, to comply with environmental conditions at installed location.
 - 2. Material: **[Galvanized][Powder-coated][Stainless]** steel **<Insert material>**.
- L. Controls:
 - 1. **[Cycle][Vary speed of]** motor **[and][sequence solenoid valve stages]** to satisfy humidistat.
 - 2. Multilevel probe and supply solenoid to maintain tank water level.
 - 3. Conductivity drain controls manage the total dissolved solids concentration in the reservoir.
 - 4. Building Automation System Interface:
 - a. For Each Control Zone, Provide Points for the Following:
 - 1) Start/stop.
 - 2) Status indication.
 - 3) **<Insert other points>**.
 - b. Full Communication Interface: **[Modbus][BACnet]<Insert interface type>**.
- M. Accessories:
 - 1. **[Humidistat][Humidity Sensor]: [Wall][Return duct]** mounted.
 - 2. High-Limit **[Humidistat][Humidity Sensor]:** Supply duct mounted.
 - 3. Airflow switch prevents humidifier operation without airflow.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine ducts, air-handling units, and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Examine roughing-in for piping systems to verify actual locations of piping connections before humidifier installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install humidifiers with required clearance for service and maintenance. [**Maintain path, downstream from humidifiers, clear of obstructions as required by ASHRAE 62.1.**]
- B. Seal all duct and plenum penetrations with flange.
- C. Install humidifier manifolds in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."
- D. Install **[galvanized][stainless]**-steel drain pan under each manifold.
 - 1. Construct drain pans with connection for drain; insulated [**and complying with ASHRAE 62.1.**]
 - 2. Connect to condensate trap and drainage piping.
 - 3. Extend drain pan upstream and downstream from manifold a minimum distance recommended by manufacturer but not less than that required by ASHRAE 62.1.
- E. Equipment Mounting:
 - 1. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 2. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- F. Install all manufacturer-furnished accessories in accordance with manufacturer's written installation instructions.

3.3 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
 - 1. Install piping adjacent to humidifiers to allow service and maintenance.
- B. Install devices and piping specialties furnished by manufacturer but not factory mounted.

3.4 ELECTRICAL CONNECTIONS

- A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate shall be laminated acrylic or melamine plastic signs as layers of black with engraved white letters at least **1/2-inch (13-mm)** high.
 - 3. Locate nameplate where easily visible.

3.5 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring between humidity sensors, high-limit humidity sensors, and **[DDC control system]<Insert system description>**.
- C. Connect control wiring between humidistats and controlled devices.
- D. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.6 FIELD QUALITY CONTROL

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

3.7 DEMONSTRATION

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

END OF SECTION 23 84 13 16



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 84 13 16	23 84 13 00	Heat Exchanger Humidifiers



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SECTION 23 84 13 23 - DIRECT-STEAM-INJECTION HUMIDIFIERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Direct-steam-injection distributor tube humidifiers.
2. Direct-steam-injection panel distribution manifold humidifiers.
3. Area-type direct-steam-injection humidifiers.
4. Condensate drain coolers.

1.2 DEFINITIONS

- A. Low Voltage:** As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

1.3 ACTION SUBMITTALS

- A. Product Data:** For each type of product. Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Sustainable Design Submittals:**
1. Product data showing compliance with ASHRAE 62.1.
 2. Product Data: For adhesives, indicating VOC content.
 3. Laboratory Test Reports: For adhesives, indicating compliance with requirements for low-emitting materials.
 4. Laboratory Test Reports: For Insulation, indicating compliance with requirements for low-emitting materials.
 5. Laboratory Test Reports: For insulation, indicating compliance with requirements for low-emitting materials.
 6. Laboratory Test Reports: For insulation, indicating compliance with requirements for low-emitting materials.
 7. Laboratory Test Reports: For insulation, indicating compliance with requirements for low-emitting materials.
- C. Shop Drawings:** Detail fabrication and installation of humidifiers. Include piping details, plans, elevations, sections, details of components, distributor tubes/manifolds, and attachments to other work.
1. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings:** Detail humidifiers and adjacent equipment. Show support locations, type of support, weight on each support, required clearances, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Structural members to which humidifiers will be attached.
2. Size and location of initial access modules for acoustical tile.

B. Seismic Qualification Data: Certificates, for humidifiers, accessories, and components, from manufacturer.

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

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For humidifiers to include in operation and maintenance manuals.

1.6 COORDINATION

A. Coordinate location and installation of humidifiers with distributor tubes/manifolds in ducts and plenums or occupied space. Revise locations and elevations to suit field conditions and to ensure proper humidifier operation.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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

B. Comply with AHRI 640.

C. Comply with **<Insert standard>**.

D. Seismic Performance: Direct-steam-injection humidifiers shall withstand the effects of earthquake motions determined according to **[ASCE/SEI 7]<Insert requirement>**.

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

E. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: **[25]<Insert value>** or less.

2. Smoke-Developed Index: **[50]<Insert value>** or less.

2.2 DIRECT-STEAM-INJECTION DISTRIBUTER TUBE HUMIDIFIERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 1. **[Armstrong International, Inc]**
 2. **[Carel USA, LLC]**
 3. **[DriSteem]**
 4. **[Herrmidifier; a brand of Trion]**
 5. **[Hygromatik; Spirax Sarco]**
 6. **[Neptronic; National Environmental Products, Inc.]**
 7. **[Nortec Industries Inc.]**
 8. **[Pure Humidifier Company]**
 9. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 1. **[Armstrong International, Inc]**
 2. **[Carel USA, LLC]**
 3. **[DriSteem]**
 4. **[Herrmidifier; a brand of Trion]**
 5. **[Hygromatik; Spirax Sarco]**
 6. **[Neptronic; National Environmental Products, Inc.]**
 7. **[Nortec Industries Inc.]**
 8. **[Pure Humidifier Company]**
 9. **<Insert manufacturer's name>**
- C. Capacities and Characteristics:
 1. Humidification Rate: **<Insert lb/h (g/s)>**.
 2. Steam Supply Pressure: **<Insert psig (kPa)>**.
 3. Dry-Bulb Air Temperature at Discharge: **<Insert deg F (deg C)>**.
 4. Wet-Bulb Air Temperature at Discharge: **<Insert deg F (deg C)>**.
 5. Maximum Absorption Distance: **<Insert inches (mm)>**.
 6. Number of Distributer Tubes: **<Insert number>**.
- D. Steam Distributer Tube(s): Single or multiple, steam-jacketed tubes suitable for pressurized steam applications.
- E. Material: **[Stainless steel][Stainless steel, type 304][Stainless steel, type 316]**.
- F. Insulation: **[Uninsulated][Insulated][Insulated, minimum R-0.5]**.
- G. Steam Separator: **[Cast iron][Stainless steel, type 304][Stainless steel, type 316]**.
- H. Humidifier Control Valve:
 1. Actuator:
 - a. **[Pneumatic][Electric]** modulating with spring return.
 - b. As specified in Section 230923.11 "Control Valves."



2. Body: [Bronze][Stainless steel][Stainless steel, type 304][Stainless steel, type 316].

I. Steam Trap:

1. Material: [Cast iron][Stainless steel][Stainless steel, type 304][Stainless steel, type 316].
2. Type: [Inverted-bucket][or][Float and thermostatic].
3. Capacity: Sized for a minimum of [3 times]<Insert value> the maximum rated condensate flow of humidifier at [1/2-psig (3.4-kPa)]<Insert value> differential pressure.

J. Accessories:

1. [Humidistat][Humidity Sensor]: [Wall][Return-duct] mounted.
2. Duct-mounted high-limit [humidistat][humidity sensor].
3. [AquaStat][Temperature sensor] mounted on steam condensate return piping to prevent cold operation of humidifier.
4. In-Line Strainer, Y-Pattern: [Stainless-steel][Stainless-steel, type 304][Stainless-steel, type 316][Cast-iron] body with [20]<Insert number>-mesh [type 304][type 316] stainless-steel screen.
5. Airflow switch for preventing humidifier operation without airflow.
6. Humidifier Controller:
 - a. Digital, with keypad and display.
 - b. Building Automation System Interface:
 - 1) Full Communication Interface: [BACnet][Modbus][Lontalk][Ethernet][Johnson Controls N2]<Insert interface type>.

2.3 DIRECT-STEAM-INJECTION PANEL DISTRIBUTION MANIFOLD HUMIDIFIERS

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

1. [Armstrong International, Inc]
2. [Carel USA, LLC]
3. [DriSteem]
4. [Herrmidifier; a brand of Trion]
5. [Hygromatik; Spirax Sarco]
6. [Neptronic; National Environmental Products, Inc.]
7. [Nortec Industries Inc.]
8. [Pure Humidifier Company]
9. <Insert manufacturer's name>

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

1. [Armstrong International, Inc]
2. [Carel USA, LLC]
3. [DriSteem]
4. [Herrmidifier; a brand of Trion]
5. [Hygromatik; Spirax Sarco]
6. [Neptronic; National Environmental Products, Inc.]
7. [Nortec Industries Inc.]
8. [Pure Humidifier Company]

9. **<Insert manufacturer's name>**
- C. Capacities and Characteristics:
1. Humidification Rate: **<Insert lb/h (g/s)>**.
 2. Steam Supply Pressure: **<Insert psig (kPa)>**.
 3. Dry-Bulb Air Temperature at Discharge: **<Insert deg F (deg C)>**.
 4. Wet-Bulb Air Temperature at Discharge: **<Insert deg F (deg C)>**.
 5. Maximum Absorption Distance: **<Insert inches (mm)>**.
 6. Number of Distribution Manifolds: **<Insert number>**.
- D. Panel Distribution Manifold:
1. Prefabricated steam dispersion grid assembly.
 2. Designed for short absorption distance.
 3. Suitable for pressurized steam applications.
 4. Extending the full width and height of duct or plenum.
 5. **[Horizontal][or][vertical]** header with multiple **[vertical][or][horizontal]**, **[nonsteam-jacketed][steam-jacketed]** tubes, designed for dry-steam injection, within short absorption distance.
 6. **[Nozzles/metered orifices in conjunction with nonsteam-jacketed manifolds][or][punched orifices/no nozzles in conjunction with steam-jacketed manifolds]** spaced evenly along manifold tubes and providing dry and uniform steam distribution.
 7. Headers and Distribution Tubes:
 - a. Material: **[Stainless steel][Stainless steel, type 304][Stainless steel, type 316]**.
 - b. Insulation: **[Uninsulated][Insulated][Insulated, minimum R-0.5]**.
- E. Steam Separator: External separator, or separator/baffles integral to header, to provide condensate-free steam to the distribution tubes.
1. Material: **[Stainless steel][Stainless steel, type 304][Stainless steel, type 316]**.
- F. Humidifier Control Valve:
1. Actuator:
 - a. **[Pneumatic][Electric]** modulating with spring return.
 - b. As specified in Section 230923.11 "Control Valves."
 2. Body: **[Bronze][Stainless steel][Stainless steel, type 304][Stainless steel, type 316]**.
- G. Steam Trap:
1. Material: **[Cast iron][Stainless steel][Stainless steel, type 304][Stainless steel, type 316]**.
 2. Type: **[Inverted-bucket][or][Float and thermostatic]**.
 3. Capacity: Sized for a minimum of **[3]<Insert number>** times the maximum rated condensate flow of humidifier at **[1/2-psig (3.4-kPa)]<Insert value>** differential pressure.
- H. Accessories:
1. **[Humidistat][Humidity Sensor]**: **[Wall][Return-duct]** mounted.
 2. Duct-mounted, high-limit **[humidistat][humidity sensor]**.
 3. **[Aquastat][Temperature sensor]** mounted on steam condensate return piping to prevent cold operation of humidifier.
 4. In-Line Strainer, Y-Pattern: **[Stainless steel][Stainless steel, type 304][Cast iron]** body with

[20]<Insert number>-mesh [stainless steel][stainless steel, type 304][stainless steel, type 316] screen.

5. Airflow switch for preventing humidifier operation without airflow.

6. Humidifier Controller:

- a. Digital, with keypad and display.
- b. Building Automation System Interface:

- 1) Full Communication Interface: [BACnet][Modbus][Lontalk][Ethernet][Johnson Controls N2]<Insert interface type>.

2.4 DIRECT-STEAM-INJECTION AREA HUMIDIFIERS

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

- 1. [Armstrong International, Inc]
- 2. [DriSteem]
- 3. [Hygromatik; Spirax Sarco]
- 4. [Pure Humidifier Company]
- 5. <Insert manufacturer's name>

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

- 1. [Armstrong International, Inc]
- 2. [DriSteem]
- 3. [Hygromatik; Spirax Sarco]
- 4. [Pure Humidifier Company]
- 5. <Insert manufacturer's name>

C. Capacities and Characteristics:

- 1. Humidification Rate: <Insert lb/h (g/s)>.
- 2. Steam Supply Pressure: <Insert psig (kPa)>.
- 3. Dry-Bulb Air Temperature at Discharge: <Insert deg F (deg C)>.
- 4. Wet-Bulb Air Temperature at Discharge: <Insert deg F (deg C)>.
- 5. Maximum Absorption Distance: <Insert inches (mm)>.
- 6. Dispersion Fan:

- a. Airflow: <Insert cfm (L/s)>.
- b. Motor Horsepower: <Insert hp (W)>.

7. Electrical Characteristics: Single point of connection.

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

D. Discharge Nozzle and Dispersion Fan:

1. Steam-jacketed discharge nozzle, aluminum blade propeller fan with finger guard, and motor interlocked to operate with humidifier.
2. Fan Mounting: Above and behind discharge outlet on bracket integral to discharge outlet.
3. Steam Separator: External separator, or separator/baffles integral to the nozzle assembly, to provide condensate-free steam to the discharge nozzle.
4. Dispersion Nozzle Material: **[Stainless steel][Stainless steel, type 304][Stainless steel, type 316]**.

E. Humidifier Control Valve:

1. Actuator:
 - a. **[Pneumatic][Electric]** modulating with spring return.
 - b. As specified in Section 230923.11 "Control Valves."
2. Body: **[Bronze][Stainless steel][Stainless steel, type 304][Stainless steel, type 316]**.

F. Accessories:

1. **[Humidistat][Humidity Sensor]**: Wall mounted.
2. In-Line Strainer, Y-Pattern: **[Stainless steel][Stainless steel, type 304][Stainless steel, type 316][Cast iron]** body with **[20]<Insert number>**-mesh **[stainless steel][stainless steel, type 304][stainless steel, type 316]** screen.
3. Humidifier Controller:
 - a. Digital, with keypad and display.
 - b. Building Automation System Interface:
 - 1) Full Communication Interface: **[BACnet][Modbus][Lontalk][Ethernet][Johnson Controls N2]<Insert interface type>**.

2.5 CONDENSATE DRAIN COOLERS

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

1. **[Armstrong International, Inc]**
2. **[DriSteem]**
3. **[Neptronic; National Environmental Products, Inc.]**
4. **[Nortec Industries Inc.]**
5. **[Pure Humidifier Company]**
6. **<Insert manufacturer's name>**

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

1. **[Armstrong International, Inc]**
2. **[DriSteem]**
3. **[Neptronic; National Environmental Products, Inc.]**
4. **[Nortec Industries Inc.]**
5. **[Pure Humidifier Company]**
6. **<Insert manufacturer's name>**

C. Capacities and Characteristics:



1. Hot Condensate in: **<Insert gpm (L/s)>**.
 2. Hot Condensate Temperature: **<Insert deg F (deg C)>**.
 3. Cold Water in **<Insert gpm (L/s)>**.
 4. Cold Water Temperature: **<Insert deg F (deg C)>**.
 5. Tempered Water out **<Insert gpm (L/s)>**.
 6. Tempered Water Temperature: **<Insert deg F (deg C)>**.
- D. Description: Mixes hot condensate with a cold water supply to reduce the drain temperature, as required by state and local codes.
- E. Cold Water Tempering Valve: Bronze body, **[thermostatic self-actuated with aquastat][24 V ac electric actuated with temperature sensor]**.
- F. Drain Temperature Set-Point Range: Field adjustable between **115 deg F (46 deg C)** and **140 deg F (60 deg C)**. Drain sensor to control cold water tempering valve to limit drain discharge temperature to set point.
- G. Reservoir Body Material: **[Stainless steel][Stainless steel, type 304][Stainless steel, type 316][Cast iron or carbon steel]**.
- H. Mounting: Suitable for **[wall][floor][suspended]** mounting.
- I. Vacuum breaker or air vent connection.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine ducts, air-handling units, and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Examine roughing-in for piping systems to verify actual locations of piping connections before humidifier installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install humidifiers with required clearance for service and maintenance. **[Maintain path, downstream from humidifiers, clear of obstructions as required by ASHRAE 62.1.]**
- B. Seal all duct and plenum penetrations with flange.
- C. Install humidifier assemblies in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."
- D. Install **[galvanized][stainless]**-steel drain pan under each manifold mounted in duct.
 1. Construct drain pans with connection for drain; insulated **[and complying with ASHRAE 62.1]**.
 2. Connect to condensate trap and drainage piping.
 3. Extend drain pan upstream and downstream from humidifier tube(s)/manifold a minimum distance

recommended by manufacturer but not less than that required by ASHRAE 62.1.

- E. Install drip leg upstream from steam trap a minimum of **[12 inches (300 mm)]<Insert height>** tall for proper operation of trap.
- F. Equipment Mounting:
 - 1. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 2. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- G. Install all manufacturer-furnished accessories in accordance with manufacturer's written installation instructions.

3.3 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
 - 1. Install piping adjacent to humidifiers to allow service and maintenance.
 - 2. Where condensate drain cooler is used, install shutoff valve, strainer, backflow preventer, and union in tempering water makeup piping.
- B. Install piping specialties furnished by manufacturer but not factory mounted.
- C. Provide P-trap in atmospheric drain piping serving area humidifiers in accordance with manufacturer recommendations.

3.4 ELECTRICAL CONNECTIONS

- A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate shall be laminated acrylic or melamine plastic signs as layers of black with engraved white letters at least **1/2 inch (13 mm)** high.
 - 3. Locate nameplate where easily visible.

3.5 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring between humidity sensors, high-limit humidity sensors, condensate temperature sensors, and **[DDC control system]<Insert system description>**.
- C. Connect control wiring between humidistats, thermostats, and control devices.



- D. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.6 FIELD QUALITY CONTROL

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

3.7 DEMONSTRATION

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

END OF SECTION 23 84 13 23



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 84 13 23	23 84 13 00	Heat Exchanger Humidifiers



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SECTION 23 84 13 29 - SELF-CONTAINED STEAM HUMIDIFIERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
1. Self-contained electric-resistance humidifiers.
 2. Self-contained electrode humidifiers.
 3. Self-contained gas-fired humidifiers.
 4. Condensate drain coolers.

1.2 DEFINITIONS

- A. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Sustainable Design Submittals:
1. Product data showing compliance with ASHRAE 62.1.
 2. Product Data: For adhesives, indicating VOC content.
 3. Laboratory Test Reports: For adhesives, indicating compliance with requirements for low-emitting materials.
 4. Laboratory Test Reports: For Insulation, indicating compliance with requirements for low-emitting materials.
 5. Laboratory Test Reports: For insulation, indicating compliance with requirements for low-emitting materials.
 6. Laboratory Test Reports: For insulation, indicating compliance with requirements for low-emitting materials.
 7. Laboratory Test Reports: For insulation, indicating compliance with requirements for low-emitting materials.
- C. Shop Drawings: Detail fabrication and installation of humidifiers. Include piping details, plans, elevations, sections, details of components, distributor tubes/manifolds, and attachments to other work.
1. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Detail humidifiers and adjacent equipment. Show support locations, type of support, weight on each support, required clearances, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Structural members to which humidifiers will be attached.
2. Size and location of initial access modules for acoustical tile.

B. Seismic Qualification Data: Certificates, for humidifiers, accessories, and components from manufacturer.

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

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For humidifiers to include in operation and maintenance manuals.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An NRTL.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Supply one replacement electrode cylinder with each self-contained humidifier.

1.8 COORDINATION

- A. Coordinate location and installation of humidifiers with distributor tubes/manifolds in ducts and plenums or occupied space. Revise locations and elevations to suit field conditions and to ensure proper humidifier operation.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with AHRI 640.
- C. Comply with UL 998.
- D. Listed and labeled by [CE][ETL][CSA], as complying with applicable AGA/CGA standards].

- E. Listed and labeled by **[ETL]<Insert option>**.
- F. Seismic Performance: Self-contained steam humidifiers shall withstand the effects of earthquake motions determined according to **[ASCE/SEI 7]<Insert requirement>**.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified **[and the unit will be fully operational after the seismic event]**."
 - 2. Component Importance Factor: **[1.5][1.0]**.
 - 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.
- G. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1. Flame-Spread Index: **[25]<Insert value>** or less.
 - 2. Smoke-Developed Index: **[50]<Insert value>** or less.

2.2 SELF-CONTAINED ELECTRIC-RESISTANCE HUMIDIFIERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Armstrong International, Inc]**
 - 2. **[Carel USA, LLC]**
 - 3. **[DriSteem]**
 - 4. **[Herrmidifier; a brand of Trion]**
 - 5. **[Hygromatik; Spirax Sarco]**
 - 6. **[Neptronic; National Environmental Products, Inc.]**
 - 7. **[Nortec Industries Inc.]**
 - 8. **[Pure Humidifier Company]**
 - 9. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Armstrong International, Inc]**
 - 2. **[Carel USA, LLC]**
 - 3. **[DriSteem]**
 - 4. **[Herrmidifier; a brand of Trion]**
 - 5. **[Hygromatik; Spirax Sarco]**
 - 6. **[Neptronic; National Environmental Products, Inc.]**
 - 7. **[Nortec Industries Inc.]**
 - 8. **[Pure Humidifier Company]**
 - 9. **<Insert manufacturer's name>**
- C. Capacities and Characteristics:
 - 1. Humidification Rate: **<Insert lb/h (g/s)>**.
 - 2. Dry-Bulb Air Temperature at Discharge: **<Insert deg F (deg C)>**.
 - 3. Wet-Bulb Air Temperature at Discharge: **<Insert deg F (deg C)>**.
 - 4. Maximum Absorption Distance: **<Insert inches (mm)>**.
 - 5. Minimum Makeup Water Supply Pressure: **<Insert psig (kPa)>**.
 - 6. Electric-Resistance Evaporation Chamber:

- a. Power Input per Chamber: **<Insert number> kW.**
 - b. Number of Chambers: **<Insert number>.**
7. Steam Distribution Method - Atmospheric Distributer Tube:
 - a. Number of Distributer Tubes: **<Insert number>.**
8. Steam Distribution Method - Atmospheric Panel Distribution Manifold:
 - a. Number of Distribution Manifolds: **<Insert number>.**
9. Steam Distribution Method - Area Dispersion:
 - a. Number of Distributer Tubes: **<Insert number>.**
 - b. Fan Airflow: **<Insert cfm (L/s)>.**
 - c. Fan Motor Horsepower: **<Insert hp (watts)>.**
 - d. Fan Electrical Characteristics:
 - 1) Volts: **<Insert number> V.**
 - 2) Phase: **[Single][Three] phase.**
 - 3) Hertz: **[60]<Insert number> Hz.**
 - 4) Full-Load Amperes: **<Insert number> A.**
 - 5) Minimum Circuit Ampacity: **<Insert number> A.**
 - 6) Maximum Overcurrent Protection: **<Insert number> A.**
- D. Water Type: Suitable for use with **[tap][softened][reverse osmosis][deionized]** water.
- E. Immersion Heating:
 1. Evaporation Chamber: Cleanable, **[stainless steel][stainless steel, Type 304 or stainless steel, Type 316].**
 2. Elements: Incoloy-sheathed, stainless-steel sheathed, or alloy-sheathed aluminum.
- F. Cabinet:
 1. **[Stainless-steel][or][painted-steel]** enclosure[, **factory-insulated for safe operating surface temperature,**] for housing heater cylinder, electrical wiring, components, controls, and control panel.
 2. Hinged or removable cover, keyed to restrict unauthorized access.
 3. Plumbing and electrical components housed in separate parts of the cabinet.
 4. Threaded outlet in bottom of cabinet for drain piping.
- G. Weatherproof Outdoor Enclosure: **[Insulated, with automatically controlled heating and ventilating system to maintain minimum operating conditions within the enclosure.]**
- H. Control Panel:
 1. Microprocessor-based control system for **[modulating][cycling]** control.
 2. Factory-wired disconnect switch.
 3. Liquid-crystal display.
 4. Programmable keypad.
 5. Low-voltage control circuit, with fused transformer.
 6. Diagnostic, maintenance, alarm, and status features.
 7. Safety switch interlocked to shut off heaters when cabinet is open.
 8. Internal electrical controls prewired to appropriately marked terminals for field connection.

9. Electrical terminals for connection to each controlling device and alarm.
 10. NEMA 250, [Type 3R][Type 4][Type 4X][Type 12]<Insert type>, to comply with environmental conditions at installed locations.
 11. Material: [Galvanized][Powder-coated][Stainless] steel <Insert material>.
 12. Building Automation System Interface:
 - a. Full Communication Interface: [Modbus][BACnet][LonWorks]<Insert interface type>.
 - b. [Web-based remote factory online monitoring with same functionality as local keypad/display.]
- I. Controls:
1. Solenoid Fill Valve Maintains Water Level: [Stainless steel][Bronze], including fill tee with built-in air gap to prevent back siphoning. Include [stainless-steel][bronze] inlet strainer.
 2. Field-adjustable [timer][conductivity controller] to control drain cycle for flush duration and interval.[Automatic flush is not required for reverse osmosis or deionized water applications.]
 3. Controls shall drain tanks if no demand for humidification for more than 72 hours.
 4. Set-point adjustment.
 5. [Tri-conductivity sensor probes][Stainless-steel float switches] for water-level control.
 6. Low-water switch shuts down heater to protect elements.
 7. Over-temperature switch shuts down heater.
 8. Aquastat maintains minimum water temperature in tank during short periods of no demand.
 9. Foaming detection and correction.
- J. Area Dispersion Accessory: Stainless-steel tube, with integral fan that discharges vapor directly into occupied space. Designed for [remote mounting][integral mounting onto humidifier cabinet].
- K. Atmospheric Steam Distributer Tube(s): Single or multiple, atmospheric steam distributer tube extending across entire width of duct or plenum and equipped with mounting brackets on ends. Nozzles/metered orifices are spaced evenly along distributer tubes and provide dry and uniform steam distribution.
1. Material: [Stainless steel][Stainless steel, Type 304][Stainless steel, Type 316].
 2. Insulation: [Uninsulated][Insulated][Insulated, minimum R-0.5].
- L. Atmospheric Steam Panel Distribution Manifold:
1. Prefabricated steam dispersion grid assembly.
 2. Designed for short absorption distance.
 3. Suitable for atmospheric steam applications.
 4. Extending the full width and height of duct or plenum.
 5. [Horizontal][or][vertical] header with multiple [vertical][or][horizontal] tubes designed for dry steam injection within short absorption distance.
 6. Nozzles/metered orifices, spaced evenly along distribution tubes, provide dry and uniform steam distribution.
 7. Distribution panel extending the full width and height of duct or plenum.
 8. Headers and Distribution Tubes:
 - a. Material: [Stainless steel][Stainless steel, Type 304][Stainless steel, Type 316].
 - b. Insulation: [Uninsulated][Insulated][Insulated, minimum R-0.5].
 9. Steam Separator: Separators/baffles, integral to the header, provide condensate-free steam to distribution tubes.
- M. Accessories:



1. [Humidistat][Humidity Sensor]: [Wall][Return-duct] mounted.
2. Duct-mounted, high-limit [humidistat][humidity sensor].
3. Airflow switch prevents humidifier operation without airflow.
4. Steam and Condensate Hoses: For interconnection of humidifier to distributor tube(s)/manifold.

2.3 SELF-CONTAINED ELECTRODE HUMIDIFIERS

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

1. [Armstrong International, Inc]
2. [Carel USA, LLC]
3. [Carnes Company]
4. [DriSteem]
5. [Herrmidifier; a brand of Trion]
6. [Hygromatik; Spirax Sarco]
7. [Nortec Industries Inc.]
8. <Insert manufacturer's name>

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

1. [Armstrong International, Inc]
2. [Carel USA, LLC]
3. [Carnes Company]
4. [DriSteem]
5. [Herrmidifier; a brand of Trion]
6. [Hygromatik; Spirax Sarco]
7. [Nortec Industries Inc.]
8. <Insert manufacturer's name>

- C. Capacities and Characteristics:

1. Humidification Rate: <Insert lb/h (g/s)>.
2. Dry-Bulb Air Temperature at Discharge: <Insert deg F (deg C)>.
3. Wet-Bulb Air Temperature at Discharge: <Insert deg F (deg C)>.
4. Maximum Absorption Distance: <Insert inches (mm)>.
5. Minimum Makeup Water Supply Pressure: <Insert psig (kPa)>.
6. Electrode Cylinder:
 - a. Power Input Cylinder: <Insert number> kW.
 - b. Number of Cylinders: <Insert number>.
7. Steam Distribution Method - Atmospheric Distributer Tube:
 - a. Number of Distributer Tubes: <Insert number>.
8. Steam Distribution Method - Atmospheric Panel Distribution Manifold:
 - a. Number of Distribution Manifolds: <Insert number>.
9. Steam Distribution Method - Area Dispersion:

- a. Number of Distributer Tubes: <Insert number>.
 - b. Fan Airflow: <Insert cfm (L/s)>.
 - c. Fan Motor Horsepower: <Insert hp (watts)>.
 - d. Fan Electrical Characteristics:
 - 1) Volts: <Insert value> V.
 - 2) Phase: [Single][Three] phase.
 - 3) Hertz: [60]<Insert value> Hz.
 - 4) Full-Load Amperes: <Insert value> A.
 - 5) Minimum Circuit Ampacity: <Insert value> A.
 - 6) Maximum Overcurrent Protection: <Insert value> A.
- D. Water Type: Suitable for use with tap water.
- E. Cylinders: [Replaceable][or][cleanable] plastic humidifier water reservoir, steel electrode assembly, suitable for use with tap water.
- F. Cabinet:
1. [Baked-enamel][,][Powder-coated-steel][,][or][stainless-steel] enclosure houses heater cylinder, electrical wiring, components, controls, and control panel. **Cabinet is factory insulated for safe operating surface temperature.**
 2. Hinged or removable cover, keyed to restrict unauthorized access.
 3. Plumbing and electrical components housed in separate compartments of the cabinet.
 4. Threaded outlet in bottom of cabinet for drain piping.
- G. Weatherproof Outdoor Enclosure: Insulated, with automatically controlled heating and ventilating system to maintain minimum operating conditions within the enclosure.
- H. Control Panel:
1. Microprocessor-based control system for [modulating][cycling] control.
 2. Factory-wired disconnect switch.
 3. Liquid-crystal display.
 4. Programmable keypad.
 5. Low-voltage control circuit.
 6. Diagnostic, maintenance, alarm, and status features.
 7. Safety switch interlocked to shut off heaters when cabinet is open.
 8. Internal electrical controls prewired to appropriately marked terminals for field connection.
 9. Electrical terminals for connection to each controlling device and alarm.
 10. NEMA 250, [Type 3R][Type 4][Type 4X][Type 12]<Insert type>, to comply with environmental conditions at installed locations.
 11. Building Automation System Interface:
 - a. Full communication interface: [Modbus][BACnet][LonWorks]<Insert interface type>.
 - b. **[Web-based remote factory online monitoring with same functionality as local keypad/display.]**
- I. Controls:
1. Solenoid fill valve and automatic drain valve or drain pump maintain water level. Include bronze inlet strainer, bronze solenoid fill valve with flow regulator, bronze solenoid drain valve or drain pump, and fill tee with built-in air gap to prevent back siphoning.
 2. Controls shall drain tanks if no demand for humidification for more than 72 hours.
 3. Set-point adjustment.
 4. Electrode current shutdown upon sensing unsafe condition (e.g., drain system malfunction, fill

- system malfunction, or overcurrent malfunction).
- 5. Tri-conductivity sensor probes for water-level control.
- 6. Foaming detection and correction.

- J. Area Dispersion Accessory: Stainless-steel tube, with integral fan that discharges vapor directly into occupied space. Designed for **[remote mounting][integral mounting onto humidifier cabinet]**.
- K. Atmospheric Steam Distributer Tube(s): Single or multiple, atmospheric steam distributer tube extending across entire width of duct or plenum and equipped with mounting brackets on ends. Nozzles/metered orifices are spaced evenly along distributer tubes and provide dry and uniform steam distribution.
 - 1. Material: **[Stainless steel][Stainless steel, Type 304]**.
 - 2. Insulation: **[Uninsulated][Insulated][Insulated, minimum R-0.5]**.
- L. Atmospheric Steam Panel Distribution Manifold:
 - 1. Prefabricated steam dispersion grid assembly.
 - 2. Designed for short absorption distance.
 - 3. Suitable for atmospheric steam applications.
 - 4. Extending the full width and height of duct or plenum.
 - 5. **[Horizontal][or][vertical]** header with multiple **[vertical][or][horizontal]** tubes designed for dry steam injection within short absorption distance.
 - 6. Nozzles/metered orifices, spaced evenly along distribution tubes, provide dry and uniform steam distribution.
 - 7. Distribution panel extending the full width and height of duct or plenum.
 - 8. Headers and Distribution Tubes:
 - a. Material: **[Stainless steel][Stainless steel, Type 304]**.
 - b. Insulation: **[Uninsulated][Insulated][Insulated, minimum R-0.5]**.
 - 9. Steam Separator: Separators/baffles, integral to the header, provide condensate-free steam to distribution tubes.
- M. Accessories:
 - 1. **[Humidistat][Humidity Sensor]: [Wall][Return-duct]** mounted.
 - 2. Duct-mounted, high-limit **[humidistat][humidity sensor]**.
 - 3. Airflow switch prevents humidifier operation without airflow.
 - 4. Steam and Condensate Hoses: For interconnection of humidifier to distributer tube(s)/manifold.

2.4 SELF-CONTAINED GAS-FIRED HUMIDIFIERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Armstrong International, Inc]**
 - 2. **[Carel USA, LLC]**
 - 3. **[DriSteem]**
 - 4. **[Neptronic; National Environmental Products, Inc.]**
 - 5. **[Nortec Industries Inc.]**
 - 6. **[Pure Humidifier Company]**
 - 7. **<Insert manufacturer's name>**

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

1. **[Armstrong International, Inc]**
2. **[Carel USA, LLC]**
3. **[DriSteem]**
4. **[Neptronic; National Environmental Products, Inc.]**
5. **[Nortec Industries Inc.]**
6. **[Pure Humidifier Company]**
7. **<Insert manufacturer's name>**

C. Capacities and Characteristics:

1. Humidification Rate: **<Insert lb/h (g/s)>**.
2. Dry-Bulb Air Temperature at Discharge: **<Insert deg F (deg C)>**.
3. Wet-Bulb Air Temperature at Discharge: **<Insert deg F (deg C)>**.
4. Maximum Absorption Distance: **<Insert inches (mm)>**.
5. Minimum Makeup Water Supply Pressure: **<Insert psig (kPa)>**.
6. Gas-Fired Generator:
 - a. Fuel Input: **<Insert Btu/h (kW)>**.
 - b. Fuel Pressure: **<Insert inches wg (kPa)>**.
7. Steam Distribution Method - Atmospheric Distributer Tube:
 - a. Number of Distributer Tubes: **<Insert number>**.
8. Steam Distribution Method - Atmospheric Panel Distribution Manifold:
 - a. Number of Distribution Manifolds: **<Insert number>**.
9. Steam Distribution Method - Area Dispersion:
 - a. Number of Distributer Tubes: **<Insert number>**.
 - b. Fan Airflow: **<Insert cfm (L/s)>**.
 - c. Fan Motor Horsepower: **<Insert HP (watts)>**.
 - d. Fan Electrical Characteristics:
 - 1) Volts: **<Insert number> V**.
 - 2) Phase: **[Single][Three]<Insert value> phase**.
 - 3) Hertz: **[60]<Insert number> Hz**.
 - 4) Full-Load Amperes: **<Insert number> A**.
 - 5) Minimum Circuit Ampacity: **<Insert number> A**.
 - 6) Maximum Overcurrent Protection: **<Insert number> A**.

D. Water Type: Suitable for use with **[tap][softened][reverse osmosis][deionized]** water.

E. Burner and Heat Exchanger:

1. Description: Produces atmospheric steam.
2. Burner Type: **[Natural-gas][Propane]** fired with modulating, low-NOx infrared burner, minimum **[80]<Insert number>** percent efficient.
3. Gas Train: Safety shutoff valves, gas cock, strainer, and pressure-regulating valve.
4. Ignition: Hot-surface ignition with flame safety system.
5. Combustion Chamber: Sealed with outdoor-air and flue-vent connections.
6. Heat-Exchanger Tank: Cleanable, **[stainless steel][stainless steel, Type 304][stainless steel,**

Type 316] with corrosion-resistant coating.

F. Cabinet:

1. **[Painted-steel][,][Powder-coated-steel][,][Painted-aluminum][,][or][stainless-steel]** enclosure.**[Cabinet is factory insulated for safe operating surface temperature.]**
2. Enclosure houses internal components, controls, and control panel.
3. Hinged or removable cover, keyed to restrict unauthorized access.
4. Weatherproof outdoor enclosure, with automatically controlled heating and ventilating system to maintain minimum operating conditions within the enclosure.

G. Control Panel:

1. Microprocessor-based control system for **[modulating][cycling]** control.
2. Factory-wired disconnect switch.
3. Liquid-crystal display.
4. Programmable keypad.
5. Low-voltage control circuit.
6. Diagnostic, maintenance, alarm, and status features.
7. Internal electrical controls prewired to appropriately marked terminals for field connection.
8. Electrical terminals for connection to each controlling device and alarm.
9. NEMA 250, **[Type 3R][Type 4][Type 12]<Insert type>**, to comply with environmental conditions at installed location.
10. Building Automation System Interface:
 - a. Full Communication System Interface: **[BACnet]<Insert interface type>**.
 - b. **[Web-based remote factory online monitoring with same functionality as local keypad/display.]**

H. Controls:

1. Solenoid fill valve and automatic drain valves maintain water level. Include **[stainless-steel][bronze]** inlet strainer, **[stainless-steel][bronze]** solenoid valve with flow regulator, and fill tee with built-in air gap to prevent back siphoning.
2. Field-adjustable **[timer][conductivity controller]** to control drain/fill cycle for flush duration and interval.**[Automatic flush is not required for reverse osmosis or deionized water applications.]**
3. Controls shall drain tanks if no demand for humidification for more than 72 hours.
4. Set-point adjustment.
5. **[Tri-conductivity sensor probes][Float switches]** for water-level control and to shutdown heat exchanger upon low-water condition.
6. Over-temperature heater shutdown.
7. Aquastat maintains minimum water temperature in tank during short periods of no demand.
8. Thermal safety switch monitors stack temperature for shutdown on overheating.
9. Foaming detection and correction.

I. Area Dispersion Accessory: Stainless-steel tube with integral fan that discharges vapor directly into occupied space.

J. Atmospheric Steam Distributer Tube(s): Single or multiple, atmospheric steam distributer tube extending across entire width of duct or plenum and equipped with mounting brackets on ends. Nozzles/metered orifices are spaced evenly along distributer tubes and provide dry and uniform steam distribution.

1. Material: **[Stainless steel][Stainless steel, Type 304][Stainless steel, Type 316]**.
2. Insulation: **[Uninsulated][Insulated][Insulated, minimum R-0.5]**.

K. Atmospheric Panel Steam Distribution Manifold:

1. Prefabricated steam dispersion grid assembly.
2. Designed for short absorption distance.
3. Suitable for atmospheric steam applications.
4. Extending the full width and height of duct or plenum.
5. **[Horizontal][or][vertical]** header with multiple **[vertical][or][horizontal]** tubes designed for dry steam injection within short absorption distance.
6. Nozzles/metered orifices, spaced evenly along distribution tubes, and provide dry and uniform steam distribution.
7. Distribution panel extending the full width and height of duct or plenum.
8. Headers and Distribution Tubes:
 - a. Material: **[Stainless steel][Stainless steel, Type 304][Stainless steel, Type 316]**.
 - b. Insulation: **[Uninsulated][Insulated][Insulated, minimum R-0.5]**.
9. Steam Separator: Separators/baffles, integral to the header, provide condensate-free steam to distribution tubes.

L. Accessories:

1. **[Humidistat][Humidity Sensor]: [Wall][Return-duct]** mounted.
2. Duct-mounted, high-limit **[humidistat][humidity sensor]**.
3. Airflow switch prevents humidifier operation without airflow.
4. Steam and Condensate Hoses: For interconnection of humidifier to distributor tube(s)/manifold.

2.5 CONDENSATE DRAIN COOLERS

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

1. **[Armstrong International, Inc]**
2. **[DriSteem]**
3. **[Neptonic; National Environmental Products, Inc.]**
4. **[Nortec Industries Inc.]**
5. **[Pure Humidifier Company]**
6. **<Insert manufacturer's name>**

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

1. **[Armstrong International, Inc]**
2. **[DriSteem]**
3. **[Neptonic; National Environmental Products, Inc.]**
4. **[Nortec Industries Inc.]**
5. **[Pure Humidifier Company]**
6. **<Insert manufacturer's name>**

C. Capacities and Characteristics:

1. Hot Condensate in: **<Insert gpm (L/s)>**.
2. Hot Condensate Temperature: **<Insert deg F (deg C)>**.
3. Cold Water in **<Insert gpm (L/s)>**.
4. Cold Water Temperature: **<Insert de F (deg C)>**.

5. Tempered Water out <Insert gpm (L/s)>.
6. Tempered Water Temperature: <Insert deg F (deg C)>.
- D. Description: Mixes hot condensate with a cold water supply to reduce the drain temperature as required by state and local codes.
- E. Cold Water Tempering Valve: Bronze body, **[thermostatic self-actuated with aquastat][24 VAC electric-actuated with temperature sensor]**.
- F. Drain Temperature Set-Point Range: Field adjustable between **115 deg F (46 deg C)** and **140 deg F (60 deg C)**. Drain sensor to control cold water tempering valve to limit drain discharge temperature to set point.
- G. Reservoir Body Material: **[Stainless steel][Cast iron or carbon steel][Stainless steel, Type 304][Stainless steel, Type 316]**.
- H. Mounting: Suitable for **[wall][floor][suspended]** mounting.
- I. Vacuum breaker or air vent connection.
- J. Condensate drain cooler built into the humidifier cabinet and offered as the humidifier manufacturer's standard product is acceptable in lieu of a separate product by the listed manufacturers.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine ducts, air-handling units, and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Examine roughing-in for piping systems to verify actual locations of piping connections before humidifier installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install humidifiers with required clearance for service and maintenance. **[Maintain path, downstream from humidifiers, clear of obstructions as required by ASHRAE 62.1.]**
- B. Seal all duct and plenum penetrations with flange.
- C. Install humidifier assemblies in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."
- D. Install **[galvanized][stainless]**-steel drain pan under each manifold mounted in duct.
 1. Construct drain pans with connection for drain; insulated **[and complying with ASHRAE 62.1]**.
 2. Connect to condensate trap and drainage piping.
 3. Extend drain pan upstream and downstream from tube(s)/manifold a minimum distance recommended by manufacturer but not less than required by ASHRAE 62.1.

- E. Install tube(s)/manifold supply piping pitched to drain condensate back to humidifier or as recommended by manufacturer.
- F. Equipment Mounting:
 - 1. Install floor-mounted humidifiers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- G. Install gas-fired steam generators according to NFPA 54.
- H. Install all manufacturer-furnished accessories in accordance with manufacturer's written installation instructions.

3.3 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
 - 1. Install piping adjacent to humidifiers to allow service and maintenance.
 - 2. Install shutoff valve, strainer, backflow preventer, and union in humidifier makeup line.
- B. Install piping specialties furnished by manufacturer but not factory mounted.
- C. Install piping from safety relief valves to nearest floor drain.
- D. Connect gas piping full size to steam-generator, gas-train inlet with union. Gas piping materials and specialties are specified in **[Section 231123 "Facility Natural-Gas Piping."][Section 231126 "Facility Liquefied-Petroleum Gas Piping."]**
- E. Connect breeching full size to steam-generator outlet. Venting materials are specified in Section 235123 "Gas Vents."
- F. Connect combustion-air inlet to intake terminal using PVC piping with solvent-cemented joints. Run from boiler connection to outside and terminate adjacent to flue termination.

3.4 ELECTRICAL CONNECTIONS

- A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch (13 mm)** high.

3. Locate nameplate where easily visible.

3.5 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring between control devices.
- C. Connect control wiring according to Section 260523 "Control Voltage Electrical Power Cables."

3.6 FIELD QUALITY CONTROL

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

3.7 DEMONSTRATION

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

END OF SECTION 23 84 13 29



23 - Heating, Ventilating, and Air-Conditioning (HVAC)

Task	Specification	Specification Description
23 84 13 29	23 84 13 00	Heat Exchanger Humidifiers



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SECTION 23 84 16 16 - INDOOR, MECHANICAL DEHUMIDIFICATION UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Indoor, mechanical dehumidification units.

1.2 ACTION SUBMITTALS

A. Product Data:

1. For each type of product.
 - a. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Sustainable Design Submittals:

1. Product Data: For energy performance.
2. Product Data: Showing compliance with ASHRAE 62.1.
3. Product Data: For adhesives, indicating VOC content.
4. Laboratory Test Reports: For insulation, indicating compliance with the VOC emissions evaluation.
5. Laboratory Test Reports: For insulation, indicating compliance with requirements for low-emitting materials.
6. Refrigerant: Product Data for refrigerants, indicating compliance with refrigerant management practices.
7. Product Data: Provide the following:
 - a. Manufacturer cut sheet indicating water consumption.
 - b. WaterSense certification for residential fixtures, commercial water closets, commercial urinals, and commercial showers.

C. Shop Drawings: For each indoor, mechanical dehumidification unit.

1. Include plans, elevations, sections and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of dehumidification units.
4. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
5. Include diagrams for power, signal, and control wiring.

D. Delegated Design Submittals: For indoor, mechanical dehumidification units.

1. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to

structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

2. Include design calculations for selecting vibration isolators[**and seismic restraints**] and for designing vibration isolation bases.

1.3 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Data: Certificates for indoor, mechanical dehumidification units, accessories, and components, from manufacturer.
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- B. Product Test Reports: For each indoor, mechanical dehumidification unit, for tests performed by a qualified testing agency.
- C. Field quality-control reports.
- D. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For dehumidification units to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Filters: [**One**]<Insert number> set(s) of each type of filter specified.
 2. Fan Belts: [**One**]<Insert number> set(s) for each belt-drive fan.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An NRTL.

1.7 COORDINATION

- A. Coordinate sizes and locations of concrete bases. Cast anchor-bolt inserts into bases.
- B. Coordinate installation of roof curbs, equipment supports, and roof penetrations.



1.8 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of indoor, mechanical dehumidification units that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Compressors: Manufacturer's standard, but not less than **[two][five]<Insert number>** years from date of Substantial Completion.
 - 2. Warranty Period for Refrigerant Coils: Manufacturer's standard, but not less than **[five]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Seismic Performance: Dehumidification units are to withstand the effects of earthquake motions determined according to **[ASCE/SEI 7]<Insert requirement>**.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified**[and the unit will be fully operational after the seismic event].**"
 - 2. Component Importance Factor: **[1.5][1.0]**.
 - 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.
- C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.
- D. ASHRAE 62.1 Compliance: Section 5, "Systems and Equipment" and Section 7, "Construction and System Start-up."
- E. ASHRAE 15 Compliance: "Safety Standard for Refrigeration Systems."
- F. Capacities and Characteristics:
 - 1. Airflow through Unit:
 - a. Supply Air: **<Insert cfm (L/s)>**.
 - b. Outside Air: **<Insert cfm (L/s)>**.
 - c. Exhaust/Return Air: **<Insert cfm (L/s)>**.
 - 2. Supply Fan:
 - a. Speed: **<Insert number>** rpm.
 - b. External Static Pressure: **<Insert inches wg (kPa)>**.
 - c. Motor Size: **<Insert number>** hp.
 - 3. Exhaust and Return Fan:
 - a. External Static Pressure: **<Insert inches wg (kPa)>**.
 - b. Speed: **<Insert number>** rpm.
 - c. Motor Size: **<Insert number>** hp.

4. Refrigeration System:
 - a. Sensible Heat-Transfer Rate: **<Insert Btu/h (kW)>**.
 - b. Total Heat-Transfer Rate: **<Insert Btu/h (kW)>**.
 - c. Energy-Efficiency Ratio: **<Insert number>**.
 - d. Dehumidification Capacity: **<Insert lb of water/h (kg/h)>**.
 - e. Evaporator Coil Conditions:
 - 1) Entering-Air, Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
 - 2) Entering-Air, Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
 - 3) Entering-Air, Dew-Point Temperature: **<Insert deg F (deg C)>**.
 - 4) Leaving-Air, Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
 - 5) Leaving-Air, Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
 - 6) Leaving-Air, Dew-Point Temperature: **<Insert deg F (deg C)>**.
5. Energy Recovery Heat Exchanger (Pool Heater):
 - a. Water Flow Rate: **<Insert gpm (L/s)>**.
 - b. Water Pressure Loss: **<Insert feet of head (kPa)>**.
 - c. Entering-Water Temperature: **<Insert deg F (deg C)>**.
 - d. Leaving-Water Temperature: **<Insert deg F (deg C)>**.
6. Filters:
 - a. Thickness or Depth: **<Insert inches (mm)>**.
7. Hydronic Heating Coil:
 - a. Heat-Transfer Rate: **<Insert Btu/h (kW)>**.
 - b. Entering-Air Temperature: **<Insert deg F (deg C)>**.
 - c. Leaving-Air Temperature: **<Insert deg F (deg C)>**.
 - d. Water:
 - 1) Water Flow: **<Insert gpm (L/s)>**.
 - 2) Maximum Water Pressure Drop: **<Insert feet of head (kPa)>**.
 - 3) Entering-Water Temperature: **<Insert deg F (deg C)>**.
 - 4) Leaving-Water Temperature: **<Insert deg F (deg C)>**.
8. Steam Heating Coil:
 - a. Steam Flow: **<Insert lb/h (g/s)>**.
 - b. Inlet Steam Pressure: **<Insert psig (kPa)>**.
9. Electric Heating Coil:
 - a. kW: **<Insert number> kW**.
 - b. Volts: **[120][208][230]<Insert number> V ac**.
 - c. Phase: **[Single][Three] Ph**.
 - d. Hertz: **[60]<Insert number> Hz**.
 - e. Full-Load Amperes: **<Insert number> A**.
 - f. Number of Steps: **<Insert number>**.
10. Electrical Characteristics:
 - a. Volts: **[120][208][230]<Insert number> V ac**.

- b. Phase: **[Single][Three]** phase.
- c. Hertz: **[60]<Insert number>** Hz.
- d. Full-Load Amperes: **<Insert number>** A.
- e. Minimum Circuit Ampacity: **<Insert number>** A.
- f. Maximum Overcurrent Protection: **<Insert number>** A.

2.2 INDOOR, MECHANICAL DEHUMIDIFICATION UNITS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Dectron Internationale]**
 - 2. **[Dehumidifier Corporation of America]**
 - 3. **[Desert Aire]**
 - 4. **[DryAire Systems]**
 - 5. **[MSP Technology, LLC]**
 - 6. **[PoolPak Technologies Corporation]**
 - 7. **[Thermoplus Air Inc]**
 - 8. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Dectron Internationale]**
 - 2. **[Dehumidifier Corporation of America]**
 - 3. **[Desert Aire]**
 - 4. **[DryAire Systems]**
 - 5. **[MSP Technology, LLC]**
 - 6. **[PoolPak Technologies Corporation]**
 - 7. **[Thermoplus Air Inc]**
 - 8. **<Insert manufacturer's name>**
- C. Casings:
 - 1. Casing: **[Single][Double]**-wall construction with **[interior corrosion-resistant coating and exterior [baked-enamel][powder-coated]]** steel or aluminum, stainless steel fasteners, knockouts for electrical and piping connections, condensate drain connection, and lifting lugs.
 - a. Access: **[Removable panels][Hinged access doors]** with neoprene compression gaskets and cam latches.
 - b. Insulation: Minimum **2-inch- (50-mm-)** thick, glass-fiber-insulation fill or closed cell foam, with thermal breaks.
 - c. Airstream Surfaces: Surfaces in contact with the airstream are to comply with requirements in ASHRAE 62.1.
 - 2. Drain Pan and Connection: **[Stainless steel]<Insert material>**; insulated**[and complying with ASHRAE 62.1]**.
- D. Fans:
 - 1. Supply Fans:
 - a. Blades: **[Forward curved][Backward inclined]**.
 - b. Type: **[Housed][Unhoused plenum type]**, centrifugal.



- c. Blade and Housing Material: Galvanized steel with **[baked-enamel][powder-coated]** finish.
 - d. Drive: **[Direct-driven with keyed motor shaft][Belt-driven with adjustable sheaves and self-aligning, grease-lubricated ball bearings, with extended grease fittings easily accessible inside the casing of the dehumidification unit].**
2. Exhaust and Return Fans:
- a. Blades: **[Forward curved][Backward inclined].**
 - b. Type: **[Housed][Unhoused plenum type]**, centrifugal.
 - c. Blade and Housing Material: Galvanized steel with **[baked-enamel][powder-coated]** finish.
 - d. Drive: **[Direct-driven with keyed motor shaft][Belt-driven with adjustable sheaves and self-aligning, grease-lubricated ball bearings, with extended grease fittings easily accessible inside the casing of the dehumidification unit].**
3. Fan Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
- a. Enclosure Type: Totally enclosed, fan cooled.
4. Variable-frequency motor controller complies with Section 262923 "Variable-Frequency Motor Controllers."
5. Variable-Frequency Motor Controller:
- a. Manufactured Units: Pulse-width modulated; **[constant torque][and][variable torque]<Insert application>** for **[Design A and Design B motors][inverter-duty motors].**
 - b. Output Rating: Three phase; 10 to **[60 Hz, with voltage proportional to frequency throughout voltage range][66 Hz, with torque constant as speed changes]**; maximum voltage equals input voltage.
 - c. Unit Operating Requirements:
 - 1) Internal Adjustability:
 - a) Minimum Speed: 5 to 25 percent of maximum rpm.
 - b) Maximum Speed: 80 to 100 percent of maximum rpm.
 - c) Acceleration: **[0.1 to 999.9]<Insert range>** seconds.
 - d) Deceleration: **[0.1 to 999.9]<Insert range>** seconds.
 - e) Current Limit: 30 to minimum of 150 percent of maximum rating.
 - 2) Self-Protection and Reliability Features:
 - a) Surge suppression.
 - b) Loss of input signal protection.
 - c) Under- and overvoltage trips.
 - d) Variable-frequency controller and motor-overload/overtemperature protection.
 - e) Critical frequency rejection.
 - f) Loss-of-phase protection.
 - g) Reverse-phase protection.
 - h) Motor-temperature fault.
 - 3) Bidirectional autospeed search.
 - 4) Torque boost.
 - 5) Motor temperature compensation at slow speeds.

- a) Panel-mounted operator station.
 - b) Historical logging information and displays.
 - c) Digital indicating devices.
 - 6) Control Signal Interfaces: **[Electric][Pneumatic]**.
 - 7) Proportional-integral-derivative control interface.
 - 8) DDC system for HVAC Protocols for Network Communications: **[ASHRAE 135]<Insert protocol type>**.
 - d. Line Conditioning:
 - 1) Input line conditioning.
 - 2) Output filtering.
 - 3) EMI/RFI filtering.
 - e. Bypass Systems:
 - 1) Bypass Mode: **[Manual operation only][Field-selectable automatic or manual]**.
 - 2) Bypass Controller:
 - a) Two-contactor style, with bypass and output isolating contactors[**and isolating switch**].
 - b) Three-contactor style, with bypass and input and output isolating contactors[**and isolating switch**].
 - 3) Bypass Contactor Configuration: **[Full-voltage (across the line)][Reduced-voltage (autotransformer)]<Insert type>** type.
- E. Filters:
- 1. Pleated:
 - a. Thickness: **[1 inch (25 mm)][2 inches (50 mm)][4 inches (100 mm)][Manufacturer's standard depth]**.
 - b. MERV Rating: **[MERV 6][MERV 13]<Insert value>**, according to ASHRAE 52.2.
- F. Refrigeration System:
- 1. Energy Efficiency: Equal to or greater than prescribed by ASHRAE/IES 90.1.
 - 2. Refrigerant Coils with Multiple Refrigerant Circuits:
 - a. Tubes: **[Copper]<Insert material>**.
 - b. Fins:
 - 1) Material: **[Aluminum][Copper]<Insert material>**.
 - 2) Fin Spacing: Maximum **[12][10][8]<Insert number>** fins per inch (mm).
 - c. Fin and Tube Joints: Mechanical bond.
 - d. Headers: **[Seamless-copper headers with brazed connections]<Insert material and connections>**.
 - e. Frames: **[Galvanized-steel][Stainless steel]<Insert material>** frame.
 - f. Coatings: **[None][Corrosion-resistant coating]**.
 - g. Ratings: Designed, tested, and rated according to ASHRAE 33 and AHRI 410.
 - h. Source Quality Control: Factory test to minimum **450-psig (3105-kPa)** internal pressure and to minimum **300-psig (2070-kPa)** internal pressure while underwater.

3. Compressors: Hermetic, scroll compressors with integral vibration isolators and crankcase heaters that de-energize during compressor operation; with thermal-expansion valves, filter-dryers, sight glasses, compressor service valves, and liquid- and suction-line service valves.
 - a. Minimum Number of Refrigerant Circuits: Two for compressor capacities of more than 7-1/2 tons (26.4 kW).
 - b. Refrigerant: **[R-134a][R-407C][R-410A][R-134a, R-407C, or R-401A]**.
 - c. Capacity Control:
 - 1) Hot-gas bypass valve and piping on one compressor.
 - 2) Cycle compressor.
 - d. Low-Pressure Cutout: Manual reset after three automatic-reset failures.
 - e. High-Pressure Cutout: Manual reset.
 - f. Compressor Motor Overload Protection: Manual reset.
 - g. Antirecycling Timing Device: Prevent compressor restart for five minutes after shutdown.
 - h. Defrost Cycle: Adjustable timer shuts off supply fan. Compressor cycles until suction-line temperature confirms thawed evaporator coil. **[Timer limits defrost time to 10 minutes.]**
 - i. **<Insert additional control features>**.
4. Energy Recovery Heat Exchanger (Pool Heater): Cupronickel, coaxial, vented, double-wall construction for potable-water service.

G. Remote-Mounted, Air-Cooled Condenser Unit:

1. Casing: Steel, **[baked-enamel]<Insert finish type>** finish; with access doors or removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
2. Refrigerant Coil:
 - a. Copper tube with mechanically bonded aluminum fins; with liquid subcooler.
 - b. Coating: **[None][Corrosion-resistant coating]**.
3. Fan: Aluminum-propeller type, directly connected to permanently lubricated motor with integral thermal-overload protection.
4. Adjustable, Low Ambient Head-Pressure Control: Designed to operate at temperatures as low as **0 deg F (minus 18 deg C)** by cycling condenser fans and controlling speed of last fan of each circuit.
5. Mounting Base: **[Same material as unit base]<Insert material>**.

H. Heating Coils:

1. Hot-Water Coil: Continuous circuit coil.
 - a. Tubes: **[Copper]<Insert material>**.
 - b. Fins:
 - 1) Material: **[Aluminum][Copper]<Insert material>**.
 - 2) Fin Spacing: Maximum **[12][10][8]<Insert number>** fins per inch (mm).
 - c. Fin and Tube Joints: Mechanical bond.
 - d. Headers: **[Cast iron]<Insert material>** with drain and air vent tappings.
 - e. Frames: **[Galvanized-steel channel, minimum 0.052 inch (1.3 mm)]<Insert material>**.
 - f. Coatings: **[None][Corrosion-resistant coating]**.
 - g. Ratings: Designed, tested, and rated according to ASHRAE 33 and AHRI 410.

- 1) Working-Pressure Ratings: Minimum **200 psig (1380 kPa)**, **325 deg F (163 deg C)**.
- h. Source Quality Control: Test to minimum **300 psig (2070 kPa)** internal pressure.
2. Steam Coil: Distribution header coil fabricated according to AHRI 410, with threaded steam supply and condensate connections.
 - a. Tubes: **[Copper]<Insert material>**.
 - b. Fins:
 - 1) Material: **[Aluminum][Copper]<Insert material>**.
 - 2) Fin Spacing: Maximum **[12][10][8]<Insert number>** fins per **inch (mm)**.
 - c. Fin and Tube Joints: Mechanical bond.
 - d. Headers: **[Cast iron]<Insert material>** with drain and air vent tappings.
 - e. Frames: **[Galvanized-steel channel, minimum 0.052 inch (1.3 mm)]<Insert material>**.
 - f. Coatings: **[None][Corrosion-resistant coating]**.
 - g. Ratings: Designed, tested, and rated according to ASHRAE 33 and AHRI 410.
 - 1) Working-Pressure Ratings: Minimum **100 psig (690 kPa)**, **400 deg F (205 deg C)**.
 - h. Source Quality Control: Test to **200-psig (1380-kPa)**.
3. Electric-Resistance Heating Coil: Comply with UL 1995.
 - a. Heating Element:
 - 1) Coiled resistance wire of 80 percent nickel and 20 percent chromium; surrounded by compacted magnesium oxide powder in tubular-steel sheath; with spiral-wound, copper-plated steel fins continuously brazed to sheath.
 - 2) Open-coil resistance wire of 80 percent nickel and 20 percent chromium; supported and insulated by floating ceramic bushings recessed into casing openings; fastened to supporting brackets and mounted in galvanized-steel frame.
 - b. Coatings: **[None][Corrosion-resistant coating]**.
 - c. Overtemperature Protection: Disk-type, automatic-reset, thermal-cutout safety device; serviceable through terminal box without removing heater from unit.
 - d. Thermal Cutouts: Load carrying, manual reset or replaceable, and factory wired in series with each heater stage.
 - e. Control: Disconnecting means, overcurrent protection, and airflow proving switch.
- I. Dampers:
 1. Outdoor-Air Dampers: Opposed-blade, **[galvanized-steel][aluminum][extruded-aluminum]<Insert material>** dampers with **[zinc-plated-steel]<Insert material>** operating rod rotating in sintered bronze or nylon bearings. Provide blade gaskets and edge seals, and mechanically fasten blades to operating rod. Size for 0 to 25 percent outdoor air, with **[manual][motorized]** operator and filter.
 2. Face-and-Bypass Dampers: Opposed-blade, **[galvanized-steel][aluminum][extruded-aluminum]** dampers with **[zinc-plated-steel]<Insert material>** operating rods rotating in sintered bronze or nylon bearings with operating rods connected with a common linkage. Provide blade gaskets and edge seals, and mechanically fasten blades to operating rod.
 3. Standard Duty Dampers: **[Outdoor and return air][Outdoor, return, and exhaust air]**.
 - a. Parallel-blade, **[galvanized-steel][aluminum][extruded-aluminum]<Insert material>** dampers.

- b. Mechanically fastened to **[zinc-plated-steel]<Insert material>** operating rod in reinforced cabinet.
 - c. Connect operating rods with common linkage and interconnect linkages, so dampers operate simultaneously.
4. Low-Leakage Dampers: **[Outdoor and return air][Outdoor, return, and exhaust air]**.
- a. Low-leakage, double-skin, airfoil-blade, **[galvanized-steel][aluminum][extruded-aluminum]<Insert material>** dampers.
 - b. Compressible jamb seals and extruded-vinyl blade edge seals in **[opposed][parallel]**-blade arrangement.
 - c. **[Zinc-plated-steel]<Insert material>** operating rods rotating in **[stainless steel sleeve][sintered bronze or nylon]<Insert material>** bearings mounted in a single **[galvanized-steel][aluminum][extruded-aluminum]<Insert material>** frame.
 - d. Operating rods connected with a common linkage.
 - e. Leakage rate is not to exceed **5 cfm/sq. ft. (0.22 L/s per sq. m) at 1-inch wg (250 Pa) and 9 cfm/sq. ft. (0.4 L/s per sq. m) at 4-inch wg (1.0 MPa)**.
5. Damper Operator: **[115][24]** V ac, close coupled, with gear train sealed in oil and with spring return.
- J. Controls:
- 1. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC" for control equipment and in Section 230993.11 "Sequence of Operations for HVAC DDC."
 - 2. Control Panel: Integral service compartment containing fan-motor thermal and overload cutouts, compressor thermal and overload cutouts, 115-V control transformer if required, magnetic contactors for fan and compressor motors, and a nonfused factory-mounted and -wired disconnect switch for single external electrical power connection.
 - 3. Interface with DDC System for HVAC: Factory-installed hardware and software to enable the DDC system for HVAC to monitor, control, and display status and alarms.
 - 4. Operating Control, Ice Rinks: Space humidistat cycles the compressor. Humidistat is to incorporate fan on-off-auto switch.
 - 5. Operating Control, Indoor Pool Units: Factory-installed microprocessor controller, capable of being remotely mounted.
 - a. Display the following on the face of controller:
 - 1) System on.
 - 2) System dehumidifying mode.
 - 3) System air-conditioning mode.
 - 4) System outdoor-air (economizer) mode.
 - 5) System heating pool water.
 - 6) Auxiliary space heat is operating.
 - 7) Unit requires service.
 - 8) Return-air (space) temperature.
 - 9) Return-air (space) humidity.
 - 10) Pool-water temperature.
 - 11) Outdoor-air temperature.
 - b. Indicate the following sensor failures on panel:
 - 1) Airflow: Dirty air filter, blocked airflow, and fan failure.
 - 2) Refrigerant high and low pressure.
 - 3) High water temperature.

- 4) High and low evaporator temperature.
 - 5) Low water flow.
 - 6) Communication fault.
 - 7) System off.
 - 8) Antishort cycle delay.
 - 9) Power failure.
 - c. Provide access to the following set points on panel:
 - 1) Space temperature.
 - 2) Space relative humidity.
 - 3) Outdoor ventilation/air-conditioning changeover temperature.
 - 4) Airflow alarm.
 - d. Provide the following displays on panel:
 - 1) Space temperature.
 - 2) Space relative humidity.
 - 3) Outdoor-air temperature.
 - 4) Supply-air temperature.
 - 5) Return-air temperature.
 - 6) Airflow rating.
 - 7) Air-off evaporator temperature.
 - 8) Return-air relative humidity.
 - 9) Service codes.
 - e. Provide the following controls on panel:
 - 1) System on-off, fan continues to run.
 - 2) Fan on-off.
 - 3) Service code access.
 - 4) System dehumidifying mode.
 - 5) System air-conditioning mode.
 - 6) System outdoor-air (economizer) mode.
 - 7) Auxiliary space heat is operating.
 - 8) Outdoor-air-temperature, conditioned-space-temperature, and control set-point-temperature digital display.
 - 9) Outdoor enthalpy digital display.
 - 10) Filter pressure drop digital display.
 - 11) Status: Airflow, fans, system, unit operation, and operating mode.
 - 12) Alarm digital display.
6. Operating Control, Factory-Installed Microprocessor Controller:
 - a. Factory-installed operator panel with backlit display, capable of being remotely mounted, allows menu-driven display for navigation and control of unit.
 - b. Integral clock.
 - c. Personal computer interface.
 - d. Integral LAN for direct connection to **[BACnet][LonWorks][MODBUS]<Insert other communication protocol>**.
 - e. Factory programmed.
 - f. Unit-Mounted Sensors:
 - 1) Airflow switch.
 - 2) Compressor-discharge temperature.
 - 3) Evaporator-air temperature.

- 4) Pool-water-out temperature.
 - 5) Pool-water-in temperature.
 - 6) Relative humidity.
 - 7) Return-air temperature.
 - 8) Supply-air temperature.
 - g. Integral diagnostics.
 - h. Nonvolatile memory.
 - i. IP or SI display.
 - j. Provide the following status and alarm functions:
 - 1) System: On-off.
 - 2) Power failure.
 - 3) Fan: Off, overload.
 - 4) Compressor: On, turned off, overload, high pressure, low pressure, overheat, oil failure, and pumpdown.
 - 5) Evaporator damper closed.
 - 6) Pool: Low water flow, heating on.
 - 7) Dehumidification: Call for, on.
 - 8) Air Conditioning: Call for, on.
 - 9) System outdoor-air (economizer) mode.
 - 10) Auxiliary space heat on.
 - 11) Alarms: Firestat, freezestat, and filters.
 - k. Provide the following controls via operator panel:
 - 1) Compressor auto-off.
 - 2) Fan auto-off.
 - 3) Set-Point Adjustments: Relative humidity, temperatures, deadbands, and differentials.
 - 4) Sensor calibration.
- K. Accessories:
 1. Water-Cooling Heat Exchanger: Coaxial, vented, double-wall construction; with three-way refrigerant control valve.
 2. Smoke Detectors: Photoelectric detector located in return-air plenum, to de-energize unit.
 - a. Operating Voltage: 24 V dc, nominal.
 - b. Self-Restoring: Detectors do not require resetting or readjusting after actuation to restore them to normal operation.
 - c. Plug-in Arrangement: Detector and associated electronic components mounted in module with tamper-resistant connection to fixed base with twist-locking plug. Terminals in fixed base accept building wiring.
 - d. Integral Visual-Indicating Light: Digital-display type indicating detector operation.
 - e. Sensitivity can be tested and adjusted in-place after installation.
 - f. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the fire-alarm control panel.
 - g. Sensor: Digital display or infrared light source with matching silicon-cell receiver.
 - h. Detector Sensitivity: Between **2.5 and 3.5 percent/foot (0.008 and 0.011 percent/mm)** of smoke obscuration when tested according to UL 268A.
 - i. Integral Thermal Detector: Fixed-temperature type with **135 deg F (57 deg C)** setting.
 3. Electrical Convenience Outlet: 115 V ac fused, duplex, straight-blade receptacles, separately fused and located inside control panel.

2.3 MATERIALS

A. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for steel sheet.

B. Stainless Steel:

1. Manufacturer's standard grade for casing.
2. Manufacturer's standard type, ASTM A240/240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653/A653M.

D. Aluminum: ASTM B209.

E. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating.

F. Corrosion-Resistant Coating: Coat with a corrosion-resistant coating capable of withstanding a [3,000]<Insert time>-hour salt-spray test according to ASTM B117.

1. Standards:

- a. ASTM B117 for salt spray.
- b. ASTM D2794 for minimum impact resistance of 100 in./lb (11.3 N/m).
- c. ASTM B3359 for cross hatch adhesion of 5B.

2. Application: [Immersion][Spray].

3. Thickness: [1 mil (0.025 mm)]<Insert measurement>.

4. Gloss: Minimum gloss of 60 on a 60-degree meter.

2.4 SOURCE QUALITY CONTROL

A. Verification of Performance: Factory test and rate dehumidification units according to AHRI 910.

B. Sound-Power-Level Ratings: Factory test and rate dehumidification units according to AHRI 575.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for [hot-water][steam][refrigerant] piping systems to verify actual locations of piping connections before equipment installation.

C. Examine walls, floors, and roofs for suitable conditions where dehumidification units will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF INDOOR, MECHANICAL DEHUMIDIFICATION UNITS

A. Equipment Mounting:

1. Install dehumidification units on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

3.3 PIPING CONNECTIONS

- A. Where piping is installed adjacent to dehumidification units, allow space for service and maintenance of dehumidification units.
- B. Connect piping to dehumidification units mounted on vibration isolators with flexible connectors.
- C. Connect condensate drain pans using minimum **NPS 1-1/4 (DN 32)** copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan, and install cleanout at changes in direction.
- D. Refrigerant Piping: Comply with requirements in Section 232300 "Refrigerant Piping." Connect to supply and return coil tapplings with shutoff valve and union or flange at each connection.
- E. Hot-Water Piping: Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Connect to supply coil tapplings with shutoff valve, return coil tapplings with balancing valve, and union or flange at each connection.
- F. Steam and Condensate Piping: Comply with requirements in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties." Connect with shutoff valve and union or flange.
- G. Duct installation requirements are specified in **[Section 233113 "Metal Ducts."][Section 233113 "Nonmetal Ducts.][Section 233113 "Metal Ducts" and Section 233116 "Nonmetal Ducts."]** Drawings indicate the general arrangement of ducts. The following are specific connection requirements:
 1. Install ducts to termination in roof-mounted frames. Where indicated, terminate return-air duct through roof structure, and insulate the space between roof and bottom of dehumidification unit.

3.4 ELECTRICAL CONNECTIONS

- A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 1. Nameplate is to be laminated acrylic or melamine plastic signs, as specified in Section 260553

"Identification for Electrical Systems."

2. Nameplate is to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch (13 mm)** high.
3. Locate nameplate where easily visible.

3.5 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring between control devices.
- C. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."
- D. Connect smoke detector to fire alarm system.

3.6 FIELD QUALITY CONTROL

- A. Testing Agency:
 1. Owner will engage a qualified testing agency to perform tests and inspections.
 2. Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
 1. Leak Test: After installation, fill water coils with water, and test coils and connections for leaks. Repair leaks and retest until no leaks exist.
 2. Charge refrigerant coils with refrigerant and test for leaks. Repair leaks and retest until no leaks exist.
 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Dehumidification unit will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

3.7 CLEANING

- A. Clean dehumidification units internally, on completion of installation, according to manufacturer's written instructions. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils' entering-air face.
- B. After completing system installation, testing, and startup service of dehumidification units, clean filter housings and install new filters.

3.8 ADJUSTING

- A. Adjust damper linkages for proper damper operation.

- B. Adjust initial temperature and humidity set points.

3.9 STARTUP SERVICE

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
- B. Perform the following final checks before startup:
 - 1. Verify that shipping, blocking, and bracing are removed.
 - 2. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
 - 3. Perform cleaning and adjusting specified in this Section.
 - 4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify free fan wheel rotation and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
 - 5. Check lubrication of bearings, pulleys, belts, and other moving parts.
 - 6. Set outside- and return-air mixing dampers to minimum outside-air setting.
 - 7. Install clean filters.
 - 8. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.
- C. Starting procedures for dehumidification units include the following:
 - 1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace malfunctioning motors, bearings, and fan wheels.
 - 2. Measure and record motor's electrical values for voltage and amperage.
 - 3. Manually operate dampers from fully closed to fully open position and record fan performance.
- D. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing of dehumidification unit.
- E. Startup Report: Report findings during startup. Identify startup steps, corrective measures taken, and final results.

3.10 DEMONSTRATION

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

END OF SECTION 23 84 16 16

SECTION 26 01 00 00 - SUPPLEMENTAL REQUIREMENTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes requirements generally applicable to all electrical Work on the Project, including but not limited to Work specified in Divisions 26, 27, and 28.
- B. Related Requirements:
 - 1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
 - 2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
 - 3. **[Section 013100 "Project Management and Coordination"]<Insert Section number and title>** specifies preinstallation conference procedures.

1.2 REFERENCES

- A. Abbreviations and Acronyms for Electrical Terms and Units of Measure:
 - 1. 8P8C: An 8-position 8-contact modular jack.
 - 2. A: Ampere, unit of electrical current.
 - 3. AC or ac: Alternating current.
 - 4. AFCI: Arc-fault circuit interrupter.
 - 5. AGC: Automatic gain control.
 - 6. AIC: Ampere interrupting capacity.
 - 7. AL, Al, or ALUM: Aluminum.
 - 8. ASD: Adjustable-speed drive.
 - 9. ATP: Acceptance test procedure.
 - 10. ATS: Automatic transfer switch.
 - 11. A/V: Audio/visual.
 - 12. AWG: American wire gauge; see ASTM B258.
 - 13. BAS: Building automation system.
 - 14. BDA: Bi-directional amplifier.
 - 15. BIL: Basic impulse insulation level.
 - 16. BIM: Building information modeling.
 - 17. BMS: Building management system.
 - 18. BNC: Bayonet Neill-Concelman - type of connector.
 - 19. B/W: Black and white.
 - 20. CAD: Computer-aided design or drafting.
 - 21. CATV: Community antenna television.
 - 22. CB: Circuit breaker.
 - 23. CCD: Charge-coupled device.
 - 24. CCTV: Closed-circuit television.
 - 25. cd: Candela, the SI fundamental unit of luminous intensity.
 - 26. CO/ALR: Copper-aluminum, revised.
 - 27. COPS: Critical operations power system.
 - 28. CU or Cu: Copper.
 - 29. CU-AL or AL-CU: Copper-aluminum.

30. DACR: Digital alarm communicator receiver.
31. DACT: Digital alarm communicator transmitter.
32. DAS: Distributed antenna system.
33. dB: Decibel, a unitless logarithmic ratio of two electrical, acoustical, or optical power values.
34. dB(A-weighted) or dB(A): Decibel acoustical sound pressure level with A-weighting applied in accordance with IEC 61672-1.
35. dB(adjusted) or dBa: Decibel weighted absolute noise power with respect to 3.16 pW (minus 85 dBm).
36. dBm: Decibel absolute power with respect to 1 mW.
37. dBmV: Decibel absolute voltage with respect to 1 mV across identical impedance.
38. DC or dc: Direct current.
39. DCOA: Designated critical operations area.
40. DDC: Direct digital control (HVAC).
41. DGP: Data gathering panel.
42. DHCP: Dynamic host configuration protocol.
43. EGC: Equipment grounding conductor.
44. ELV: Extra-low voltage.
45. EMF: Electromotive force.
46. EMI: Electromagnetic interference.
47. EMP: Electrical maintenance program (operation and maintenance); electromagnetic pulse (transient analysis).
48. EPS: Emergency power supply.
49. EPSS: Emergency power supply system.
50. ERCES: Emergency responder communications enhancement system.
51. ESS: Energy storage system.
52. EV: Electric vehicle.
53. EVPE: Electric vehicle power export equipment.
54. EVSE: Electric vehicle supply equipment.
55. FACU: Fire-alarm control unit.
56. FAS: Fire-alarm system.
57. fc: Footcandle, an internationally recognized unit of illuminance equal to one lumen per square foot or 10.76 lx. The simplified conversion 1 fc = 10 lx in the Specifications is common practice and considered adequate precision for building construction activities. When there are conflicts, lux is the primary unit; footcandle is specified for convenience.
58. FCC: Federal Communications Commission; fire command center.
59. FLC: Full-load current.
60. ft: Foot.
61. ft-cd: Foot-candle, the antiquated U.S. standard unit of illuminance, equal to one international candle measured at a distance of one foot, that was superseded in 1948 by the unit "footcandle" when the SI unit candela (cd) replaced the international candle; see "fc."
62. FTP: File transfer protocol.
63. FXO: Foreign exchange office.
64. GEC: Grounding electrode conductor.
65. GFCI: Ground-fault circuit interrupter.
66. GFPE: Ground-fault protection of equipment.
67. GND: Ground.
68. GROL: General Radiotelephone Operator License (FCC).
69. H.323: Audio and video protocol.
70. HACR: Heating, air conditioning, and refrigeration.
71. HDPE: High-density polyethylene.
72. HID: High-intensity discharge.
73. HP or hp: Horsepower.
74. HVAC: Heating, ventilating, and air conditioning.
75. Hz: Hertz.
76. I&TFAS: Inspection and testing of fire-alarm system.

- 77. IB-PSC: In-building public safety communications.
- 78. IBT: Intersystem bonding termination.
- 79. ICT: Information and communications technology.
- 80. IDC: Initiating device circuit.
- 81. inch: Inch. To avoid confusion, the abbreviation "in." is not used.
- 82. I/O: Input/output.
- 83. IP: Ingress protection rating (enclosures); Internet protocol (communications).
- 84. IR: Infrared.
- 85. IS: Intrinsically safe.
- 86. IT&R: Inspecting, testing, and repair.
- 87. ITE: Information technology equipment.
- 88. kAIC: Kiloampere interrupting capacity.
- 89. kcmil or MCM: One thousand circular mils.
- 90. kV: Kilovolt.
- 91. kVA: Kilovolt-ampere.
- 92. kvar: Kilovolt-ampere reactive.
- 93. kW: Kilowatt.
- 94. kWh: Kilowatt-hour.
- 95. LAN: Local area network.
- 96. lb: Pound (weight).
- 97. lbf: Pound (force).
- 98. LCD: Liquid-crystal display.
- 99. LCDI: Leakage-current detector-interrupter.
- 100. LED: Light-emitting diode.
- 101. Li-ion: Lithium-ion.
- 102. lm: Lumen, the SI-derived unit of luminous flux.
- 103. LNG: Liquefied natural gas.
- 104. LP-Gas: Liquefied petroleum gas.
- 105. LRC: Locked-rotor current.
- 106. LTE: Long-term evolution (mobile device technology standard).
- 107. LV: Low voltage.
- 108. lx: Lux, the SI-derived unit of illuminance equal to one lumen per square meter.
- 109. m: Meter.
- 110. MATV: Master antenna television.
- 111. MCC: Motor-control center.
- 112. MDC: Modular data center.
- 113. MG set: Motor-generator set.
- 114. MIDI: Musical instrument digital interface.
- 115. MLO: Main lugs only.
- 116. MPEG: Moving Picture Experts Group.
- 117. MPEG-2: Abbreviation for the ISO/IEC Moving Picture Experts Group's standard for generic coding of moving pictures and associated audio information (ISO/IEC 13818) released in 1995 and used for most over-the-air and satellite broadcast digital television.
- 118. MPEG-4: Abbreviation for the ISO/IEC Moving Picture Experts Group's standard framework for coding of audio-visual objects (ISO/IEC 14496) released in 1999, with digital rights management and more advanced compression algorithms than MPEG-2.
- 119. MOV: Metal-oxide varistor.
- 120. MV: Medium voltage.
- 121. MVA: Megavolt-ampere.
- 122. mW: Milliwatt.
- 123. MW: Megawatt.
- 124. MWh: Megawatt-hour.
- 125. NAC: Notification appliance circuit.
- 126. N.C.: Normally closed.
- 127. NFC: Near field communications.
- 128. Ni-Cd: Nickel-cadmium.

129. NICET: National Institute for Certification in Engineering Technologies, a division of the National Society of Professional Engineers.
130. Ni-MH: Nickel-metal hydride.
131. NIU: Network interface unit.
132. N.O.: Normally open.
133. NPT: National (American) standard pipe taper.
134. NTSC: National Television System Committee.
135. OCPD: Overcurrent protective device.
136. ONT: Optical network terminal.
137. PC: Personal computer.
138. PCS: Power conversion system.
139. PCU: Power-conditioning unit.
140. Percent obs/ft (percent obs/m): Percent obscuration per unit distance; unit of measure for sensitivity of smoke detectors.
141. PF or pf: Power factor.
142. PHEV: Plug-in hybrid electric vehicle.
143. PIR: Passive infrared.
144. PLC: Programmable logic controller.
145. PLFA: Power-limited fire alarm.
146. PoE: Power over Ethernet.
147. POTS: Plain old telephone service. See "public switched telephone network" definition.
148. PSTN: Public switched telephone network.
149. PTZ: Pan-tilt-zoom.
150. PV: Photovoltaic.
151. PVC: Polyvinyl chloride.
152. pW: Picowatt.
153. RAID: Redundant array of inexpensive disks; redundant array of independent disks.
154. RAM: Random-access memory.
155. RAT: Radio alarm transmitter.
156. REX: Request-to-exit.
157. RF: Radio frequency.
158. RFI: (electrical) Radio-frequency interference; (contract) Request for interpretation.
159. RMS or rms: Root-mean-square.
160. RPM or rpm: Revolutions per minute.
161. SCADA: Supervisory control and data acquisition.
162. SCCR: Short-circuit current rating.
163. SCR: Silicon-controlled rectifier.
164. SIP: Session initiation protocol.
165. SLC: Signaling-line circuit.
166. SPD: Surge protective device.
167. SPDT: Single pole, double throw.
168. sq.: Square.
169. SWD: Switching duty.
170. TCP/IP: Transmission Control Protocol/Internet Protocol.
171. TEFC: Totally enclosed fan-cooled.
172. TR: Tamper resistant.
173. TVSS: Transient voltage surge suppressor.
174. UHF: Ultra-high frequency.
175. UL: (standards) UL Standards & Engagement Inc.; (product categories) UL, LLC.
176. UL CCN: UL Category Control Number.
177. UPS: Uninterruptible power supply.
178. USB: Universal serial bus.
179. UTC: Coordinated universal time.
180. UV: Ultraviolet.
181. V: Volt, unit of electromotive force.

182. V(ac): Volt, alternating current.
183. V(dc): Volt, direct current.
184. VA: Volt-ampere, unit of complex electrical power.
185. VAR: Volt-ampere reactive, unit of reactive electrical power.
186. VFC: Variable-frequency controller.
187. VOM: Volt-ohm-multimeter.
188. VoIP: Voice over Internet Protocol.
189. VPN: Virtual private network.
190. VRLA: Valve regulated lead acid; also called "sealed lead acid (SLA)" or "valve regulated sealed lead acid."
191. VU: Volume unit.
192. W: Watt, unit of real electrical power.
193. WAN: Wide area network.
194. Wh: Watt-hour, unit of electrical energy usage.
195. WPT: Wireless power transfer.
196. WPTE: Wireless power transfer equipment.
197. WR: Weather resistant.

B. Abbreviations and Acronyms for Electrical Raceway Types:

1. EMT: Electrical metallic tubing.
2. EMT-A: Aluminum electrical metallic tubing.
3. EMT-S: Steel electrical metallic tubing.
4. EMT-SS: Stainless steel electrical metallic tubing.
5. ENT: Electrical nonmetallic tubing.
6. EPEC: Electrical HDPE underground conduit (thin wall).
7. EPEC-A: Type A electrical HDPE underground conduit.
8. EPEC-B: Type B electrical HDPE underground conduit.
9. ERMC: Electrical rigid metal conduit.
10. ERMC-A: Aluminum electrical rigid metal conduit.
11. ERMC-S: Steel electrical rigid metal conduit.
12. ERMC-S-G: Galvanized-steel electrical rigid metal conduit.
13. ERMC-S-PVC: PVC-coated-steel electrical rigid metal conduit.
14. ERMC-SS: Stainless steel electrical rigid metal conduit.
15. FMC: Flexible metal conduit.
16. FMC-A: Aluminum flexible metal conduit.
17. FMC-S: Steel flexible metal conduit.
18. FMT: Steel flexible metallic tubing.
19. FNMC: Flexible nonmetallic conduit. See "LFNC."
20. HDPE: HDPE underground conduit (thick wall).
21. HDPE-40: Schedule 40 HDPE underground conduit.
22. HDPE-80: Schedule 80 HDPE underground conduit.
23. IMC: Steel electrical intermediate metal conduit.
24. LFMC: Liquidtight flexible metal conduit.
25. LFMC-A: Aluminum liquidtight flexible metal conduit.
26. LFMC-S: Steel liquidtight flexible metal conduit.
27. LFMC-SS: Stainless steel liquidtight flexible metal conduit.
28. LFNC: Liquidtight flexible nonmetallic conduit.
29. LFNC-A: Layered (Type A) liquidtight flexible nonmetallic conduit.
30. LFNC-B: Integral (Type B) liquidtight flexible nonmetallic conduit.
31. LFNC-C: Corrugated (Type C) liquidtight flexible nonmetallic conduit.
32. PVC: Rigid PVC conduit.
33. PVC-40: Schedule 40 rigid PVC conduit.
34. PVC-80: Schedule 80 rigid PVC Conduit.
35. PVC-A: Type A rigid PVC concrete-encased conduit.
36. PVC-EB: Type EB rigid PVC concrete-encased underground conduit.

37. RGS: See ERM-C-S-G.
38. RMC: See ERM-C.
39. RTRC: Reinforced thermosetting resin conduit.
40. RTRC-AG: Low-halogen, aboveground reinforced thermosetting resin conduit.
41. RTRC-AG-HW: Heavy wall, low-halogen, aboveground reinforced thermosetting resin conduit.
42. RTRC-AG-SW: Standard wall, low-halogen, aboveground reinforced thermosetting resin conduit.
43. RTRC-AG-XW: Extra heavy wall, low-halogen, aboveground reinforced thermosetting resin conduit.
44. RTRC-BG: Low-halogen, belowground reinforced thermosetting resin conduit.

C. Abbreviations and Acronyms for Electrical Single-Conductor and Multiple-Conductor Cable Types:

1. AC: Armored cable.
2. CATV: Coaxial general-purpose cable.
3. CATVP: Coaxial plenum cable.
4. CATVR: Coaxial riser cable.
5. CI: Circuit integrity cable.
6. CL2: Class 2 cable.
7. CL2P: Class 2 plenum cable.
8. CL2R: Class 2 riser cable.
9. CL2X: Class 2 cable, limited use.
10. CL3: Class 3 cable.
11. CL3P: Class 3 plenum cable.
12. CL3R: Class 3 riser cable.
13. CL3X: Class 3 cable, limited use.
14. CM: Communications general-purpose cable.
15. CMG: Communications general-purpose cable.
16. CMP: Communications plenum cable.
17. CMR: Communications riser cable.
18. CMUC: Under-carpet communications wire and cable.
19. CMX: Communications cable, limited use.
20. DG: Distributed generation cable.
21. FC: Flat cable.
22. FCC: Flat conductor cable.
23. FPL: Power-limited fire-alarm cable.
24. FPLP: Power-limited fire-alarm plenum cable.
25. FPLR: Power-limited fire-alarm riser cable.
26. IGS: Integrated gas spacer cable.
27. ITC: Instrumentation tray cable.
28. ITC-ER: Instrumentation tray cable, exposed run.
29. MC: Metal-clad cable.
30. MC-FPL/FPLR/FPLP: Metal-clad cable containing FPL, FPLR, or FPLP.
31. MC-HL: Metal-clad cable, hazardous location.
32. MI: Mineral-insulated, metal-sheathed cable.
33. MTW: (machine tool wiring) Moisture-, heat-, and oil-resistant thermoplastic cable.
34. MV: Medium-voltage cable.
35. NM: Nonmetallic sheathed cable.
36. NMC: Nonmetallic sheathed cable with corrosion-resistant nonmetallic jacket.
37. NMS: Nonmetallic sheathed cable with signaling, data, and communications conductors, plus power or control conductors.
38. NPLF: Non-power-limited fire-alarm circuit cable.
39. NPLFP: Non-power-limited fire-alarm circuit cable for environmental air spaces.
40. NPLFR: Non-power-limited fire-alarm circuit riser cable.
41. NUCC: Nonmetallic underground HDPE conduit with conductors.
42. OFC: Conductive optical fiber general-purpose cable.

43. OFCG: Conductive optical fiber general-purpose cable.
44. OFCP: Conductive optical fiber plenum cable.
45. OFCR: Conductive optical fiber riser cable.
46. OFN: Nonconductive optical fiber general-purpose cable.
47. OFNG: Nonconductive optical fiber general-purpose cable.
48. OFNP: Nonconductive optical fiber plenum cable.
49. OFNR: Nonconductive optical fiber riser cable.
50. P: Marine shipboard cable.
51. PLTC: Power-limited tray cable.
52. PLTC-ER: Power-limited tray cable, exposed run.
53. PV: Photovoltaic cable.
54. RHH: (high heat) Thermoset rubber, heat-resistant cable.
55. RHW: Thermoset rubber, moisture-resistant cable.
56. SA: Silicone rubber cable.
57. SE: Service-entrance cable.
58. SER: Service-entrance cable, round.
59. SEU: Service-entrance cable, flat.
60. SIS: Thermoset cable for switchboard and switchgear wiring.
61. TBS: Thermoplastic cable with outer braid.
62. TC: Tray cable.
63. TC-ER: Tray cable, exposed run.
64. TC-ER-HL: Tray cable, exposed run, hazardous location.
65. THW: Thermoplastic, heat- and moisture-resistant cable.
66. THHN: Thermoplastic, heat-resistant cable with nylon jacket outer sheath.
67. THHW: Thermoplastic, heat- and moisture-resistant cable.
68. THWN: Thermoplastic, moisture- and heat-resistant cable with nylon jacket outer sheath.
69. TW: Thermoplastic, moisture-resistant cable.
70. UF: Underground feeder and branch-circuit cable.
71. USE: Underground service-entrance cable.
72. XHH: Cross-linked polyethylene, heat-resistant cable.
73. XHHW: Cross-linked polyethylene, heat- and moisture-resistant cable.

D. Abbreviations and Acronyms for Electrical Flexible Cord Types:

1. SEO: 600 V extra-hard-usage, hard-service cord with thermoplastic elastomer insulation and oil-resistant thermoplastic elastomer outer covering for damp locations.
2. SEOW: 600 V extra-hard-usage, hard-service cord with thermoplastic elastomer insulation and oil-resistant thermoplastic elastomer outer covering for damp or wet locations.
3. SEOO: 600 V extra-hard-usage, hard-service cord with oil-resistant thermoplastic elastomer insulation and oil-resistant thermoplastic elastomer outer covering for damp locations.
4. SEOOO: 600 V extra-hard-usage, hard-service cord with oil-resistant thermoplastic elastomer insulation and oil-resistant thermoplastic elastomer outer covering for damp or wet locations.
5. SJEO: 300 V hard-usage, junior hard-service cord with thermoplastic elastomer insulation and oil-resistant thermoplastic elastomer outer cover for damp locations.
6. SJEOO: 300 V hard-usage, junior hard-service cord with thermoplastic elastomer insulation and oil-resistant thermoplastic elastomer outer cover for damp or wet locations.
7. SJEOO: 300 V hard-usage, junior hard-service cord with oil-resistant thermoplastic elastomer insulation and oil-resistant thermoplastic elastomer outer cover for damp locations.
8. SJEOOW: 300 V hard-usage, junior hard-service cord with oil-resistant thermoplastic elastomer insulation and oil-resistant thermoplastic elastomer outer cover for damp or wet locations.
9. SJO: 300 V hard-usage, junior hard-service cord with thermoset insulation and oil-resistant thermoset outer cover for damp locations.
10. SJOW: 300 V hard-usage, junior hard-service cord with thermoset insulation and oil-resistant thermoset outer cover for damp or wet locations.
11. SJOO: 300 V hard-usage, junior hard-service cord with oil-resistant thermoset insulation and oil-resistant thermoset outer cover for damp locations.

12. SJOOW: 300 V hard-usage, junior hard-service cord with oil-resistant thermoset insulation and oil-resistant thermoset outer cover for damp or wet locations.
13. SJTO: 300 V hard-usage, junior hard-service cord with thermoplastic insulation and oil-resistant thermoplastic outer cover for damp locations.
14. SJTOW: 300 V hard-usage, junior hard-service cord with thermoplastic insulation and oil-resistant thermoplastic outer cover for damp or wet locations.
15. SJTOO: 300 V hard-usage, junior hard-service cord with oil-resistant thermoplastic insulation and oil-resistant thermoplastic outer cover for damp locations.
16. SJTOOW: 300 V hard-usage, junior hard-service cord with oil-resistant thermoplastic insulation and oil-resistant thermoplastic outer cover for damp or wet locations.
17. SO: 600 V extra-hard-usage, hard-service cord with thermoset insulation and oil-resistant thermoset outer covering for damp locations.
18. SOW: 600 V extra-hard-usage, hard-service cord with thermoset insulation and oil-resistant thermoset outer covering for damp or wet locations.
19. SOO: 600 V extra-hard-usage, hard-service cord with oil-resistant thermoset insulation and oil-resistant thermoset outer covering for damp locations.
20. SOOW: 600 V extra-hard-usage, hard-service cord with oil-resistant thermoset insulation and oil-resistant thermoset outer covering for damp or wet locations.
21. STO: 600 V extra-hard-usage, hard-service cord with thermoplastic insulation and oil-resistant thermoplastic outer covering for damp locations.
22. STOW: 600 V extra-hard-usage, hard-service cord with thermoplastic insulation and oil-resistant thermoplastic outer covering for damp or wet locations.
23. STOO: 600 V extra-hard-usage, hard-service cord with oil-resistant thermoplastic insulation and oil-resistant thermoplastic outer covering for damp locations.
24. STOOW: 600 V extra-hard-usage, hard-service cord with oil-resistant thermoplastic insulation and oil-resistant thermoplastic outer covering for damp or wet locations.

E. Abbreviations for Communications Spaces:

1. EF: Entrance facility; generally serves campus or building. EF may include an ER.
2. ER: Equipment room; generally serves campus or building.
3. TE: Telecommunications enclosure; generally serves a single tenant or floor.
4. TR: Telecommunications room; generally serves a single tenant or floor.

F. Abbreviations for Communications Facilities:

1. HC: Horizontal cross-connect; also called "floor distributor" (FD).
2. IC: Intermediate cross-connect; also called "building distributor" (BD).
3. MC: Main cross-connect; also called "campus distributor" (CD).

G. Abbreviations for Grounding and Bonding:

1. BBC: Backbone bonding conductor, for connecting multiple TBBs serving the same floor.
2. PBB: Primary bonding busbar; located in main distribution frame room, ideally near electrical service entrance.
3. RBB: Rack bonding busbar; located in equipment cabinets and racks.
4. SBB: Secondary bonding busbar; located in intermediate distribution frame rooms.
5. TBB: Telecommunications bonding backbone, for connecting SBBs to PBB.
6. TBC: Telecommunications bonding conductor, for connecting PBB to intersystem bonding termination device or busbar at electrical service entrance.
7. TEBC: Telecommunications equipment bonding conductor, for connecting RBBs to SBBs or PBB.
8. UBC: Unit bonding conductor, for connecting individual communications equipment to RBBs or SBBs.

H. Definitions:

1. 8-Position 8-Contact (8P8C) Modular Jack: An unkeyed jack with up to eight contacts commonly used to terminate twisted pair and multiconductor Ethernet cable. Also called a "TIA-1096 miniature 8-position series jack" (8PSJ), or an "IEC 8877 8-pole jack."
 - a. Be careful when suppliers use "RJ45" generically. Obsolete RJ45 jacks used for analog telephone cables have rejection keys. 8P8C jacks used for digital telephone cables and Ethernet cables do not have rejection keys.
2. Agile Receiver: A broadband receiver that can be tuned to any desired channel.
3. Backbone: Primary segment of ERCES between donor antenna and distribution cabling.
4. Basic Impulse Insulation Level (BIL): Reference insulation level expressed in impulse crest voltage with a standard wave not longer than 1.5 times 50 microseconds and 1.5 times 40 microseconds.
5. Broadband: For the purposes of this Section, wide bandwidth equipment or systems that can carry signals occupying in the frequency range of 54 to 1002 MHz. A broadband communication system can simultaneously accommodate television, voice, data, and many other services.
6. Broadcast Media: Loudspeakers, radios, cellular phones, and other media that will carry the selected message to the selected audience.
7. Cable: In accordance with NIST NBS Circular 37 and IEEE standards, in the United States for the purpose of interstate commerce, the definition of "cable" is (1) a conductor with insulation, or a stranded conductor with or without insulation (single-conductor cable); or (2) a combination of conductors insulated from one another (multiple-conductor cable).
8. Carrier: A pure-frequency signal that is modulated to carry information. In the process of modulation, the signal is spread out over a wider band. The carrier frequency is the center frequency on any television channel.
9. Channels: Separate parallel signal paths, from sources to loudspeakers or loudspeaker zones, with separate amplification and switching that permit selection between paths for speaker alternative program signals.
10. Communications Jack: A fixed connecting device designed for insertion of a communications cable plug.
11. Communications Outlet: One or more communications jacks, or cables and plugs, mounted in a box or ring, with a suitable protective cover.
12. Conductive Cable: Cable containing non-current-carrying electrically conductive members such as metallic strength members and metallic vapor barriers.
13. Conductor: In accordance with NIST NBS Circular 37 and IEEE standards, in the United States for the purpose of interstate commerce, the definition of "conductor" is (1) a wire or combination of wires not insulated from one another, suitable for carrying an electric current; (2) (National Electrical Safety Code) a material, usually in the form of wire, cable, or bar, suitable for carrying an electric current; or (3) (general) a substance or body that allows a current of electricity to pass continuously along it.
14. Conduit: A structure containing one or more duct raceways.
15. Control Unit: A system component that monitors inputs and controls outputs through various types of circuits.
 - a. Autonomous Control Unit (ACU): The primary control unit for an in-building mass notification system (MNS).
 - b. Emergency Communications Control Unit (ECCU): A system capable of sending mass notification messages to individual buildings, zones of buildings, individual outdoor loudspeaker arrays, or zones of outdoor loudspeaker arrays; or a building, multiple buildings, outside areas, or a combination of these.
 - c. Fire-alarm control unit (FACU).
 - d. Wireless Control Unit: A component that transmits/receives and processes wireless signals.
16. Designated Seismic System: An architectural, electrical, or mechanical system and its components for which the component importance factor is greater than 1.0 when determined in

- accordance with Section 018123 "Facility Seismic and Wind Criteria."
17. Direct Buried: Installed underground without encasement in concrete or other protective material.
 18. Downlink: The signal from a base station to portable radios.
 19. Duct Bank: An arrangement of conduit providing one or more continuous duct raceways between two points.
 20. Duct Raceway: A single enclosed raceway for conductors or cable.
 21. Electrical Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.
 22. Emergency Communications System (ECS): A system for the protection of life by indicating the existence of an emergency situation and communicating information necessary to facilitate an appropriate response and action.
 - a. Distributed Recipient Mass Notification System (DRMNS): A system meant to communicate directly to targeted individuals and groups that might not be in a contiguous area.
 - b. Emergency Voice/Alarm Communications System (EVACS): Dedicated manual or automatic facilities for originating and distributing voice instructions, as well as evacuation signals pertaining to an emergency, to the occupants of a building.
 - c. Mass Notification System (MNS): A system used to provide information and instructions to people in buildings or other spaces using intelligible voice communications and including visual signals, text, graphics, tactile, or other communication methods (in-building MNS); and could have the capability to provide real-time information to outdoor areas and to communicate with other notification systems provided for a campus, region, or global geographic setting (wide-area MNS).
 23. Emergency Systems: Those systems legally required and classed as emergency by municipal, state, federal, or other codes, or by any governmental agency having jurisdiction that is designed to ensure continuity of lighting, electrical power, or both, to designated areas and equipment in the event of failure of the normal supply for safety of human life.
 24. Enclosure: The case or housing of an apparatus, or the fence or wall(s) surrounding an installation, to prevent personnel from accidentally contacting energized parts or to protect the equipment from physical damage. Types of enclosures and enclosure covers include the following:
 - a. Cabinet: An enclosure that is designed for either surface mounting or flush mounting and is provided with a frame, mat, or trim in which a swinging door or doors are or can be hung.
 - b. Concrete Box: A box intended for use in poured concrete.
 - c. Conduit Body: A means for providing access to the interior of a conduit or tubing system through one or more removable covers at a junction or terminal point. In the United States, conduit bodies are listed in accordance with outlet box requirements.
 - d. Conduit Box: A box having threaded openings or knockouts for conduit, EMT, or fittings.
 - e. Cover Plate: A cover designed for protecting wiring devices installed in flush-mounted device boxes while permitting their safe operation; also called a faceplate or wallplate.
 - f. Cutout Box: An enclosure designed for surface mounting that has swinging doors or covers secured directly to and telescoping with the walls of the enclosure.
 - g. Device Box: A box with provisions for mounting a wiring device directly to the box.
 - h. Extension Ring: A ring intended to extend the sides of an outlet box or device box to increase the box depth, volume, or both.
 - i. Floor Box: A box mounted in the floor intended for use with a floor box cover and other components to complete the floor box enclosure.
 - j. Floor-Mounted Enclosure: A floor box and floor box cover assembly with means to mount in the floor that is sealed against the entrance of scrub water at the floor level.
 - k. Floor Nozzle: An enclosure used on a wiring system, intended primarily as a housing for a receptacle, provided with a means, such as a collar, for surface-mounting on a floor, which may or may not include a stem to support it above the floor level, and is sealed against the

- entrance of scrub water at the floor level.
- l. Junction Box: A box with a blank cover that joins different runs of raceway or cable and provides space for connection and branching of the enclosed conductors.
 - m. Outlet Box: A box that provides access to a wiring system having pryout openings, knockouts, threaded entries, or hubs in either the sides or the back, or both, for the entrance of conduit, conduit or cable fittings, or cables, with provisions for mounting an outlet box cover, but without provisions for mounting a wiring device directly to the box.
 - n. Pedestal Floor Box Cover: A floor box cover that, when installed as intended, provides a means for typically vertical or near-vertical mounting of receptacle outlets above the floor's finished surface.
 - o. Pull Box: A box with a blank cover that joins different runs of raceway and provides access for pulling or replacing the enclosed cables or conductors.
 - p. Raised-Floor Box: A floor box intended for use in raised floors.
 - q. Recessed Access Floor Box: A floor box with provisions for mounting wiring devices below the floor surface.
 - r. Recessed Access Floor Box Cover: A floor box cover with provisions for passage of cords to recessed wiring devices mounted within a recessed floor box.
 - s. Ring: A sleeve, which is not necessarily round, used for positioning a recessed wiring device flush with the plaster, concrete, drywall, or other wall surface.
 - t. Ring Cover: A box cover, with raised center portion to accommodate a specific wall or ceiling thickness, for mounting wiring devices or luminaires flush with the surface.
 - u. Termination Box: An enclosure designed for installation of termination base assemblies consisting of bus bars, terminal strips, or terminal blocks with provision for wire connectors to accommodate incoming or outgoing conductors, or both.
25. Essential Electrical Systems: (healthcare facilities) Those systems designed to ensure continuity of electrical power to designated areas and functions of a healthcare facility during disruption of normal power sources, and also to minimize disruption within the internal wiring system.
26. Fault Limited: Providing or being served by a source of electrical power that is limited to not more than 100 W when tested in accordance with UL 62368-1.
- a. The term "fault limited" is intended to encompass most Class 1, 2, and 3 power-limited sources complying with Article 725 of NFPA 70; Class ES1 and ES2 electrical energy sources that are Class PS1 electrical power sources (e.g., USB); and Class ES3 electrical energy sources that are Class PS1 and PS2 electrical power sources (e.g., PoE). See UL 62368-1 for discussion of classes of electrical energy sources and classes of electrical power sources.
27. Headend: The control center of the MATV system, where incoming signals are amplified, converted, processed, and combined into a common cable along with any locally originated television signals, for transmission to user-interface points. It is also called the "central retransmission facility."
28. High-Performance Building: A building that integrates and optimizes on a life-cycle basis all major high-performance attributes, including energy conservation, environment, safety, security, durability, accessibility, cost-benefit, productivity, sustainability, functionality, and operational considerations.
29. High Power Loudspeaker Array (HPLA): A product providing capability for voice and tone communication to large outdoor areas.
30. Jack: Also commonly called an "outlet," it is the fixed, female connector.
31. Jacket: A continuous nonmetallic outer covering for conductors or cables.
32. Local Operator Console (LOC): Equipment used by authorized personnel and emergency responders to activate and operate a mass notification system (MNS).
33. Luminaire: A complete lighting unit consisting of a light source such as a lamp, together with the parts designed to position the light source and connect it to the power supply. It may also include parts to protect the light source or the ballast or to distribute the light.
34. Master Control Unit: System component that accepts inputs from other control units and may also

perform control-unit functions. The unit has limited capacity for the number of protected zones and is installed at an unattended location or at a location where it is not the attendant's primary function to monitor the security system.

35. Mode: The terms "Active Mode," "Off Mode," and "Standby Mode" are used as defined in the Energy Independence and Security Act (EISA) of 2007.
36. Monitoring: Acquisition, processing, communication, and display of system and equipment status data and event and alarm signals.
37. Monitoring Station: Facility that receives signals and has personnel in attendance at all times to respond to signals. A central station is a monitoring station that is listed.
38. Multi-Outlet Assembly: A type of surface, flush, or freestanding raceway designed to hold conductors, receptacles, and switches, assembled in the field or at the factory.
39. Nonsecure: Unlocked or open. (For doors and gates.)
40. One-Line Diagram: A diagram that shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein. Also called "single-line diagram."
41. Plenum: A compartment or chamber to which one or more air ducts are connected and that forms part of the air distribution system.
42. Plug: Also commonly called a "connector," it is the removable, male telecommunications connector.
43. Protected Zone: A protected premises or an area within a protected premises that is provided with means to prevent an unwanted event.
44. Protective Device: A device that senses when an abnormal current flow, abnormal voltage potential, or other abnormal electrical waveform exists and then disconnects the affected portion of the circuit from the system. Common protective devices include fuses, circuit breakers, relays, ground-fault circuit interrupters, and arc-fault circuit interrupters.
45. Public Switched Telephone Network (PSTN): Analog telephone technology that uses twisted pair cables from a telephone-provider central office for the transmission medium. "PSTN" refers to the telephone network; "POTS" refers to the individual subscriber line.
46. Receptacle: A fixed connecting device arranged for insertion of a power cord plug. Also called a power jack.
47. Receptacle Outlet: One or more receptacles mounted in a box with a suitable protective cover.
48. Screen: A metallic layer, either a foil or braid, placed around a pair or group of conductors.
49. Secure: Closed and locked and with no unlock or open commands pending. (For doors and gates.)
50. Sheath: A continuous metallic covering for conductors or cables.
51. Shield: A metallic layer, either a foil or braid, placed around a pair or group of conductors.
52. Systems Integration: The bringing together of components of several systems containing interacting components to achieve indicated functional operation of combined systems.
53. UL Category Control Number (CCN): An alphabetic or alphanumeric code used to identify product categories covered by UL's Listing, Classification, and Recognition Services.
54. Uplink: The signal from a portable radio to the base station.
55. Voice over Internet Protocol (VoIP): Digital telephone packet technology that uses the internet for its transmission medium.
56. Voltage Class: For specified circuits and equipment, voltage classes are defined as follows:
 - a. Control Voltage: Having electromotive force between any two conductors, or between a single conductor and ground, that is supplied from a battery or other Class 2 or Class 3 power-limited source.
 - b. Line Voltage: (1) (controls) Designed to operate using the supplied low-voltage power without transformation. (2) (transmission lines, transformers, SPDs) The line-to-line voltage of the supplying power system.
 - c. Extra-Low Voltage (ELV): Not having electromotive force between any two conductors, or between a single conductor and ground, exceeding 30 V(ac rms), 42 V(ac peak), or 60 V(dc).
 - d. Low Voltage (LV): Having electromotive force between any two conductors, or between a

- single conductor and ground, that is rated above 30 V but not exceeding 1000 V.
 - e. Medium Voltage (MV): Having electromotive force between any two conductors, or between a single conductor and ground, that is rated about 1 kV but not exceeding 69 kV.
 - f. High Voltage: (1) (circuits) Having electromotive force between any two conductors, or between a single conductor and ground, that is rated above 69 kV but not exceeding 230 kV. (2) (safety) Having sufficient electromotive force to inflict bodily harm or injury.
- 57. Wire: In accordance with NIST NBS Circular 37 and IEEE standards, in the United States for the purpose of interstate commerce, the definition of "wire" is a slender rod or filament of drawn metal. A group of small wires used as a single wire is properly called a "stranded wire." A wire or stranded wire covered with insulation is properly called an "insulated wire" or a "single-conductor cable." Nevertheless, when the context indicates that the wire is insulated, the term "wire" will be understood to include the insulation.
- 58. Zone. A defined area within a protected premises. It is a space or area for which an intrusion must be detected and uniquely identified. The sensor or group of sensors must then be assigned to perform the detection, and any interface equipment between sensors and communication must link to master control unit.

1.3 COORDINATION

- A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions:
 - 1. Notify **[Architect][Construction Manager][Owner][Tenant]** no fewer than **[seven]<Insert number>** days in advance of proposed interruption of electrical service.
 - 2. Do not proceed with interruption of electrical service without **[Architect's][Construction Manager's][Owner's][Tenant's]** written permission.
 - 3. Coordinate interruption with systems impacted by outage including, but not limited to, the following:
 - a. Exercising generators.
 - b. Emergency lighting.
 - c. Elevators.
 - d. Fire-alarm systems.
 - 4. Arrange to provide temporary emergency and standby electrical **[service][or][power]** so facility may remain occupied during the outage in accordance with requirements specified in Section 015000 "Temporary Facilities and Controls." Coordinate power requirements with Owner.
- B. Interruption of Existing Telephone Service: Do not interrupt telephone service to facilities occupied by Owner or others unless permitted under the following conditions:
 - 1. Notify **[Architect][Construction Manager][Owner][Tenant]** no fewer than **[seven]<Insert number>** days in advance of proposed interruption of telephone service.
 - 2. Do not proceed with interruption of telephone service without **[Architect's][Construction Manager's][Owner's][Tenant's]** written permission.
- C. Interruption of Existing Internet Service: Do not interrupt internet service to facilities occupied by Owner or others unless permitted under the following conditions:
 - 1. Notify **[Architect][Construction Manager][Owner][Tenant]** no fewer than **[seven]<Insert number>** days in advance of proposed interruption of internet service.
 - 2. Do not proceed with interruption of internet service without **[Architect's][Construction Manager's][Owner's][Tenant's]** written permission.



- D. Interruption of Existing Security System: Do not interrupt security system to facilities occupied by Owner or others unless permitted under the following conditions:
 - 1. Notify **[Architect][Construction Manager][Owner][Tenant]** no fewer than **[seven]<Insert number>** days in advance of proposed interruption of security system.
 - 2. Do not proceed with interruption of security system without **[Architect's][Construction Manager's][Owner's][Tenant's]** written permission.
- E. Interruption of Existing Fire-Alarm System: Do not interrupt fire-alarm system to facilities occupied by Owner or others unless permitted under the following conditions:
 - 1. Notify **[Architect][Construction Manager][Owner][Tenant]** no fewer than **[seven]<Insert number>** days in advance of proposed interruption of fire-alarm system.
 - 2. Do not proceed with interruption of fire-alarm system without **[Architect's][Construction Manager's][Owner's][Tenant's]** written permission.

1.4 PREINSTALLATION MEETINGS

- A. Electrical Preconstruction Conference: Schedule conference with Architect and Owner, not later than **[10]<Insert number>** days after Notice to Proceed. Agenda topics include, but are not limited to, the following:
 - 1. Electrical installation schedule.
 - 2. Status of power system studies.
 - 3. Value analysis proposals and requests for substitution of electrical equipment.
 - 4. Utility work coordination and class of service requests.
 - 5. Commissioning activities.
 - 6. Sustainability activities[, **including Measurement and Verification Plan**].
- B. Communications Preconstruction Conference: Schedule conference with Architect and Owner not later than **[10]<Insert number>** days after Notice to Proceed. Agenda topics include, but are not limited to, the following:
 - 1. Installation schedule for communications systems.
 - 2. Value analysis proposals and requests for substitution of communications equipment.
 - 3. Utility services work coordination and monitoring service requests.
 - 4. Commissioning activities.
 - 5. Sustainability activities.
- C. Electronic Safety and Security Preconstruction Conference: Schedule conference with Architect and Owner not later than **[10]<Insert number>** days after Notice to Proceed. Agenda topics include, but are not limited to, the following:
 - 1. Installation schedule for security, fire-alarm, and other life-safety systems.
 - 2. Value analysis proposals and requests for substitution of electronic safety and security equipment.
 - 3. Monitoring services work coordination and monitoring service requests.
 - 4. Commissioning activities.
 - 5. Sustainability activities.

1.5 SEQUENCING

- A. Conduct and submit results of power system studies before submitting product data and Shop Drawings

for electrical equipment.

1.6 SCHEDULING

- A. **<Insert requirements for unusual scheduling coordination>.**

1.7 ACTION SUBMITTALS

- A. Coordination Drawings for Structural Supports: Show coordination of structural supports for equipment and devices, including restraints and bracing for control of seismic and wind loads, with other systems, equipment, and structural supports in the vicinity.
- B. Coordination Drawings for Ceiling Areas: Where indicated on drawings, provide reflected ceiling plan(s), supplemented by sections and other details, drawn to scale, in accordance with Section 013100 "Project Management and Coordination," on which the following items are shown and coordinated with each other, using input from installers of the items involved:
1. Suspended ceiling components.
 2. Structural members to which equipment and suspension systems will be attached.
 3. Size and location of access panels on ceilings.
 4. Elevation, size, and route of sprinkler piping.
 5. Elevation, size, and route of plumbing piping.
 6. Elevation, size, and route of ductwork.
 7. Elevation, size, and route of cable tray.
 8. Elevation, size, and route of conduit.
 9. Elevation and size of wall-mounted and ceiling-mounted equipment.
 10. Access panels.
 11. Sprinklers.
 12. Air inlets and outlets.
 13. Control modules.
 14. Luminaires.
 15. Communications devices.
 16. Speakers.
 17. Security devices.
 18. Fire-alarm devices.
 19. Indicate clear dimensions for maintenance access in front of equipment.
 20. Indicate dimensions of fully open access doors.
- C. Coordination Drawings for Cable Tray Routing: Reflected ceiling plan(s), supplemented by sections and other details, drawn to scale, in accordance with Section 013100 "Project Management and Coordination," on which the following items are shown and coordinated with each other, using input from installers of the items involved:
1. Elevation, size, and route of cable trays.
 2. Relationships between components and adjacent structural, electrical, and mechanical elements.
 3. Vertical and horizontal offsets and transitions.
 4. Elevation and size of sleeves for wall, ceiling, and floor cable penetrations.
 5. Elevation of ceilings and size of ceiling tiles.
 6. Locations of access panels on ceilings.
 7. Locations where cable tray crosses or parallels sprinkler piping.
 8. Locations where cable tray crosses plumbing piping.
 9. Locations where cable tray crosses or parallels ductwork.
 10. Locations of access panels on ductwork.
 11. Locations where cable tray crosses conduit.

12. Items blocking access around cable trays, including the following:
 - a. Light fixtures.
 - b. Speakers.
 - c. Fire-alarm devices.
 - d. Power outlets.
 - e. Wall-mounted equipment.
 - f. Equipment racks.
 - g. Furniture.
 - h. Door swings.
 - i. Building features.
 13. Indicate clear dimension between cable tray and walls or obstructions that are closer than **10 ft (3 m)**.
 14. Highlight locations where cable tray is greater than **3 ft (1 m)** above ceilings. Explain how personnel access will be accommodated for cable tray maintenance.
- D. Coordination Drawings for Conduit Routing: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:
1. Structural members in paths of conduit groups with common supports.
 2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.
- E. Coordination Drawings for Bus Assembly Routing: Floor plans and sections, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:
1. Scaled bus-assembly layouts and relationships between components and adjacent structural, mechanical, and electrical elements.
 2. Vertical and horizontal enclosed bus-assembly runs, offsets, and transitions.
 3. Clearances for access above and to the side of enclosed bus assemblies.
 4. Vertical elevation of enclosed bus assemblies above the floor or bottom of structure.
 5. Support locations, type of support, and weight on each support.
 6. Location of adjacent construction elements, including luminaires, HVAC and plumbing equipment, fire sprinklers and piping, signal and control devices, and other equipment.
- F. Coordination Drawings for Large Equipment Indoor Installations:
1. Location plan, drawn to scale, showing heavy equipment or truck access paths to loading dock or other freight access into building. Indicate available width and height of doors or openings.
 2. Floor plan for entry floor and floor where equipment is located, drawn to scale, showing heavy equipment access paths for maintenance and replacement, with the following items shown and coordinated with each other, based on input from installers of the items involved:
 - a. Dimensioned concrete bases, outlines of equipment, conduit entries, and grounding equipment locations.
 - b. If freight elevator must be used, indicate width and height of door and depth of car. Indicate if large equipment must be tipped to use elevator.
 - c. Dimensioned working clearances and dedicated areas below and around electrical equipment where obstructions and tripping hazards are prohibited.
 3. Reflected ceiling plans for entry floor and floor where equipment is located, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

- a. Support locations, type of support, and weight on each support. Locate structural supports for structure-supported raceways[, **busways**,][**and seismic bracing**].
- b. Location of lighting fixtures, sprinkler piping and sprinklers, ducts and diffusers, and other obstructions, indicating available overhead clearance.
- c. Dimensioned working clearances and dedicated areas above and around electrical equipment where foreign systems and equipment are prohibited.

G. Coordination Drawings for Large Equipment Outdoor Installations:

1. Utilities site plan, drawn to scale, showing heavy equipment or truck access paths for maintenance and replacement, with the following items shown and coordinated with each other, based on input from installers of the items involved:
 - a. Fences and walls, dimensioned concrete bases, outlines of equipment, conduit entries, and grounding and bonding locations.
 - b. Indicate clear dimensions for fence gates and wall openings.
 - c. Indicate depth and type of ground cover, and locations of trees, shrubbery, and other obstructions in access path.
 - d. Indicate clear height below tree branches, overhead lines, bridges, and other overhead obstructions in access path, or where cranes and hoists will be needed to handle large electrical equipment.
 - e. Support locations, type of support, and weight on each support. Locate structural supports for structure-supported raceways[, **busways**,][**and seismic bracing**].
 - f. Dimensioned working clearances and dedicated areas around electrical equipment.

H. Coordination Drawings for Duct Banks:

1. Show duct profiles and coordination with other utilities and underground structures.
2. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.

I. Sustainable Design Submittals:

1. Electrical Waste Management (Wire): Provide documentation for quantity of abandoned electrical wire that has been removed from Project site, in accordance with Rule 645.5(G) of NFPA 70, and provide verification that abandoned wire containing lead stabilizers has been identified and disposed of in accordance with jurisdictional hazardous waste requirements.
2. Electrical Waste Management (Lamps): Provide documentation that an area has been provided to serve entire Project for collection and storage of fluorescent and HID lamps and ballasts for their appropriate disposal or recycling in accordance with jurisdictional hazardous waste requirements.
3. Electrical Waste Management (Electronics and Batteries): Provide documentation that an area has been provided to serve entire Project for collection and storage of electronics, alkaline batteries, and rechargeable batteries for their appropriate disposal or recycling in accordance with jurisdictional hazardous waste requirements.

1.8 INFORMATIONAL SUBMITTALS

- A. Electrical Installation Schedule: At preconstruction meeting, and periodically thereafter as dates change, provide schedule for electrical installation Work to Owner and Architect including, but not limited to, milestone dates for the following activities:
1. Submission of power system studies.
 2. Submission of specified coordination drawings.
 3. Submission of action submittals specified in Division 26.
 4. Orders placed for major electrical equipment.

5. Arrival of major electrical equipment on-site.
6. Preinstallation meetings specified in Division 26.
7. Utility service outages.
8. Utility service inspection and activation.
9. Mockup reviews.
10. Closing of walls and ceilings containing electrical Work.
11. System startup, testing, and commissioning activities for major electrical equipment.
12. System startup, testing, and commissioning activities for emergency lighting.
13. System startup, testing, and commissioning activities for automation systems (SCADA, BMS, lighting, HVAC, fire alarm, fire pump, etc.).
14. Pouring of concrete housekeeping pads for electrical equipment and testing of concrete samples.
15. Requests for special inspections.
16. Requests for inspections by authorities having jurisdiction.

B. Installation Schedule for Communications Systems: At preconstruction meeting, and periodically thereafter as dates change, provide schedule for installation of the communications Work to Owner and Architect including, but not limited to, milestone dates for the following activities:

1. Submission of specified coordination drawings.
2. Submission of action submittals specified in Division 27.
3. Orders placed for major equipment.
4. Arrival of major equipment on-site.
5. Preinstallation meetings specified in Division 27.
6. Telephone and internet service outages.
7. Telephone and internet service inspection and activation.
8. Mockup reviews.
9. Closing of walls and ceilings containing the communications Work.
10. System startup, testing, and commissioning activities for communications equipment.
11. System startup, testing, and commissioning activities for the Work specified in other divisions that depends on the Work specified in Division 27.
12. System startup, testing, and commissioning activities for automation systems (SCADA, BMS, lighting, HVAC, fire alarm, fire pump, etc.).
13. Requests for special inspections.
14. Requests for inspections by authorities having jurisdiction.

C. Installation Schedule for Security, Fire-Alarm, and Other Life-Safety Systems: At preconstruction meeting, and periodically thereafter as dates change, provide schedule for installation of security, fire-alarm, and the other life-safety Work to Owner and Architect including, but not limited to, milestone dates for the following activities:

1. Submission of specified coordination drawings.
2. Submission of action submittals specified in Division 28.
3. Orders placed for major equipment.
4. Arrival of major equipment on-site.
5. Preinstallation meetings specified in Division 28.
6. Security and fire-alarm system outages.
7. Security and fire-alarm system inspection and activation.
8. Mockup reviews.
9. Closing of walls and ceilings containing the security and fire-alarm Work.
10. System startup, testing, and commissioning activities for security and fire-alarm equipment.
11. System startup, testing, and commissioning activities for fire-alarm interfaces with the Work specified in other divisions.
12. System startup, testing, and commissioning activities for automation systems (SCADA, BMS, lighting, HVAC, fire alarm, fire pump, etc.).
13. Requests for special inspections.

14. Requests for inspections by authorities having jurisdiction.
- D. Welding certificates.
- E. Seismic Performance Certificates: Provide special certification for designated seismic systems as required to meet requirements specified in Section 018123 "Facility Seismic and Wind Criteria" for all designated seismic systems identified on the Drawings or in the Specifications.
 1. Include the following information:
 - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
 - d. Detailed description of conduit support devices and interconnections on which the certification is based and their installation requirements.
 - e. Equipment manufacturer's written certification for each designated active electrical seismic device and system, stating that it will remain operable following the basis-of-design seismic criteria specified in Section 018123 "Facility Seismic and Wind Criteria."
 - f. Equipment manufacturer's written certification that components with hazardous contents maintain containment following the basis-of-design seismic criteria specified in Section 018123 "Facility Seismic and Wind Criteria."
 - g. Evidence demonstrating compliance with these requirements for approval to authorities having jurisdiction after review and acceptance by qualified structural professional engineer.
- F. Wind Performance Certificates: Provide special certification for systems and components designated on the Drawings or in the Specifications to be subject to high wind exposure and impact damage.
 1. Include the following information:
 - a. Provide equipment manufacturer's written certification for each designated system and component, stating that it will remain in place and operable following the design wind event and comply with requirements of authorities having jurisdiction.
 - b. Certification must be based on ICC-ES or similar nationally recognized testing standard procedures acceptable to authorities having jurisdiction.
- G. Qualification Statements:
 1. For qualified regional manufacturer.
 2. For structural professional engineer.
 3. For electrical professional engineer.
 4. For lighting professional engineer.
 5. For EPM specialist.
 6. For welder.
 7. For ERM-C-S-PVC raceway Installer.
 8. For medium-voltage cable Installer.
 9. For medium-voltage duct Installer.
 10. For medium-voltage equipment Installer.
 11. For electrical power monitoring Installer.
 12. For switchboard Installer.
 13. For EVSE Installer.
 14. For generator set Installer.
 15. For lightning protection system Installer.

16. For theatrical lighting Installer.
17. For exterior athletic lighting Installer.
18. For power quality specialist.
19. For electrical testing and inspecting agency and its on-site electrical testing supervisor.
20. For structural testing and inspecting agency.
21. For outdoor pole testing and inspecting agency.
22. For luminaire photometric testing laboratory.
23. For lighting testing and inspecting agency.
24. For communications design professional.
25. For communications cable Installer.
26. For communications testing and inspecting agency and its on-site communications testing supervisor.
27. For nurse call/code blue system Installer.
28. For security design professional.
29. For fire-alarm system design professional.
30. For mass notification design professional.
31. For IB-PSC design professional.
32. For general radiotelephone operator license (GROL) designer.
33. For emergency communications design professional.
34. For fire-alarm cable Installer and its on-site fire-alarm cable installation supervisor.
35. For security testing and inspecting agency and its on-site security testing supervisor.
36. For intrusion detection systems installer.
37. For perimeter security systems integrator.
38. For fire-alarm testing agency and its on-site fire-alarm testing supervisor.
39. For detention electronics systems Installer.
40. For detention electronics systems integrator.
41. For detention electronics systems testing and inspecting agency.

1.9 CLOSEOUT SUBMITTALS

A. Facility EMP Binders:

1. Complete Set: On **[approved online or cloud solution][and][USB media that is clearly and permanently labeled with attached placard on lanyard to prevent misplacement]**.
2. Volumes 2 and 8: Reproducible hardcopy on archival quality, **28 lb (105 GSM)**, acid-free, bond paper.

B. Operation and Maintenance Data:

1. Provide emergency operation, normal operation, and preventive maintenance manuals for each system, equipment, and device listed below:
 - a. **<Insert system, equipment, or device>.**
2. Include the following information:
 - a. Manufacturer's operating specifications.
 - b. User's guides for software and hardware.
 - c. Schedule of maintenance material items recommended to be stored at the Project site.
 - d. Detailed instructions covering operation under both normal and abnormal conditions.
 - e. Time-current curves for overcurrent protective devices and manufacturer's written instructions for testing and adjusting their settings.
 - f. List of load-current and overload-relay heaters with related motor nameplate data.
 - g. List of lamp types and photoelectric relays used on the Project, with ANSI and

- h. Manufacturers' codes.
 - i. Manufacturer's instructions for setting field-adjustable components.
 - j. Manufacturer's instructions for testing, adjusting, and reprogramming microprocessor controls.
 - k. EPSS: Manufacturer's system checklists, maintenance schedule, and maintenance log sheets in accordance with NFPA 110.
 - l. Exterior pole inspection and repair procedures.
 - C. Software and Firmware Operational Documentation: Provide software and firmware operational documentation[**in Facility EPM Binders**], including the following:
 - 1. Software operating and upgrade manuals.
 - 2. Names, versions, and website addresses for locations of installed software.
 - 3. Device address list.
 - 4. Printout of software application and graphic screens.
 - 5. Testing and adjusting of panic and emergency power features.
 - 6. For lighting controls, include the following:
 - a. Adjustments of scene preset controls, adjustable fade rates, and fade overrides.
 - b. Operation of adjustable zone controls.
 - D. Software:
 - 1. Program Software Backup: Provide [**username and password for approved online or cloud solution**][and][**USB media that is clearly and permanently labeled with attached placard on lanyard to prevent misplacement**].
 - 2. Provide to Owner upgrades and unrestricted licenses[**for Government use**] for installed and backup software, including operating systems and programming tools required for operation and maintenance.
- 1.10 MOCKUPS
- A. Simple Mockups for Coordinating Accessibility of Electrical Devices around Fixed Furnishings and Equipment:
 - 1. Build simple mockups using art supplies and other inexpensive materials for verification of general arrangement, actual dimensions, and accessibility of **<Insert identification of room and fabrication>** by [**Architect**][**Owner**][**Tenant**]**<Insert approving stakeholders>** prior to fabrication and installation of Work. Depict products from all Divisions requiring coordination, including, but not limited to, fixed furnishings, casework, outlet covers and plates, HVAC controls, exposed raceway, exposed plumbing, equipment, and signage.
 - B. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Owner specifically approves such deviations by Change Order.

PART 2 - PRODUCTS

2.1 SUBSTITUTION LIMITATIONS FOR ELECTRICAL EQUIPMENT

- A. Substitution requests for electrical equipment will be entertained under the following conditions:
 - 1. Substitution requests may be submitted for consideration prior to the Electrical Preconstruction Conference if accompanied by value analysis data indicating that substitution will comply with the

Project performance requirements while significantly increasing value for Owner throughout life of facility.

2. Substitution requests may be submitted for consideration concurrently with submission of power system study reports when those reports indicate that substitution is necessary for safety of maintenance personnel and facility occupants.
3. Contractor is responsible for sequencing and scheduling power system studies and electrical equipment procurement. After the Electrical Preconstruction Conference, insufficient lead time for electrical equipment delivery will not be considered a valid reason for substitution.

2.2 SUBSTITUTION LIMITATIONS FOR COMMUNICATIONS EQUIPMENT

A. Substitution requests for communications equipment will be entertained under the following conditions:

1. Substitution requests may be submitted for consideration prior to the Communications Preconstruction Conference if accompanied by value analysis data indicating that substitution will comply with the Project performance requirements while significantly increasing value for Owner throughout life of facility.
2. Contractor is responsible for sequencing and scheduling equipment procurement. After the Communications Preconstruction Conference, insufficient lead time for equipment delivery will not be considered a valid reason for substitution.

2.3 SUBSTITUTION LIMITATIONS FOR ELECTRONIC SAFETY AND SECURITY EQUIPMENT

A. Substitution requests for electronic safety and security equipment will be entertained under the following conditions:

1. Substitution requests may be submitted for consideration prior to the Electronic Safety and Security Preconstruction Conference if accompanied by value analysis data indicating that substitution will comply with the Project performance requirements while significantly increasing value for Owner throughout life of facility.
2. Contractor is responsible for sequencing and scheduling equipment procurement. After the Electronic Safety and Security Preconstruction Conference, insufficient lead time for equipment delivery will not be considered a valid reason for substitution.

2.4 FACILITY ELECTRICAL MAINTENANCE PROGRAM (EMP) BINDERS

A. Description: Set of binders containing operation and maintenance data for facility's electrical equipment that was compiled during analysis of installed electrical Work for Facility EMP development.

B. Applicable Standards:

1. Regulatory Requirements: Comply with requirements in NFPA 70B.
2. General Characteristics:
 - a. Volume 1 - Introduction:
 - 1) Summarize how Facility EMP analysis was performed, how data were collected, and how volumes are organized.
 - 2) Describe Facility EMP and provide recommended policies and procedures for implementing the program and keeping it current.
 - 3) Provide place for Owner to identify contact information for employees responsible for implementing and maintaining Facility EMP.

- b. Volume 2 - Facility Safety, Hazards Awareness, and Emergency Procedures:
 - 1) Include training requirements for employees and contractors.
 - 2) Include list of known facility hazards impacting IT&R activities.
 - 3) Include approval and permitting procedures for IT&R activities.
 - 4) Include incident emergency response procedures.
 - 5) Include emergency shutdown procedures.
 - 6) Include electrical disaster recovery procedures.
 - 7) Include procedures for investigating the following incidents:
 - a) Electrical safety incidents.
 - b) Equipment malfunctions.
 - c) Unintended operations or alarms.
 - d) Operation of protective devices.
- c. Volume 3 - Operating Procedures for Electrical Equipment and Controls:
 - 1) <Insert requirements>.
- d. Volume 4 - Facility Diagrams and Schedules:
 - 1) Include single-line diagrams.
 - 2) Include grounding and bonding diagrams.
 - 3) Include essential wiring diagrams.
 - 4) Include system automation diagrams (SCADA, BMS, lighting, HVAC, etc.).
 - 5) Include records of switchgear, switchboard, and panelboard schedules.
 - 6) Include time-current curves for overcurrent protective devices.
 - 7) Include list of load-current and overload-relay heaters with related motor nameplate data.
- e. Volume 5 - Inventory of Facility Equipment Using Electrical Power:
 - 1) Include simplified floor plans showing equipment locations.
 - 2) Identify critical equipment (electrical or otherwise).
 - 3) Include identifying designations and nameplate data.
 - 4) Include warranty and maintenance contract information.
- f. Volume 6 - Inventory of Facility Tools, Supplies, and Personnel Protective Equipment:
 - 1) Include schedules of maintenance material items recommended to be stored at facility.
 - 2) Include list of lamp types and photoelectric relays used in facility with ANSI and manufacturers' codes.
 - 3) Include calibration and servicing data for each item.
- g. Volume 7 - Inspection, Testing, and Repair (IT&R) Plan:
 - 1) Include tables showing frequency of activities for each item.
 - 2) Include annual schedule with activities mapped to specific days of the year.
 - 3) Include exterior pole inspection and repair procedures.
- h. Volume 8 - Inspection, Testing, and Repair (IT&R) Forms:
 - 1) <Insert requirements>.
- i. Volume 9 - Inspection, Testing, and Repair (IT&R) Procedures:

- 1) **<Insert requirements>.**
- j. Volume 10 - Spare Parts List:
 - 1) Include list of all parts required to perform IT&R procedures.
 - 2) Identify quantities of which parts are recommended to be stored on-site.
 - 3) Include source contact information and budget cost for each item.
- k. Volume 11 - Construction Project Closeout Record Documentation:
 - 1) Include records of power system studies and photometric studies.
 - 2) Include records of risk assessment studies.
 - 3) Include records of electrical system startup and commissioning activities.
 - 4) Include records of baseline inspections and tests.
 - 5) Include records of baseline infrared photographs with normal light photographs showing the location, direction, angle, and conditions necessary for reproducing each infrared photograph.
 - 6) Include records of baseline settings for adjustable equipment and devices.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verification of Conditions:
 1. **<Insert Project requirements>.**
- B. Preinstallation Testing:
 1. **<Insert Project requirements>.**
- C. Evaluation and Assessment:
 1. **<Insert Project requirements>.**

3.2 PREPARATION

- A. Protection of In-Place Conditions:
 1. **<Insert Project requirements>.**

3.3 DEVELOPMENT OF FACILITY ELECTRICAL MAINTENANCE PROGRAM (EMP)

- A. Facility EMP must be developed by qualified EMP specialist.
- B. Conduct Facility EMP analysis in accordance with NFPA 70B requirements.
 1. Renovation Projects:
 - a. Facility diagrams must include connected existing equipment for entire facility where

- known. Areas of uncertainty should be clearly indicated.
- b. Obtain copies of existing operation and maintenance data and existing Facility EMP information from Owner.
- c. Facility EMP analysis should identify existing equipment that does not have available operation and maintenance data, and should explain Owner's risks because this equipment is not included in Facility EMP.
- d. Data for existing equipment outside scope of the Project may be inserted in Facility EMP Binders without analysis.
- e. Data for existing equipment impacted by scope of the Project should be analyzed and documented similar to the Project's new equipment data as much as possible.

- C. Compile operation and maintenance data from Facility EMP analysis and submit **[updated]** Facility EMP Binders.

3.4 INSTALLATION OF ELECTRICAL WORK

- A. Unless more stringent requirements are specified in the Contract Documents or manufacturers' written instructions, comply with NFPA 70 and NECA NEIS 1 for installation of electrical Work on the Project. Consult Architect for resolution of conflicting requirements.

3.5 CLEANING

- A. Electrical or Electronic Waste Management:
 - 1. **<Insert requirements for special handling or diversion of electrical and electronics waste for recycling or disposal>.**

3.6 CLOSEOUT ACTIVITIES

- A. Training:
 - 1. **[With assistance from factory-authorized service representatives, train][Train]** Owner's maintenance personnel on the following topics:
 - a. How to implement **[updated]** Facility EMP.
 - b. **<Insert system or equipment>.**
 - 2. **[Provide video recordings of training sessions to Owner.][Allow Owner to record training sessions.]**

END OF SECTION 26 01 00 00



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Task	Specification	Specification Description
26 01 10 00	26 01 00 00	Supplemental Requirements for Electrical
26 01 10 91	26 01 00 00	Supplemental Requirements for Electrical
26 01 20 00	26 01 00 00	Supplemental Requirements for Electrical
26 01 20 91	26 01 00 00	Supplemental Requirements for Electrical
26 01 50 00	26 01 00 00	Supplemental Requirements for Electrical
26 01 50 51	02 84 16 00	Handling of Lighting Ballasts and Lamps Containing PCBs and Mercury
26 01 50 51	26 01 00 00	Supplemental Requirements for Electrical
26 01 50 52	02 84 16 00	Handling of Lighting Ballasts and Lamps Containing PCBs and Mercury
26 01 50 52	26 01 00 00	Supplemental Requirements for Electrical
26 01 50 53	02 84 16 00	Handling of Lighting Ballasts and Lamps Containing PCBs and Mercury
26 01 50 53	26 01 00 00	Supplemental Requirements for Electrical
26 01 50 81	26 01 00 00	Supplemental Requirements for Electrical



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SECTION 26 05 00 00 - SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Round sleeves.
2. Rectangular sleeves.
3. Sleeve-seal systems.
4. Sleeve-seal fittings.
5. Grout.
6. Sealants.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
3. Section 078413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.
4. Section 260526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding of raceways, electrical power cabling, and communications cabling referenced by this Section.
5. Section 260529 "Hangers and Supports for Electrical Systems" specifies hangers, supports, and concrete bases referenced by this Section.
6. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs referenced by this Section.
7. Section 270528 "Pathways for Communications Systems" [**and Section 271100 "Communications Equipment Room Fittings"**] specifies additional requirements for raceway materials, routing, locations, and identification of communications equipment and cabling.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of specified product.

B. Sustainable Design Submittals:

1. Product data for sustainable design features for each type of product.

PART 2 - PRODUCTS

2.1 ROUND SLEEVES

A. Steel Wall Sleeves:



1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Advance Products & Systems, LLC]**
 - b. **[CCI Piping Systems]**
 - c. **[Flexicraft Industries]**
 - d. **[GPT Industries, LLC.]**
 - e. **[Specified Technologies Inc.]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Advance Products & Systems, LLC]**
 - b. **[CCI Piping Systems]**
 - c. **[Flexicraft Industries]**
 - d. **[GPT Industries, LLC.]**
 - e. **[Specified Technologies Inc.]**
 - f. **<Insert manufacturer's name>**
3. Standard Features:
 - a. Referenced Standard: ASTM A53/A53M, Type E, Grade B.
 - b. Dimensions: Schedule 40; sized so outer diameter of sleeve matches inner diameter of penetration hole.
 - c. Corrosion Resistance: Coated with **[Zinc][or][Gal-vo-plast]** .
 - d. Configuration: Plain ends and integral waterstop.

B. Cast-Iron Wall Sleeves:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[American Cast Iron Pipe Company]**
 - b. **[Flexicraft Industries]**
 - c. **[McWane Ductile; a part of the McWane family of companies]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Cast Iron Pipe Company]**
 - b. **[Flexicraft Industries]**
 - c. **[McWane Ductile; a part of the McWane family of companies]**
 - d. **<Insert manufacturer's name>**
3. Standard Features:

- a. Description: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe.
- b. Configuration: Plain ends and integral waterstop.

C. PVC Pipe Sleeves:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[CCI Piping Systems]**
 - b. **[GPT Industries, LLC.]**
 - c. **[Metraflex Company (The)]**
 - d. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[CCI Piping Systems]**
 - b. **[GPT Industries, LLC.]**
 - c. **[Metraflex Company (The)]**
 - d. **<Insert manufacturer's name>**
- 3. Standard Features:
 - a. Referenced Standard: ASTM D1785.
 - b. Dimensions: Schedule 40.

D. PVC Molded Sleeves:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[ABB Electrification Installations Products]**
 - b. **[American Polywater Corporation]**
 - c. **[Arlington Industries, Inc.]**
 - d. **[Reliance Worldwide Corporation]**
 - e. **[Roxtec Inc.]**
 - f. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB Electrification Installations Products]**
 - b. **[American Polywater Corporation]**
 - c. **[Arlington Industries, Inc.]**
 - d. **[Reliance Worldwide Corporation]**
 - e. **[Roxtec Inc.]**
 - f. **<Insert manufacturer's name>**
- 3. Standard Features: With nailing flange for attaching to wooden forms.

**Sleeves and Sleeve Seals for Electrical Raceways and
Cabling**



E. PE or PP Molded Sleeves:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[American Polywater Corporation]**
 - b. **[Crete-Sleeve]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Polywater Corporation]**
 - b. **[Crete-Sleeve]**
 - c. **<Insert manufacturer's name>**
3. Standard Features: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

F. Round, Galvanized-Steel, Sheet Metal Sleeves:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Benefast]**
 - b. **[Specified Technologies Inc.]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Benefast]**
 - b. **[Specified Technologies Inc.]**
 - c. **<Insert manufacturer's name>**
3. Standard Features: Galvanized-steel sheet; thickness not less than **0.0239 inch (0.6 mm)**; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

2.2 RECTANGULAR SLEEVES

A. Rectangular, Galvanized-Steel, Sheet Metal Sleeves:

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

- a. **[Abesco Fire LLC]**
 - b. **[Specified Technologies Inc.]**
 - c. **[Wiremold; Legrand North America, LLC]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Abesco Fire LLC]**
 - b. **[Specified Technologies Inc.]**
 - c. **[Wiremold; Legrand North America, LLC]**
 - d. **<Insert manufacturer's name>**
3. Standard Features:
 - a. Material: Galvanized sheet steel.
 - b. Minimum Metal Thickness:
 - 1) For sleeve cross-section rectangle perimeter less than **50 inch (1270 mm)** and with no side larger than **16 inch (400 mm)**, thickness must be **0.052 inch (1.3 mm)**.
 - 2) For sleeve cross-section rectangle perimeter not less than **50 inch (1270 mm)** or with one or more sides larger than **16 inch (400 mm)**, thickness must be **0.138 inch (3.5 mm)**.

2.3 SLEEVE-SEAL SYSTEMS

A. Sleeve-Seal System:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Advance Products & Systems, LLC]**
 - b. **[American Polywater Corporation]**
 - c. **[BWM Company]**
 - d. **[CALPICO, Inc.]**
 - e. **[Flexicraft Industries]**
 - f. **[GPT Industries, LLC.]**
 - g. **[Metraflex Company (The)]**
 - h. **[Proco Products, Inc]**
 - i. **[Roxtec Inc.]**
 - j. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Advance Products & Systems, LLC]**
 - b. **[American Polywater Corporation]**
 - c. **[BWM Company]**
 - d. **[CALPICO, Inc.]**
 - e. **[Flexicraft Industries]**

- f. **[GPT Industries, LLC.]**
- g. **[Metraflex Company (The)]**
- h. **[Proco Products, Inc]**
- i. **[Roxtec Inc.]**
- j. **<Insert manufacturer's name>**

3. Standard Features:

- a. Modular Sealing Device: Designed for field assembly, to fill annular space between sleeve and raceway or cable or between raceway and cable.
- b. Sealing Elements: **[EPDM][Nitrile (Buna N)]** rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
- c. Pressure Plates: **[Carbon steel][Fiber-reinforced plastic][Stainless steel]** .
- d. Connecting Bolts and Nuts: **[Carbon steel, with corrosion-resistant coating,][Stainless steel,]** of length required to secure pressure plates to sealing elements.

2.4 SLEEVE-SEAL FITTINGS

A. Sleeve-Seal Fitting:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Holdrite; a division of Reliance Worldwide Corporation]**
 - b. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Holdrite; a division of Reliance Worldwide Corporation]**
 - b. **<Insert manufacturer's name>**
- 3. Standard Features:
 - a. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall.
 - b. Waterstop Collar: Unit must have plastic or rubber waterstop collar with center opening to match piping OD.

2.5 GROUT

A. Grout for Sealing Penetrations:

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

- a. **[Specified Technologies Inc.]**
 - b. **[W. R. Meadows, Inc]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Specified Technologies Inc.]**
 - b. **[W. R. Meadows, Inc]**
 - c. **<Insert manufacturer's name>**
3. Standard Features:
 - a. Description: Nonshrinking grout; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.
 - b. Referenced Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
 - c. Design Mix: **5000 psi (34.5 MPa)**, 28-day compressive strength.
 - d. Packaging: Premixed and factory packaged.

2.6 SEALANTS

A. Pourable Sealants:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Carlisle SynTec Systems; a Carlisle Company]**
 - b. **[GAF]**
 - c. **[Johns Manville; a Berkshire Hathaway company]**
 - d. **[Specified Technologies Inc.]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Carlisle SynTec Systems; a Carlisle Company]**
 - b. **[GAF]**
 - c. **[Johns Manville; a Berkshire Hathaway company]**
 - d. **[Specified Technologies Inc.]**
 - e. **<Insert manufacturer's name>**
3. Standard Features:
 - a. Description: Single-component, neutral-curing elastomeric sealants of grade indicated below.
 - b. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.

4. Sustainability Characteristics:
 - a. Solvent cements for use with nonmetallic raceways and covers have VOC content less than **[510][490]** g/L.
- B. Foam Sealants:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Innovative Chemical Products (Building Solutions Group)]**
 - b. **[The Dow Chemical Company]**
 - c. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Innovative Chemical Products (Building Solutions Group)]**
 - b. **[The Dow Chemical Company]**
 - c. **<Insert manufacturer's name>**
 3. Standard Features:
 - a. Description: Multicomponent, liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.
 - b. Foam Expansion: Must not damage cables or crack penetrated structure.
 4. Sustainability Characteristics:
 - a. Solvent cements for use with nonmetallic raceways and covers have VOC content less than **[510][490]** g/L.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:
 1. Electrical Construction: ICC IBC, ICC IFB, NFPA 1, NFPA 70, and NECA NEIS 1.
 2. Electrical Maintenance: NFPA 70B and NECA NEIS 91.
 3. Electrical Safety: NFPA 70E.
 4. Commissioning of Active and Passive Fire Protection Features: NFPA 3 and NFPA 4.
 5. Hot Work: NFPA 51B.
 6. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
 7. Communications Work: BICSI N1.

8. Work in ITE Rooms: NFPA 75.
9. Work in Confined Spaces: NFPA 350.
10. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
11. Consult Architect for resolution of conflicting requirements.

C. Special Installation Techniques:

1. Sleeves for Conduits Penetrating Non-Fire-Rated Wall Assemblies: Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Interfaces with Other Work:

1. Identification: Provide labels for penetrations and associated electrical equipment.
 - a. Identify field-installed conductors, interconnecting wiring, and components.
 - b. Label each enclosure with engraved metal or laminated-plastic nameplate.
 - c. Provide warning signs and arc-flash hazard warning labels for electrical equipment.
2. Grounding and Bonding:
 - a. Bonding of Metal Sleeve for Metal Raceway Penetrations: Bond metal raceway to metal sleeve on both sides of penetration.
 - b. Bonding of Metal Sleeve for Cable Penetrations: Bond equipment grounding conductor for electrical power cables, or cable shield for communications cables, to metal sleeve on both sides of penetration.
 - c. Bonding is not required for nonmetallic sleeves.
 - d. Grounding of communications cables entering buildings from outside must be provided at the penetration.
3. Hangers and Supports:
 - a. Support of Raceways and Cables in Sleeve: Comply with manufacturer's published instructions for supporting raceways or cables on both sides of penetration. Sleeve sealing products are typically not rated for supporting the weight of raceways and cables.

3.2 INSTALLATION OF ROUND SLEEVES

A. Sleeves for Conduits Penetrating Above-Grade, Non-Fire-Rated, Concrete and Masonry-Unit Floors and Walls:

1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
 - a. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall or floor so no voids remain. Tool exposed surfaces smooth; protect material while curing.
 - b. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."
2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
3. Size pipe sleeves to provide [1/4 inch (6.4 mm)]<Insert dimension> annular clear space between sleeve and raceway or cable, unless sleeve-seal system is to be installed [or seismic criteria require different clearance] .

4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
5. Install sleeves for floor penetrations. Extend sleeves installed in floors **[2 inch (50 mm)]<Insert dimension>** above finished floor level. Install sleeves during erection of floors.
6. Seal space outside of sleeves with approved joint compound for wall assemblies.

- B. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- C. Aboveground, Exterior-Wall Penetrations: Seal penetrations using **[steel][cast-iron]** pipe sleeves and mechanical sleeve-seal systems. Size sleeves to allow for **1 inch (25 mm)** annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- D. Underground, Exterior-Wall and Floor Penetrations:
 1. Install **[steel][cast-iron]** pipe sleeves with integral waterstops. Size sleeves to allow for **1 inch (25 mm)** annular clear space between raceway or cable and sleeve for installing sleeve-seal system. Install sleeve during construction of floor or wall.
 2. Install steel pipe sleeves. Size sleeves to allow for **1 inch (25 mm)** annular clear space between raceway or cable and sleeve for installing sleeve-seal system. Grout sleeve into wall or floor opening.

3.3 INSTALLATION OF RECTANGULAR SLEEVES

- A. Install sleeves in existing walls without compromising structural integrity of walls. Do not cut structural elements without reinforcing the wall to maintain the designed weight bearing and wall stiffness.
- B. Install conduits and cable with no crossings within the sleeve.
- C. Fill opening around conduits and cables with expanding foam without leaving voids.
- D. Provide metal sheet covering at both wall surfaces and finish to match surrounding surfaces. Metal sheet must be same material as sleeve.

3.4 INSTALLATION OF SLEEVE-SEAL SYSTEMS

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.
- B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

END OF SECTION 26 05 00 00

SECTION 26 05 13 00 - MEDIUM-VOLTAGE CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cables.
2. Connectors.
3. Solid terminations.
4. Separable insulated connectors.
5. Splice kits.
6. Medium-voltage tapes.
7. Arc-proofing materials.
8. Fault indicators.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of cable. Include splices and terminations for cables and cable accessories.

B. Samples: **16 inch (400 mm)** lengths for each type of cable specified.

C. Sustainable Design Submittals:

1. Product Data: For each conductor and cable indicating lead content.
2. Product Data: For solvents and adhesives, indicating VOC content.
3. Laboratory Test Reports: For solvents and adhesives, indicating compliance with requirements for low-emitting materials.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Indicate location of each cable, splice, and termination.

B. Material Certificates: For each type of cable and accessory.

C. Design Data: Cable pulling calculations, including conduit size and fill percentage, pulling tensions, cable sidewall pressure, jam probability, voltage drop, and ground wire sizing for each cable.

D. Source quality-control reports.

- E. Field quality-control reports.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with IEEE C2 and NFPA 70.
- C. Source Limitations: Obtain cables and accessories from single source from single manufacturer.

2.2 CABLES

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[General Cable; Prysmian Group North America]**
 - 2. **[Hendrix Wire and Cable; Marmon Holdings, Inc.; Berkshire Hathaway Inc.]**
 - 3. **[Kerite Power Cable; Marmon Holdings, Inc.; Berkshire Hathaway Inc.]**
 - 4. **[Okonite Company (The)]**
 - 5. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - 6. **[Southwire Company, LLC]**
 - 7. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[General Cable; Prysmian Group North America]**
 - 2. **[Hendrix Wire and Cable; Marmon Holdings, Inc.; Berkshire Hathaway Inc.]**
 - 3. **[Kerite Power Cable; Marmon Holdings, Inc.; Berkshire Hathaway Inc.]**
 - 4. **[Okonite Company (The)]**
 - 5. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - 6. **[Southwire Company, LLC]**
 - 7. **<Insert manufacturer's name>**
- C. Cable Type: **[Type MV 90][Type MV 105]**.
- D. Conductor Insulation: **[Crosslinked polyethylene][Ethylene-propylene rubber]**.
 - 1. Voltage Rating: **[5][8][15][25][35]** kV.
 - 2. Insulation Thickness: **[100][133]** percent insulation level.
- E. Conductor: **[Copper][Aluminum]**.
- F. Comply with UL 1072, AEIC CS8, **ICEA S-93-639/NEMA WC 74**, and **ICEA S-97-682**, and **ICEA S-94-649**.
- G. Conductor Stranding: **[Compact round, concentric lay, Class B][Concentric lay, Class B]**.

- H. Strand Filling: Conductor interstices are filled with impermeable compound.
- I. Lead Content: Less than 300 parts per million.
- J. Shielding: **[Copper tape][Solid copper wires]**, helically applied over semiconducting insulation shield.
- K. Shielding and Jacket: Corrugated copper drain wires embedded in extruded, chlorinated, polyethylene jacket.
- L. Three-Conductor Cable Assembly: Three insulated, shielded conductors cabled together **[with ground conductors]**.
 - 1. Circuit Identification: Color-coded tape (black, red, blue) under the metallic shielding.
- M. Cable Sheath: **[Interlocked aluminum][Interlocked galvanized steel][Corrugated aluminum tube]** applied over cable.
- N. Cable Jacket: **[Sunlight-resistant PVC][Chlorosulfonated polyethylene]**.

2.3 CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[3M]**
 - 2. **[ABB, Electrification Business]**
 - 3. **[DSG-Canusa; Shawcor Ltd.]**
 - 4. **[Eaton]**
 - 5. **[G&W Electric Company]**
 - 6. **[TE Connectivity Ltd.]**
 - 7. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[3M]**
 - 2. **[ABB, Electrification Business]**
 - 3. **[DSG-Canusa; Shawcor Ltd.]**
 - 4. **[Eaton]**
 - 5. **[G&W Electric Company]**
 - 6. **[TE Connectivity Ltd.]**
 - 7. **<Insert manufacturer's name>**
- C. Comply with ANSI C119.4 for connectors between aluminum conductors or for connections between aluminum to copper conductors.
- D. Copper-Conductor Connectors: **[Copper barrel crimped][Aluminum barrel crimped][Copper shear bolt]** connectors.

2.4 SOLID TERMINATIONS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide**

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

1. [3M]
2. [ABB, Electrification Business]
3. [DSG-Canusa; Shawcor Ltd.]
4. [G&W Electric Company]
5. [Shawflex; Shawcor Ltd.]
6. [TE Connectivity Ltd.]
7. <Insert manufacturer's name>

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

1. [3M]
2. [ABB, Electrification Business]
3. [DSG-Canusa; Shawcor Ltd.]
4. [G&W Electric Company]
5. [Shawflex; Shawcor Ltd.]
6. [TE Connectivity Ltd.]
7. <Insert manufacturer's name>

C. Multiconductor Cable Sheath Seals: Type recommended by seal manufacturer for type of cable and installation conditions, including orientation.

1. Compound-filled, cast-metal-body, metal-clad cable terminator for metal-clad cable [with][without] external plastic jacket.
2. Cold-shrink sheath seal kit with preformed sleeve openings sized for cable and insulated conductors.
3. Heat-shrink sheath seal kit with phase- and ground-conductor rejacketing tubes, cable-end sealing boot, and sealing plugs for unused ground-wire openings in boot.
4. Cast-epoxy-resin sheath seal kit with wraparound mold and packaged, two-part, epoxy-resin casting material.

D. Shielded-Cable Terminations: Comply with the following classes of IEEE 48. Insulation class shall be equivalent to that of cable. Include shield ground strap for shielded cable terminations.

1. Class 1 Terminations:
 - a. Modular type, furnished as a kit, with stress-relief tube; multiple, molded-silicone-rubber, insulator modules; shield ground strap; and compression-type connector.
 - b. Heat-shrink type with heat-shrink inner stress control and outer nontracking tubes; multiple, molded, nontracking skirt modules; and compression-type connector.
 - c. Modular type, furnished as a kit, with stress-relief shield terminator; multiple-wet-process, porcelain, insulator modules; shield ground strap; and compression-type connector.
 - d. Indoors: Kit with stress-relief tube, nontracking insulator tube, shield ground strap, compression-type connector, and end seal.
2. Class 2 Terminations, Indoors: Kit with stress-relief tube, nontracking insulator tube, shield ground strap, and compression-type connector. Include silicone-rubber tape; cold-shrink-rubber sleeve; or heat-shrink, plastic-sleeve moisture seal for end of insulation whether or not supplied with kits.
3. Class 3 Terminations: Kit with stress cone and compression-type connector.

2.5 SEPARABLE INSULATED CONNECTORS

- A. Description: Modular system, complying with IEEE 386, with disconnecting, single-pole, cable terminators and with matching, stationary, plug-in, dead-front terminals designed for cable voltage and for sealing against moisture.
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[ABB, Electrification Business]**
 - 2. **[Eaton]**
 - 3. **[Richards Manufacturing Co.]**
 - 4. **<Insert manufacturer's name>**
- C. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[ABB, Electrification Business]**
 - 2. **[Eaton]**
 - 3. **[Richards Manufacturing Co.]**
 - 4. **<Insert manufacturer's name>**
- D. Terminations at Distribution Points: Modular type, consisting of terminators installed on cables and modular, dead-front, terminal junctions for interconnecting cables.
- E. Load-Break Cable Terminators: Elbow-type units with 200 A load make/break and continuous-current rating; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.
- F. Dead-Break Cable Terminators: Elbow-type unit with **[200 A][600 A]** continuous-current rating; designed for de-energized disconnecting and connecting; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.
- G. Dead-Front Terminal Junctions: Modular bracket-mounted groups of dead-front stationary terminals that mate and match with above cable terminators. Two-, three-, or four-terminal units as indicated, with fully rated, insulated, watertight conductor connection between terminals and complete with grounding lug, manufacturer's standard accessory stands, stainless steel mounting brackets, and attaching hardware.
 - 1. Protective Cap: Insulating, electrostatic-shielding, water-sealing cap with drain wire.
 - 2. Portable Feed-Through Accessory: Two-terminal, dead-front junction arranged for removable mounting on accessory stand of stationary terminal junction.
 - 3. Grounding Kit: Jumpered elbows, portable feed-through accessory units, protective caps, test rods suitable for concurrently grounding three phases of feeders, and carrying case.
 - 4. Standoff Insulator: Portable, single dead-front terminal for removable mounting on accessory stand of stationary terminal junction. Insulators suitable for fully insulated isolation of energized cable-elbow terminator.
- H. Test-Point Fault Indicators: Applicable current-trip ratings and arranged for installation in test points of load-break separable connectors, and complete with self-resetting indicators capable of being installed with shotgun hot stick and tested with test tool.
- I. Tool Set: Shotgun hot stick with energized terminal indicator, fault-indicator test tool, and carrying case.



2.6 SPLICE KITS

- A. Description: For connecting medium voltage cables; type as recommended by cable or splicing kit manufacturer for the application.
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1. **[3M]**
 - 2. **[ABB, Electrification Business]**
 - 3. **[DSG-Canusa; Shawcor Ltd.]**
 - 4. **[Eaton]**
 - 5. **[Richards Manufacturing Co.]**
 - 6. **[TE Connectivity Ltd.]**
 - 7. **<Insert manufacturer's name>**
- C. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[3M]**
 - 2. **[ABB, Electrification Business]**
 - 3. **[DSG-Canusa; Shawcor Ltd.]**
 - 4. **[Eaton]**
 - 5. **[Richards Manufacturing Co.]**
 - 6. **[TE Connectivity Ltd.]**
 - 7. **<Insert manufacturer's name>**
- D. Standard: Comply with IEEE 404.
- E. Splicing Products: As recommended, in writing, by splicing kit manufacturer for specific sizes, materials, ratings, and configurations of cable conductors. Include all components required for complete splice, with detailed instructions.
 - 1. Combination tape and cold-shrink-rubber sleeve kit with re-jacketing by cast-epoxy-resin encasement or other waterproof, abrasion-resistant material.
 - 2. Heat-shrink splicing kit of uniform, cross-section, polymeric construction with outer heat-shrink jacket.
 - 3. Premolded, cold-shrink-rubber, in-line splicing kit.
 - 4. Premolded, EPDM splicing body kit with cable joint sealed by interference fit of mating parts and cable.
 - 5. Separable multiway splice system with all components for the required splice configuration.

2.7 MEDIUM-VOLTAGE TAPES

- A. Description: Electrical grade, insulating tape rated for medium voltage application.
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1. **[3M]**
 - 2. **[HellermannTyton]**
 - 3. **[Scapa Industrial; Scapa Group plc]**

4. <Insert manufacturer's name>

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

1. **[3M]**
2. **[HellermannTyton]**
3. **[Scapa Industrial; Scapa Group plc]**
4. **<Insert manufacturer's name>**

- D. Ethylene/propylene rubber-based, **30 mil (0.76 mm)** splicing tape, rated for 130 deg C operation. Minimum **3/4 inch (20 mm)** wide.
- E. Silicone rubber-based, **12 mil (0.30 mm)** self-fusing tape, rated for 130 deg C operation. Minimum **1-1/2 inch (38 mm)** wide.
- F. Insulating-putty, **125 mil (3.175 mm)** elastic filler tape. Minimum **1-1/2 inch (38 mm)** wide.

2.8 ARC-PROOFING MATERIALS

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

1. **[3M]**
2. **<Insert manufacturer's name>**

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

1. **[3M]**
2. **<Insert manufacturer's name>**

- D. Tape for First Course on Metal Objects: **10 mil (250 micrometer)** thick, corrosion-protective, moisture-resistant, PVC pipe-wrapping tape.
- E. Arc-Proofing Tape: Fireproof tape, flexible, conformable, intumescent to **0.3 inch (8 mm)** thick, and compatible with cable jacket.
- F. Glass-Cloth Tape: Pressure-sensitive adhesive type, **1 inch (25 mm)** wide.

2.9 FAULT INDICATORS

- A. Indicators: **[Automatically][Manually]** reset fault indicator **[with inrush restraint feature]**, arranged to clamp to cable sheath and provide a display after a fault has occurred in cable. Instrument shall not be affected by heat, moisture, and corrosive conditions and shall be recommended by manufacturer for installation conditions.
- B. Resetting Tool: Designed for use with fault indicators, with moisture-resistant storage and carrying case.

2.10 SOURCE QUALITY CONTROL

- A. Test and inspect cables according to [ICEA S-97-682][ICEA S-94-649] before shipping.
- B. Test strand-filled cables for water-penetration resistance according to ICEA T-31-610, using a test pressure of **5 psig (35 kPa)**.

PART 3 - EXECUTION**3.1 INSTALLATION**

- A. Install cables according to IEEE 576.
- B. Proof conduits prior to conductor installation by passing a wire brush mandrel and then a rubber duct swab through the conduit. Separate the wire brush and the rubber swab by **48 to 72 inch (1200 to 1800 mm)** on the pull rope.
 - 1. Wire Brush Mandrel: Consists of a length of brush approximately the size of the conduit inner diameter with stiff steel bristles and an eye on each end for attaching the pull ropes. If an obstruction is felt, pull the brush back and forth repeatedly to break up the obstruction.
 - 2. Rubber Duct Swab: Consists of a series of rubber discs approximately the size of the conduit inner diameter on a length of steel cable with an eye on each end for attaching the pull ropes. Pull the rubber duct swab through the duct to extract loose debris from the duct.
- C. Pull Conductors: Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
 - 1. Where necessary, use manufacturer-approved pulling compound or lubricant that does not deteriorate conductor or insulation.
 - 2. Use pulling means, including fish tape, cable, rope, and basket-weave cable grips, that do not damage cables and raceways. Do not use rope hitches for pulling attachment to cable.
 - 3. Use pull-in guides, cable feeders, and draw-in protectors as required to protect cables during installation.
 - 4. Do not pull cables with ends unsealed. Seal cable ends with rubber tape.
- D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.
- E. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."
- F. Install direct-buried cables on leveled and tamped bed of **3 inch (75 mm)** thick, clean sand. Separate cables crossing other cables or piping by a minimum of **2 inch (50 mm)** of tamped earth, plus an additional **2 inch (50 mm)** of sand. Install permanent markers at ends of cable runs, changes in direction, and buried splices.
- G. Install "buried-cable" warning tape **12 inch (305 mm)** above cables.
- H. In manholes, handholes, pull boxes, junction boxes, and cable vaults, train cables around walls by the longest route from entry to exit; support cables at intervals adequate to prevent sag.
- I. Install sufficient cable length to remove cable ends under pulling grips. Remove length of conductor damaged during pulling.

- J. Install cable splices at pull points and elsewhere as indicated; use standard kits. [**Use dead-front separable watertight connectors in manholes and other locations subject to water infiltration.**]
- K. Install terminations at ends of conductors, and seal multiconductor cable ends with standard kits.
- L. Install separable insulated-connector components as follows:
 - 1. Protective Cap: At each terminal junction, with one on each terminal to which no feeder is indicated to be connected.
 - 2. Portable Feed-Through Accessory: At each terminal junction, with one on each terminal.
 - 3. Standoff Insulator: At each terminal junction, with one on each terminal.
- M. Arc Proofing: Unless otherwise indicated, arc proof medium-voltage cable at locations not protected by conduit, cable tray, direct burial, or termination materials. In addition to arc-proofing tape manufacturer's written instructions, apply arc proofing as follows:
 - 1. Clean cable sheath.
 - 2. Wrap metallic cable components with **10 mil (250 micrometer)** pipe-wrapping tape.
 - 3. Smooth surface contours with electrical insulation putty.
 - 4. Apply arc-proofing tape in one half-lapped layer with coated side toward cable.
 - 5. Band arc-proofing tape with two layers of **1 inch (25 mm)** wide half-lapped, adhesive, glass-cloth tape at each end of the arc-proof tape.
- N. Seal around cables passing through fire-rated elements according to Section 078413 "Penetration Firestopping."
- O. Install fault indicators on each phase where indicated.
- P. Ground shields of shielded cable at terminations, splices, and separable insulated connectors. Ground metal bodies of terminators, splices, cable and separable insulated-connector fittings, and hardware.
- Q. Ground shields of shielded cable at one point only. Maintain shield continuity and connections to metal connection hardware at all connection points.
- R. Identify cables according to Section 260553 "Identification for Electrical Systems." Identify phase and circuit number of each conductor at each splice, termination, pull point, and junction box. Arrange identification so that it is unnecessary to move the cable or conductor to read the identification.

3.2 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
 - 2. After installing medium-voltage cables and before electrical circuitry has been energized, test for compliance with requirements.
 - 3. Perform direct-current High Potential test of each new conductor according to NETA ATS, Ch. 7.3.3. Do not exceed cable manufacturer's recommended maximum test voltage.
 - 4. Perform Partial Discharge test of each new conductor according to NETA ATS, Ch. 7.3.3 and to test equipment manufacturer's recommendations.
 - 5. Perform Dissipation Factor test of each new conductor according to NETA ATS, Ch. 7.3.3 and to test equipment manufacturer's recommendations.
- B. Medium-voltage cables will be considered defective if they do not pass tests and inspections.

26 - Electrical



-
- C. Prepare test and inspection reports.

END OF SECTION 26 05 13 00



Task	Specification	Specification Description
26 05 13 00	26 05 00 00	Sleeves and Sleeve Seals for Electrical Raceways and Cabling
26 05 13 16	26 05 13 00	Medium-Voltage Cables
26 05 13 16	26 05 19 00	Low-Voltage Electrical Power Conductors and Cables
26 05 13 16	26 05 00 00	Sleeves and Sleeve Seals for Electrical Raceways and Cabling



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SECTION 26 05 19 00 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Thermoplastic-insulated wire.
2. Thermoset-insulated wire.
3. Nonmetallic underground conduit with conductors.
4. Metallic sheathed cable.
5. Photovoltaic single-conductor cable.
6. Nonmetallic jacketed cable.
7. Connectors and splices.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. Section 078413 "Penetration Firestopping" specifies materials and methods for sealing penetrations of rated walls and partitions referenced by this Section.
5. Section 260513 "Medium-Voltage Cables" for single-conductor and multiconductor cables, cable splices, and terminations for electrical distribution systems with 601 to 35 000 V.
6. Section 260523 "Control-Voltage Electrical Power Cables" for control systems communications cables and Classes 1, 2, and 3 control cables.
7. Section 260526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding referenced by this Section.
8. Section 260529 "Hangers and Supports for Electrical Systems" specifies hangers, supports, and concrete bases referenced by this Section.
9. Section 260533.13 "Conduits for Electrical Systems" specifies installation of raceways referenced by this Section.
10. Section 260536 "Cable Trays for Electrical Systems" specifies cable tray installation referenced by this Section.
11. Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling" specifies installation of sleeves and sleeve seals referenced by this Section.
12. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs referenced by this Section.
13. Section 271313 "Communications Copper Backbone Cabling" for twisted pair cabling used for data circuits.
14. Section 271513 "Communications Copper Horizontal Cabling" for twisted pair cabling used for data circuits.

1.2 DEFINITIONS

- ##### A.
- NICET: National Institute for Certification in Engineering Technologies; a division of the National Society of Professional Engineers (NSPE).

1.3 ACTION SUBMITTALS

- A. Product Schedule: Indicate type, use, location, and termination locations.
- B. Product Data: For each type of product.
- C. Sustainable Design Submittals:
 - 1. Product Data: For each conductor and cable indicating lead content.
 - 2. Product Data: For recycled content, indicating percentage of postconsumer and preconsumer recycled content and cost.
 - 3. Product Data: For solvents and adhesives, indicating VOC content.
 - 4. Laboratory Test Reports: For solvents and adhesives, indicating compliance with requirements for low-emitting materials.
- D. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

- A. Manufacturer's published instructions.
- B. Field Reports:
 - 1. Field reports for infrared scanning.

1.5 QUALIFICATIONS

- A. Electrical Power Testing (EPT) Technician III: Possessing active NICET EPT Level III certification. Able to manage switching procedures, to conduct tests of complex equipment, to analyze test and equipment data, to plan a job, and to lead a team. Has experience performing NFPA 70B, IEEE, and NETA electrical tests.
- B. Electrical Power Testing (EPT) Technician IV: Possessing active NICET EPT Level IV certification. Able to conduct tests of complex metering and relay systems; to evaluate tests, test equipment, test results, and power system performance; to recommend actions to maintain or improve system performance; and to lead multi-team projects.
- C. Electrical Power Testing and Inspecting Agency: Entities possessing active credentials from qualified electrical testing laboratory recognized by authorities having jurisdiction.
 - 1. On-site electrical testing supervisors must possess active NICET EPT Technician [III][IV] certification.

PART 2 - PRODUCTS**2.1 PERFORMANCE REQUIREMENTS**

- A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2.2 THERMOPLASTIC-INSULATED WIRE

- A. Description: Thermoplastic-insulated wire for use in accordance with Article 310 of NFPA 70.
- B. UL ZLGR - Type THHN Insulated Wire :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Alpha Wire; brand of Belden, Inc.]**
 - b. **[Belden Inc.]**
 - c. **[Cerro Wire LLC]**
 - d. **[Encore Wire Corporation]**
 - e. **[Okonite Company (The)]**
 - f. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - g. **[Southwire Company, LLC]**
 - h. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Alpha Wire; brand of Belden, Inc.]**
 - b. **[Belden Inc.]**
 - c. **[Cerro Wire LLC]**
 - d. **[Encore Wire Corporation]**
 - e. **[Okonite Company (The)]**
 - f. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - g. **[Southwire Company, LLC]**
 - h. **<Insert manufacturer's name>**
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Thermoplastic-Insulated Wire: UL CCN ZLGR, including UL 83.
 4. Standard Features:
 - a. Referenced Standard: Article 310 of NFPA 70.
 - b. Insulation Voltage Rating: 600 V.
 - c. Insulation Temperature Rating: 90 deg C.
 - d. Conductor Material: **[Copper][Aluminum][Copper-clad aluminum].**
 - e. Conductor Size:**[As indicated on the Drawings.]**
 - 1) Minimum Conductor Size: **[14 AWG][12 AWG][10 AWG].**
 5. Other Available Features Required by the Project:
 - a. Marked "Cable Tray Use" or "CT," indicating compliance with vertical-tray cable flame test.
 - b. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
 - c. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
 - d. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
 - e. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to



- gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
- f. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
- g. Marked "VW-1," indicating compliance with special vertical flame test.
- h. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.

C. UL ZLGR - Type THHW Insulated Wire :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Alpha Wire; brand of Belden, Inc.]**
 - b. **[Encore Wire Corporation]**
 - c. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - d. **[Southwire Company, LLC]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Alpha Wire; brand of Belden, Inc.]**
 - b. **[Encore Wire Corporation]**
 - c. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - d. **[Southwire Company, LLC]**
 - e. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Thermoplastic-Insulated Wire: UL CCN ZLGR, including UL 83.
4. Standard Features:
 - a. Referenced Standard: Article 310 of NFPA 70.
 - b. Insulation Voltage Rating: 600 V.
 - c. Insulation Temperature Rating: **[75 deg C][90 deg C]**.
 - d. Conductor Material: **[Copper][Aluminum][Copper-clad aluminum]**.
 - e. Conductor Size: **[As indicated on the Drawings.]**
 - 1) Minimum Conductor Size: **[14 AWG][12 AWG][10 AWG]**.
5. Other Available Features Required by the Project:
 - a. Marked "Cable Tray Use" or "CT," indicating compliance with vertical-tray cable flame test.
 - b. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
 - c. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
 - d. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
 - e. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
 - f. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.

- g. Marked "VW-1," indicating compliance with special vertical flame test.
- h. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.

D. UL ZLGR - Type THW Insulated Wire :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Alpha Wire; brand of Belden, Inc.]**
 - b. **[Belden Inc.]**
 - c. **[Cerro Wire LLC]**
 - d. **[Encore Wire Corporation]**
 - e. **[Okonite Company (The)]**
 - f. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - g. **[Service Wire Co.]**
 - h. **[Southwire Company, LLC]**
 - i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Alpha Wire; brand of Belden, Inc.]**
 - b. **[Belden Inc.]**
 - c. **[Cerro Wire LLC]**
 - d. **[Encore Wire Corporation]**
 - e. **[Okonite Company (The)]**
 - f. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - g. **[Service Wire Co.]**
 - h. **[Southwire Company, LLC]**
 - i. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Thermoplastic-Insulated Wire: UL CCN ZLGR, including UL 83.
4. Standard Features:
 - a. Referenced Standard: Article 310 of NFPA 70.
 - b. Insulation Voltage Rating: 600 V.
 - c. Insulation Temperature Rating: **[75 deg C][90 deg C]**.
 - d. Conductor Material: **[Copper][Aluminum][Copper-clad aluminum]**.
 - e. Conductor Size:**[As indicated on the Drawings.]**
 - 1) Minimum Conductor Size: **[14 AWG][12 AWG][10 AWG]**.
5. Other Available Features Required by the Project:
 - a. Marked "Cable Tray Use" or "CT," indicating compliance with vertical-tray cable flame test.
 - b. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
 - c. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
 - d. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.



- e. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
- f. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
- g. Marked "VW-1," indicating compliance with special vertical flame test.
- h. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.

E. UL ZLGR - Type THW-2 Insulated Wire :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Alpha Wire; brand of Belden, Inc.]**
 - b. **[Belden Inc.]**
 - c. **[Cerro Wire LLC]**
 - d. **[Encore Wire Corporation]**
 - e. **[Okonite Company (The)]**
 - f. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - g. **[Service Wire Co.]**
 - h. **[Southwire Company, LLC]**
 - i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Alpha Wire; brand of Belden, Inc.]**
 - b. **[Belden Inc.]**
 - c. **[Cerro Wire LLC]**
 - d. **[Encore Wire Corporation]**
 - e. **[Okonite Company (The)]**
 - f. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - g. **[Service Wire Co.]**
 - h. **[Southwire Company, LLC]**
 - i. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Thermoplastic-Insulated Wire: UL CCN ZLGR, including UL 83.
4. Standard Features:
 - a. Referenced Standard: Article 310 of NFPA 70.
 - b. Insulation Voltage Rating: 600 V.
 - c. Insulation Temperature Rating: 90 deg C.
 - d. Conductor Material: **[Copper][Aluminum][Copper-clad aluminum]**.
 - e. Conductor Size: **[As indicated on the Drawings.]**
 - 1) Minimum Conductor Size: **[14 AWG][12 AWG][10 AWG]**.
5. Other Available Features Required by the Project:

- a. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
- b. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
- c. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
- d. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
- e. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
- f. Marked "VW-1," indicating compliance with special vertical flame test.
- g. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.

F. UL ZLGR - Type THWN Insulated Wire :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Alpha Wire; brand of Belden, Inc.]**
 - b. **[Belden Inc.]**
 - c. **[Cerro Wire LLC]**
 - d. **[Encore Wire Corporation]**
 - e. **[Okonite Company (The)]**
 - f. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - g. **[Southwire Company, LLC]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Alpha Wire; brand of Belden, Inc.]**
 - b. **[Belden Inc.]**
 - c. **[Cerro Wire LLC]**
 - d. **[Encore Wire Corporation]**
 - e. **[Okonite Company (The)]**
 - f. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - g. **[Southwire Company, LLC]**
 - h. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Thermoplastic-Insulated Wire: UL CCN ZLGR, including UL 83.
4. Standard Features:
 - a. Referenced Standard: Article 310 of NFPA 70.
 - b. Insulation Voltage Rating: 600 V.
 - c. Insulation Temperature Rating: 75 deg C.
 - d. Conductor Material: **[Copper][Aluminum][Copper-clad aluminum]**.
 - e. Conductor Size: **[As indicated on the Drawings.]**
 - 1) Minimum Conductor Size: **[14 AWG][12 AWG][10 AWG]**.
5. Other Available Features Required by the Project:



- a. Marked "Cable Tray Use" or "CT," indicating compliance with vertical-tray cable flame test.
- b. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
- c. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
- d. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
- e. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
- f. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
- g. Marked "VW-1," indicating compliance with special vertical flame test.
- h. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.

G. UL ZLGR - Type THWN-2 Insulated Wire :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Alpha Wire; brand of Belden, Inc.]**
 - b. **[Belden Inc.]**
 - c. **[Cerro Wire LLC]**
 - d. **[Encore Wire Corporation]**
 - e. **[Okonite Company (The)]**
 - f. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - g. **[Southwire Company, LLC]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Alpha Wire; brand of Belden, Inc.]**
 - b. **[Belden Inc.]**
 - c. **[Cerro Wire LLC]**
 - d. **[Encore Wire Corporation]**
 - e. **[Okonite Company (The)]**
 - f. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - g. **[Southwire Company, LLC]**
 - h. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Thermoplastic-Insulated Wire: UL CCN ZLGR, including UL 83.
4. Standard Features:
 - a. Referenced Standard: Article 310 of NFPA 70.
 - b. Insulation Voltage Rating: 600 V.
 - c. Insulation Temperature Rating: 90 deg C.
 - d. Conductor Material: **[Copper][Aluminum][Copper-clad aluminum]**.
 - e. Conductor Size: **[As indicated on the Drawings.]**
 - 1) Minimum Conductor Size: **[14 AWG][12 AWG][10 AWG]**.

5. Other Available Features Required by the Project:
- a. Marked "Cable Tray Use" or "CT," indicating compliance with vertical-tray cable flame test.
 - b. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
 - c. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
 - d. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
 - e. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
 - f. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
 - g. Marked "VW-1," indicating compliance with special vertical flame test.
 - h. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.

H. UL ZLGR - Type TW Insulated Wire :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
- a. **[Alpha Wire; brand of Belden, Inc.]**
 - b. **[Belden Inc.]**
 - c. **[Cerro Wire LLC]**
 - d. **[Encore Wire Corporation]**
 - e. **[Okonite Company (The)]**
 - f. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - g. **[Service Wire Co.]**
 - h. **[Southwire Company, LLC]**
 - i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[Alpha Wire; brand of Belden, Inc.]**
 - b. **[Belden Inc.]**
 - c. **[Cerro Wire LLC]**
 - d. **[Encore Wire Corporation]**
 - e. **[Okonite Company (The)]**
 - f. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - g. **[Service Wire Co.]**
 - h. **[Southwire Company, LLC]**
 - i. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
- a. Thermoplastic-Insulated Wire: UL CCN ZLGR, including UL 83.
4. Standard Features:
- a. Referenced Standard: Article 310 of NFPA 70.
 - b. Insulation Voltage Rating: 600 V.
 - c. Insulation Temperature Rating: 60 deg C.
 - d. Conductor Material: **[Copper][Aluminum][Copper-clad aluminum]**.



e. Conductor Size:[**As indicated on the Drawings.**]

1) Minimum Conductor Size: [**14 AWG**][**12 AWG**][**10 AWG**].

5. Other Available Features Required by the Project:

- a. Marked "Cable Tray Use" or "CT," indicating compliance with vertical-tray cable flame test.
- b. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
- c. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
- d. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
- e. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
- f. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
- g. Marked "VW-1," indicating compliance with special vertical flame test.
- h. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.

I. UL ZLGR - Type FEP Insulated Wire :

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

- a. [**Belden Inc.**]
- b. [**Prysmian Cables and Systems; Prysmian Group North America**]
- c. [**Southwire Company, LLC**]
- d. <Insert manufacturer's name>

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

- a. [**Belden Inc.**]
- b. [**Prysmian Cables and Systems; Prysmian Group North America**]
- c. [**Southwire Company, LLC**]
- d. <Insert manufacturer's name>

3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

a. Thermoplastic-Insulated Wire: UL CCN ZLGR, including UL 83.

1) Thermoplastic Fluoropolymer Wire: Also investigated in accordance with UL 83A.

4. Standard Features:

- a. Referenced Standard: Article 310 of NFPA 70.
- b. Covering: None.
- c. Insulation Voltage Rating: 600 V.
- d. Insulation Temperature Rating: 90 deg C for dry and damp locations.
- e. Conductor Material: [**Copper**][**Aluminum**][**Copper-clad aluminum**].
- f. Conductor Size:[**As indicated on the Drawings.**]

- 1) Minimum Conductor Size: **[14 AWG][12 AWG][10 AWG]**.
5. Other Available Features Required by the Project:
- a. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
 - b. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
 - c. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
 - d. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
 - e. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
 - f. Marked "VW-1," indicating compliance with special vertical flame test.
 - g. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.
- J. UL ZLGR - Type FEPB Insulated Wire :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Belden Inc.]**
 - b. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - c. **[Southwire Company, LLC]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Belden Inc.]**
 - b. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - c. **[Southwire Company, LLC]**
 - d. **<Insert manufacturer's name>**
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Thermoplastic-Insulated Wire: UL CCN ZLGR, including UL 83.
 - 1) Thermoplastic Fluoropolymer Wire: Also investigated in accordance with UL 83A.
 4. Standard Features:
 - a. Referenced Standard: Article 310 of NFPA 70.
 - b. Covering: Glass or other suitable braid material.
 - c. Insulation Voltage Rating: 600 V.
 - d. Insulation Temperature Rating: 200 deg C for dry locations.
 - e. Conductor Material: **[Copper][Aluminum][Copper-clad aluminum]**.
 - f. Conductor Size:**[As indicated on the Drawings.]**
 - 1) Minimum Conductor Size: **[14 AWG][12 AWG][10 AWG]**.
 5. Other Available Features Required by the Project:



- a. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
- b. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
- c. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
- d. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
- e. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
- f. Marked "VW-1," indicating compliance with special vertical flame test.
- g. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.

K. UL ZLGR - Type Z Insulated Wire :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Belden Inc.]**
 - b. **[Okonite Company (The)]**
 - c. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - d. **[Southwire Company, LLC]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Belden Inc.]**
 - b. **[Okonite Company (The)]**
 - c. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - d. **[Southwire Company, LLC]**
 - e. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Thermoplastic-Insulated Wire: UL CCN ZLGR, including UL 83.
 - 1) Thermoplastic Fluoropolymer Wire: Also investigated in accordance with UL 83A.
4. Standard Features:
 - a. Referenced Standard: Article 310 of NFPA 70.
 - b. Insulation Voltage Rating: 600 V.
 - c. Insulation Temperature Rating: **[90 deg C for dry and damp locations][150 deg C for dry locations and special applications].**
 - d. Conductor Material: **[Copper][Aluminum][Copper-clad aluminum].**
 - e. Conductor Size:**[As indicated on the Drawings.]**
 - 1) Minimum Conductor Size: **[14 AWG][12 AWG][10 AWG].**
5. Other Available Features Required by the Project:
 - a. Marked "Cable Tray Use" or "CT," indicating compliance with vertical-tray cable flame test.

- b. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
- c. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
- d. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
- e. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
- f. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
- g. Marked "VW-1," indicating compliance with special vertical flame test.
- h. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.

L. UL ZLGR - Type ZW Insulated Wire :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Belden Inc.]**
 - b. **[Okonite Company (The)]**
 - c. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Belden Inc.]**
 - b. **[Okonite Company (The)]**
 - c. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - d. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Thermoplastic-Insulated Wire: UL CCN ZLGR, including UL 83.
 - 1) Thermoplastic Fluoropolymer Wire: Also investigated in accordance with UL 83A.
4. Standard Features:
 - a. Referenced Standard: Article 310 of NFPA 70.
 - b. Insulation Voltage Rating: 600 V.
 - c. Insulation Temperature Rating: **[60 deg C][75 deg C][85 deg C][90 deg C][150 deg C][200 deg C][250 deg C]**.
 - d. Conductor Material: **[Copper][Aluminum][Copper-clad aluminum]**.
 - e. Conductor Size:**[As indicated on the Drawings.]**
 - 1) Minimum Conductor Size: **[14 AWG][12 AWG][10 AWG]**.
5. Other Available Features Required by the Project:
 - a. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
 - b. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
 - c. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
 - d. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to

- gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
- e. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
- f. Marked "VW-1," indicating compliance with special vertical flame test.
- g. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.

M. UL ZLGR - Type ZW-2 Insulated Wire :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Okonite Company (The)]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Okonite Company (The)]**
 - b. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Thermoplastic-Insulated Wire: UL CCN ZLGR, including UL 83.
 - 1) Thermoplastic Fluoropolymer Wire: Also investigated in accordance with UL 83A.
4. Standard Features:
 - a. Referenced Standard: Article 310 of NFPA 70.
 - b. Insulation Voltage Rating: 600 V.
 - c. Insulation Temperature Rating: **[75 deg C for wet locations][90 deg C for dry and damp locations][150 deg C for dry locations and special applications].**
 - d. Conductor Material: **[Copper][Aluminum][Copper-clad aluminum].**
 - e. Conductor Size: **[As indicated on the Drawings.]**
 - 1) Minimum Conductor Size: **[14 AWG][12 AWG][10 AWG].**
5. Other Available Features Required by the Project:
 - a. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
 - b. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
 - c. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
 - d. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
 - e. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
 - f. Marked "VW-1," indicating compliance with special vertical flame test.
 - g. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.

N. UL ZLGR - Type TBS Insulated Switchboard Wire :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Belden Inc.]**
 - b. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - c. **[Southwire Company, LLC]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Belden Inc.]**
 - b. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - c. **[Southwire Company, LLC]**
 - d. **<Insert manufacturer's name>**
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Thermoplastic-Insulated Wire: UL CCN ZLGR, including UL 83.
 - 1) Thermoplastic and Fibrous Outer Braid: Also investigated in accordance with UL 83B.
 4. Standard Features:
 - a. Referenced Standard: Article 310 of NFPA 70.
 - b. Insulation Voltage Rating: 600 V.
 - c. Insulation Temperature Rating: 90 deg C.
 - d. Conductor Material: **[Copper][Aluminum][Copper-clad aluminum]**.
 - e. Conductor Size: **[As indicated on the Drawings.]**
 - 1) Minimum Conductor Size: **[14 AWG][12 AWG][10 AWG]**.
 5. Other Available Features Required by the Project:
 - a. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
 - b. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
 - c. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
 - d. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
 - e. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
 - f. Marked "VW-1," indicating compliance with special vertical flame test.
 - g. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.
- O. UL ZLGR - Thermoplastic-Insulated Submersible Pump Multiconductor Cable :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:



- a. [Cerro Wire LLC]
 - b. [Encore Wire Corporation]
 - c. [Prysmian Cables and Systems; Prysmian Group North America]
 - d. [Southwire Company, LLC]
 - e. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Cerro Wire LLC]
 - b. [Encore Wire Corporation]
 - c. [Prysmian Cables and Systems; Prysmian Group North America]
 - d. [Southwire Company, LLC]
 - e. <Insert manufacturer's name>

3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Thermoplastic-Insulated Wire: UL CCN ZLGR, including UL 83.
 - 1) Submersible Pump Cable: Also investigated in accordance with UL CCN FDNP, including NSF 61.

4. Standard Features:
 - a. Referenced Standard: Article 310 of NFPA 70.
 - b. Insulation Voltage Rating: 600 V.
 - c. Insulation Material: Type THW.
 - d. Insulation Temperature Rating: 75 deg C.
 - e. Conductor Material: Copper.
 - f. Conductor Size: [**As indicated on the Drawings.**]
 - 1) Minimum Conductor Size: [**14 AWG**][**12 AWG**][**10 AWG**].

5. Other Available Features Required by the Project:
 - a. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
 - b. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
 - c. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
 - d. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
 - e. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
 - f. Marked "VW-1," indicating compliance with special vertical flame test.
 - g. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.

2.3 THERMOSET-INSULATED WIRE

- A. Description: Thermoset-insulated wire for use in accordance with Article 310 of NFPA 70.
- B. UL ZKST - Type RHH Insulated Wire :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Belden Inc.]**
 - b. **[Cerro Wire LLC]**
 - c. **[Encore Wire Corporation]**
 - d. **[Okonite Company (The)]**
 - e. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - f. **[Service Wire Co.]**
 - g. **[Southwire Company, LLC]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Belden Inc.]**
 - b. **[Cerro Wire LLC]**
 - c. **[Encore Wire Corporation]**
 - d. **[Okonite Company (The)]**
 - e. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - f. **[Service Wire Co.]**
 - g. **[Southwire Company, LLC]**
 - h. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Thermoset-Insulated Wire: UL CCN ZKST, including UL 44.
4. Standard Features:
 - a. Referenced Standard: Article 310 of NFPA 70.
 - b. Insulation Voltage Rating: 600 V.
 - c. Insulation Temperature Rating: 90 deg C.
 - d. Conductor Material: **[Copper][Aluminum][Copper-clad aluminum]**.
 - e. Conductor Size:**[As indicated on the Drawings.]**
 - 1) Minimum Conductor Size: **[14 AWG][12 AWG][10 AWG]**.
5. Other Available Features Required by the Project:
 - a. Marked "Cable Tray Use" or "CT," indicating compliance with vertical-tray cable flame test.
 - b. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
 - c. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
 - d. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
 - e. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
 - f. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
 - g. Marked "VW-1," indicating compliance with special vertical flame test.
 - h. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.
 - i. Marked "ST1-HF," indicating that combustible materials are halogen-free in accordance

with UL Subject 2885.

- 1) Marked "ST1-LSHF," indicating that combustible materials are low smoke when also tested in accordance with IEC 61034-2.

C. UL ZKST - Type RHW Insulated Wire :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Belden Inc.]**
 - b. **[Cerro Wire LLC]**
 - c. **[Encore Wire Corporation]**
 - d. **[Okonite Company (The)]**
 - e. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - f. **[Service Wire Co.]**
 - g. **[Southwire Company, LLC]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Belden Inc.]**
 - b. **[Cerro Wire LLC]**
 - c. **[Encore Wire Corporation]**
 - d. **[Okonite Company (The)]**
 - e. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - f. **[Service Wire Co.]**
 - g. **[Southwire Company, LLC]**
 - h. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Thermoset-Insulated Wire: UL CCN ZKST, including UL 44.
4. Standard Features:
 - a. Referenced Standard: Article 310 of NFPA 70.
 - b. Insulation Voltage Rating: 600 V.
 - c. Insulation Temperature Rating: 75 deg C.
 - d. Conductor Material: **[Copper][Aluminum][Copper-clad aluminum]**.
 - e. Conductor Size:**[As indicated on the Drawings]**.
 - 1) Minimum Conductor Size: **[14 AWG][12 AWG][10 AWG]**.
5. Other Available Features Required by the Project:
 - a. Marked "Cable Tray Use" or "CT," indicating compliance with vertical-tray cable flame test.
 - b. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
 - c. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.

- d. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
 - e. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
 - f. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
 - g. Marked "VW-1," indicating compliance with special vertical flame test.
 - h. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.
 - i. Marked "ST1-HF," indicating that combustible materials are halogen-free in accordance with UL Subject 2885.
- 1) Marked "ST1-LSHF," indicating that combustible materials are low smoke when also tested in accordance with IEC 61034-2.

D. UL ZKST - Type RHW-2 Insulated Wire :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Belden Inc.]**
 - b. **[Cerro Wire LLC]**
 - c. **[Encore Wire Corporation]**
 - d. **[Okonite Company (The)]**
 - e. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - f. **[Service Wire Co.]**
 - g. **[Southwire Company, LLC]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Belden Inc.]**
 - b. **[Cerro Wire LLC]**
 - c. **[Encore Wire Corporation]**
 - d. **[Okonite Company (The)]**
 - e. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - f. **[Service Wire Co.]**
 - g. **[Southwire Company, LLC]**
 - h. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Thermoset-Insulated Wire: UL CCN ZKST, including UL 44.
4. Standard Features:
 - a. Referenced Standard: Article 310 of NFPA 70.
 - b. Insulation Voltage Rating: 600 V.
 - c. Insulation Temperature Rating: 90 deg C.
 - d. Conductor Material: **[Copper][Aluminum][Copper-clad aluminum]**.
 - e. Conductor Size: **[As indicated on the Drawings.]**

1) Minimum Conductor Size: **[14 AWG][12 AWG][10 AWG]**.

5. Other Available Features Required by the Project:

- a. Marked "Cable Tray Use" or "CT," indicating compliance with vertical-tray cable flame test.
- b. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
- c. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
- d. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
- e. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
- f. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
- g. Marked "VW-1," indicating compliance with special vertical flame test.
- h. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.
- i. Marked "ST1-HF," indicating that combustible materials are halogen-free in accordance with UL Subject 2885.

1) Marked "ST1-LSHF," indicating that combustible materials are low smoke when also tested in accordance with IEC 61034-2.

E. UL ZKST - Type SA Insulated Wire :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Okonite Company (The)]**
 - b. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - c. **[Southwire Company, LLC]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Okonite Company (The)]**
 - b. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - c. **[Southwire Company, LLC]**
 - d. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Thermoset-Insulated Wire: UL CCN ZKST, including UL 44.
4. Standard Features:
 - a. Referenced Standard: Article 310 of NFPA 70.
 - b. Insulation Voltage Rating: 600 V.
 - c. Insulation Temperature Rating: **[90 deg C for dry and damp locations][200 deg C for special applications]**.
 - d. Conductor Material: **[Copper][Aluminum][Copper-clad aluminum]**.
 - e. Conductor Size: **[As indicated on the Drawings.]**

1) Minimum Conductor Size: **[14 AWG][12 AWG][10 AWG]**.

5. Other Available Features Required by the Project:

- a. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
- b. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
- c. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
- d. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
- e. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
- f. Marked "VW-1," indicating compliance with special vertical flame test.
- g. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.
- h. Marked "ST1-HF," indicating that combustible materials are halogen-free in accordance with UL Subject 2885.

1) Marked "ST1-LSHF," indicating that combustible materials are low smoke when also tested in accordance with IEC 61034-2.

F. UL ZKST - Type XHH Insulated Wire :

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Encore Wire Corporation]**
 - b. **[Okonite Company (The)]**
 - c. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - d. **[Southwire Company, LLC]**
 - e. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Encore Wire Corporation]**
 - b. **[Okonite Company (The)]**
 - c. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - d. **[Southwire Company, LLC]**
 - e. **<Insert manufacturer's name>**
- 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Thermoset-Insulated Wire: UL CCN ZKST, including UL 44.
- 4. Standard Features:
 - a. Referenced Standard: Article 310 of NFPA 70.
 - b. Insulation Voltage Rating: 600 V.
 - c. Insulation Temperature Rating: 90 deg C.
 - d. Conductor Material: **[Copper][Aluminum][Copper-clad aluminum]**.
 - e. Conductor Size: **[As indicated on the Drawings.]**

1) Minimum Conductor Size: **[14 AWG][12 AWG][10 AWG]**.

5. Other Available Features Required by the Project:

- a. Marked "Cable Tray Use" or "CT," indicating compliance with vertical-tray cable flame test.
- b. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
- c. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
- d. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
- e. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
- f. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
- g. Marked "VW-1," indicating compliance with special vertical flame test.
- h. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.
- i. Marked "ST1-HF," indicating that combustible materials are halogen-free in accordance with UL Subject 2885.

1) Marked "ST1-LSHF," indicating that combustible materials are low smoke when also tested in accordance with IEC 61034-2.

G. UL ZKST - Type XHHW Insulated Wire :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Belden Inc.]**
 - b. **[Cerro Wire LLC]**
 - c. **[Encore Wire Corporation]**
 - d. **[Okonite Company (The)]**
 - e. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - f. **[Service Wire Co.]**
 - g. **[Southwire Company, LLC]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Belden Inc.]**
 - b. **[Cerro Wire LLC]**
 - c. **[Encore Wire Corporation]**
 - d. **[Okonite Company (The)]**
 - e. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - f. **[Service Wire Co.]**
 - g. **[Southwire Company, LLC]**
 - h. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Thermoset-Insulated Wire: UL CCN ZKST, including UL 44.

4. Standard Features:
 - a. Referenced Standard: Article 310 of NFPA 70.
 - b. Insulation Voltage Rating: 600 V.
 - c. Insulation Temperature Rating: **[75 deg C for wet locations][90 deg C for dry and damp locations]**.
 - d. Conductor Material: **[Copper][Aluminum][Copper-clad aluminum]**.
 - e. Conductor Size: **[As indicated on the Drawings.]**
 - 1) Minimum Conductor Size: **[14 AWG][12 AWG][10 AWG]**.
 5. Other Available Features Required by the Project:
 - a. Marked "Cable Tray Use" or "CT," indicating compliance with vertical-tray cable flame test.
 - b. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
 - c. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
 - d. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
 - e. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
 - f. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
 - g. Marked "VW-1," indicating compliance with special vertical flame test.
 - h. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.
 - i. Marked "ST1-HF," indicating that combustible materials are halogen-free in accordance with UL Subject 2885.
 - 1) Marked "ST1-LSHF," indicating that combustible materials are low smoke when also tested in accordance with IEC 61034-2.
- H. UL ZKST - Type XHHW-2 Insulated Wire :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Belden Inc.]**
 - b. **[Cerro Wire LLC]**
 - c. **[Encore Wire Corporation]**
 - d. **[Okonite Company (The)]**
 - e. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - f. **[Service Wire Co.]**
 - g. **[Southwire Company, LLC]**
 - h. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Belden Inc.]**
 - b. **[Cerro Wire LLC]**
 - c. **[Encore Wire Corporation]**
 - d. **[Okonite Company (The)]**
 - e. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - f. **[Service Wire Co.]**
 - g. **[Southwire Company, LLC]**



- h. <Insert manufacturer's name>
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Thermoset-Insulated Wire: UL CCN ZKST, including UL 44.
4. Standard Features:
 - a. Referenced Standard: Article 310 of NFPA 70.
 - b. Insulation Voltage Rating: 600 V.
 - c. Insulation Temperature Rating: 90 deg C.
 - d. Conductor Material: [Copper][Aluminum][Copper-clad aluminum].
 - e. Conductor Size: [As indicated on the Drawings.]
 - 1) Minimum Conductor Size: [14 AWG][12 AWG][10 AWG].
5. Other Available Features Required by the Project:
 - a. Marked "Cable Tray Use" or "CT," indicating compliance with vertical-tray cable flame test.
 - b. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
 - c. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
 - d. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
 - e. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
 - f. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
 - g. Marked "VW-1," indicating compliance with special vertical flame test.
 - h. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.
 - i. Marked "ST1-HF," indicating that combustible materials are halogen-free in accordance with UL Subject 2885.
 - 1) Marked "ST1-LSHF," indicating that combustible materials are low smoke when also tested in accordance with IEC 61034-2.
- I. UL ZKST - Type SIS Insulated Switchboard and Switchgear Wire :
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Belden Inc.]
 - b. [Cerro Wire LLC]
 - c. [Encore Wire Corporation]
 - d. [Okonite Company (The)]
 - e. [Prysmian Cables and Systems; Prysmian Group North America]
 - f. [Service Wire Co.]
 - g. [Southwire Company, LLC]
 - h. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [Belden Inc.]
 - b. [Cerro Wire LLC]
 - c. [Encore Wire Corporation]
 - d. [Okonite Company (The)]
 - e. [Prysmian Cables and Systems; Prysmian Group North America]
 - f. [Service Wire Co.]
 - g. [Southwire Company, LLC]
 - h. <Insert manufacturer's name>
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Thermoset-Insulated Wire: UL CCN ZKST, including UL 44.
4. Standard Features:
 - a. Referenced Standard: Article 310 of NFPA 70.
 - b. Insulation Voltage Rating: 600 V.
 - c. Insulation Temperature Rating: 90 deg C.
 - d. Conductor Material: [Copper][Aluminum][Copper-clad aluminum].
 - e. Conductor Size:[As indicated on the Drawings.]
 - 1) Minimum Conductor Size: [14 AWG][12 AWG][10 AWG].
5. Other Available Features Required by the Project:
 - a. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
 - b. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
 - c. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
 - d. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
 - e. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
 - f. Marked "VW-1," indicating compliance with special vertical flame test.
 - g. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.
 - h. Marked "ST1-HF," indicating that combustible materials are halogen-free in accordance with UL Subject 2885.
 - 1) Marked "ST1-LSHF," indicating that combustible materials are low smoke when also tested in accordance with IEC 61034-2.
- J. UL ZKST - Thermoset-Insulated Submersible Pump Multiconductor Cable :
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Belden Inc.]
 - b. [Prysmian Cables and Systems; Prysmian Group North America]
 - c. [Service Wire Co.]
 - d. [Southwire Company, LLC]
 - e. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert



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

- a. **[Belden Inc.]**
 - b. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - c. **[Service Wire Co.]**
 - d. **[Southwire Company, LLC]**
 - e. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
- a. Thermoset-Insulated Wire: UL CCN ZKST, including UL 44.
 - 1) Submersible Pump Cable: Also investigated in accordance with UL CCN FDNP, including NSF 61.
4. Standard Features:
- a. Referenced Standard: Article 310 of NFPA 70.
 - b. Insulation Voltage Rating: 600 V.
 - c. Insulation Material: Type RHW-2.
 - d. Insulation Temperature Rating: 90 deg C.
 - e. Conductor Material: **[Copper][Aluminum][Copper-clad aluminum]**.
 - f. Conductor Size: **[As indicated on the Drawings.]**
 - 1) Minimum Conductor Size: **[14 AWG][12 AWG][10 AWG]**.
5. Other Available Features Required by the Project:
- a. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
 - b. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
 - c. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
 - d. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
 - e. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
 - f. Marked "VW-1," indicating compliance with special vertical flame test.
 - g. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.
 - h. Marked "ST1-HF," indicating that combustible materials are halogen-free in accordance with UL Subject 2885.
 - 1) Marked "ST1-LSHF," indicating that combustible materials are low smoke when also tested in accordance with IEC 61034-2.

2.4 NONMETALLIC UNDERGROUND CONDUIT WITH CONDUCTORS

A. Nonmetallic Underground Conduit with Conductors, Type NUCC :

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

- a. [Blue Diamond Industries, LLC]
 - b. [Paige Electric Co, LP]
 - c. [Prysmian Cables and Systems; Prysmian Group North America]
 - d. [Southwire Company, LLC]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Blue Diamond Industries, LLC]
 - b. [Paige Electric Co, LP]
 - c. [Prysmian Cables and Systems; Prysmian Group North America]
 - d. [Southwire Company, LLC]
 - e. <Insert manufacturer's name>
3. Description: A factory assembly of conductors or cables inside a nonmetallic, smooth-wall raceway with a circular cross section.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Type NUCC Conduit with Conductors: UL CCN QQRK, including UL 1990.
5. Standard Features:
 - a. Referenced Standard: Article 354 of NFPA 70.
 - b. Conduit Material: [HDPE-40][HDPE-80][EPEC-B].
 - c. Conduit Sizes: As indicated on the Drawings.
 - d. Preinstalled Conductors: Provide insulated conductors as indicated on the Drawings.

2.5 METALLIC SHEATHED CABLE

A. UL PJAZ - Metal-Clad Cable, Type MC :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [AFC Cable Systems; Atkore International]
 - b. [Alpha Wire; brand of Belden, Inc.]
 - c. [Belden Inc.]
 - d. [Cerro Wire LLC]
 - e. [Copperweld]
 - f. [Encore Wire Corporation]
 - g. [General Cable; Prysmian Group North America]
 - h. [Okonite Company (The)]
 - i. [Southwire Company, LLC]
 - j. [WESCO]
 - k. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [AFC Cable Systems; Atkore International]
 - b. [Alpha Wire; brand of Belden, Inc.]
 - c. [Belden Inc.]
 - d. [Cerro Wire LLC]
 - e. [Copperweld]
 - f. [Encore Wire Corporation]
 - g. [General Cable; Prysmian Group North America]
 - h. [Okonite Company (The)]
 - i. [Southwire Company, LLC]
 - j. [WESCO]
 - k. <Insert manufacturer's name>
3. Description: A factory assembly of one or more current-carrying insulated conductors in an overall metallic sheath.
 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Metal-Clad Cable: UL CCN PJAZ, including UL 1569.
 5. Standard Features:
 - a. Referenced Standard: Article 330 of NFPA 70.
 - b. Circuits: [Single circuit][and][multicircuit with color-coded conductors].
 - c. Conductors: [Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors][Aluminum, complying with ASTM B800 and ASTM B801].
 - d. Ground Conductor: [Bare][Insulated][None].
 - e. Conductor Insulation:
 - 1) Type TFN/THHN/THWN-2. Comply with UL 83.
 - 2) Type XHHW-2. Comply with UL 44.
 - 3) <Insert type and standard>.
 - f. Armor: [Steel][Aluminum], interlocked.
 - g. Jacket: PVC applied over armor.
 6. Other Available Features Required by the Project:
 - a. Marked "MC-HL," indicating compliance with UL 2225 for use in hazardous (classified) locations.

B. UL AWEZ - Armored Cable, Type AC :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [AFC Cable Systems; Atkore International]
 - b. [Alpha Wire; brand of Belden, Inc.]
 - c. [Belden Inc.]
 - d. [Encore Wire Corporation]
 - e. [General Cable; Prysmian Group North America]
 - f. [Okonite Company (The)]

- g. **[Southwire Company, LLC]**
 - h. **[WESCO]**
 - i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[AFC Cable Systems; Atkore International]**
 - b. **[Alpha Wire; brand of Belden, Inc.]**
 - c. **[Belden Inc.]**
 - d. **[Encore Wire Corporation]**
 - e. **[General Cable; Prysmian Group North America]**
 - f. **[Okonite Company (The)]**
 - g. **[Southwire Company, LLC]**
 - h. **[WESCO]**
 - i. **<Insert manufacturer's name>**
 3. Description: A factory assembly of insulated current-carrying conductors with or without an equipment grounding conductor in an overall metallic sheath.
 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Armored Cable: UL CCN AWEZ, including UL 4.
 5. Standard Features:
 - a. Referenced Standard: Article 320 of NFPA 70.
 - b. Circuits: **[Single circuit][and][multicircuit with color-coded conductors]**.
 - c. Conductors: **[Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors][Aluminum, complying with ASTM B800 and ASTM B801]**.
 - d. Ground Conductor: **[Bare][Insulated][None]**.
 - e. Armor: **[Steel][Aluminum]**, interlocked.
 6. Other Available Features Required by the Project:
 - a. Marked "LS" or "For Use in Cable Trays," indicating compliance with UL 1685 flame and limited smoke test.
- C. UL PPKV and FHJR - Fire-Resistant Mineral-Insulated Metal-Sheathed Cable, Type MI, for Use in Electrical Circuit Integrity Systems :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[PYROTENAX; brand of nVent Electrical plc]**
 - b. **[TEC International]**
 - c. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[PYROTENAX; brand of nVent Electrical plc]**
 - b. **[TEC International]**
 - c. **<Insert manufacturer's name>**
 3. Description: Solid copper conductors encased in compressed metal oxide with an outer metallic sheath, rated 600 V or less.
 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Mineral-Insulated Metal-Sheathed Cable: UL CCN PPKV, including UL Subject 504.
 - b. Circuit Integrity: UL CCN FHJR, including UL 2196.
 5. Standard Features:
 - a. Referenced Standard: Article 332 of NFPA 70.
 - b. Fire-Resistance Rating: **[1 h][2 h]**.
 - c. Conductors: Copper, complying with ASTM B3 for bare annealed copper.
 - d. Insulation: **[Compressed magnesium oxide]<Insert material>**.
 - e. Sheath: **[Copper]<Insert material>**.
- D. UL PJAZ and FHJR - Fire-Resistant Metal-Clad Cable, Type MC, for Use in Electrical Circuit Integrity Systems :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Marmon Industrial Energy & Infrastructure; division of Marmon Electrical; a Berkshire Hathaway company]**
 - b. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - c. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Marmon Industrial Energy & Infrastructure; division of Marmon Electrical; a Berkshire Hathaway company]**
 - b. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - c. **<Insert manufacturer's name>**
 3. Description: A factory assembly of one or more current-carrying insulated conductors in an overall metallic sheath.
 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Metal-Clad Cable: UL CCN PJAZ, including UL 1569.
 - b. Circuit Integrity: UL CCN FHJR, including UL 2196.
 5. Standard Features:
 - a. Referenced Standard: Article 330 of NFPA 70.

- b. Fire-Resistance Rating: [1 h][2 h].
 - c. Circuits: [Single circuit][and][multicircuit with color-coded conductors].
 - d. Conductors: [Copper][Copper-clad aluminum].
 - e. Ground Conductor: [Bare][Insulated][None].
 - f. Armor: [Steel][Aluminum], interlocked.
 - g. Jacket: PVC applied over armor.
6. Other Available Features Required by the Project:
- a. Marked "MC-HL," indicating compliance with UL 2225 for use in hazardous (classified) locations.

2.6 PHOTOVOLTAIC SINGLE-CONDUCTOR CABLE

A. Photovoltaic Single-Conductor Cable, Type PV :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Copperweld]
 - b. [Encore Wire Corporation]
 - c. [General Cable; Prysmian Group North America]
 - d. [Service Wire Co.]
 - e. [Southwire Company, LLC]
 - f. [WESCO]
 - g. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Copperweld]
 - b. [Encore Wire Corporation]
 - c. [General Cable; Prysmian Group North America]
 - d. [Service Wire Co.]
 - e. [Southwire Company, LLC]
 - f. [WESCO]
 - g. <Insert manufacturer's name>
3. Description: Flexible, insulated and uninsulated, drawn-copper current-carrying conductor with an overall insulation layer or jacket, or both, rated [2000][600] V.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Photovoltaic Wire: UL CCN ZKLA, including UL 4703.
5. Standard Features:
 - a. Referenced Standard: Article 609 of NFPA 70.
 - b. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors.

2.7 NONMETALLIC JACKETED CABLE

A. UL PWVX - Nonmetallic-Sheathed Cable, Type NM-B and Type NMC-B :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Belden Inc.]**
 - b. **[Cerro Wire LLC]**
 - c. **[Copperweld]**
 - d. **[Encore Wire Corporation]**
 - e. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - f. **[Republic Wire Inc.]**
 - g. **[Southwire Company, LLC]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Belden Inc.]**
 - b. **[Cerro Wire LLC]**
 - c. **[Copperweld]**
 - d. **[Encore Wire Corporation]**
 - e. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - f. **[Republic Wire Inc.]**
 - g. **[Southwire Company, LLC]**
 - h. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Type NM-B and Type NMC-B Cables: UL CCN PWVX, including UL 719.
4. Standard Features:
 - a. Referenced Standard: Article 334 of NFPA 70.
 - b. Insulation Voltage Rating: 600 V.
 - c. Insulation Temperature Rating: Individual conductors are rated 90 deg C for multiple conductor ampacity calculations; however, final cable ampacity rating must not exceed value for 60 deg C in Table 310.15(C)(1) of NFPA 70.
 - d. Conductor Material: **[Copper][Aluminum][Copper-clad aluminum].**
 - e. Conductor Size:**[As indicated on the Drawings.]**
 - 1) Minimum Conductor Size: **[14 AWG][12 AWG][10 AWG].**
 - f. Cable Covering:
 - 1) Type NM-B: Flame retardant and moisture resistant.
 - 2) Type NMC-B: Flame retardant, moisture resistant, fungus resistant, and corrosion resistant.

B. UL YDUX - Underground Feeder and Branch-Circuit Cable, Type UF and Type UF-B :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[AFC Cable Systems; Atkore International]**
 - b. **[Belden Inc.]**
 - c. **[Cerro Wire LLC]**
 - d. **[Copperweld]**
 - e. **[Encore Wire Corporation]**
 - f. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - g. **[Republic Wire Inc.]**
 - h. **[Southwire Company, LLC]**
 - i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[AFC Cable Systems; Atkore International]**
 - b. **[Belden Inc.]**
 - c. **[Cerro Wire LLC]**
 - d. **[Copperweld]**
 - e. **[Encore Wire Corporation]**
 - f. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - g. **[Republic Wire Inc.]**
 - h. **[Southwire Company, LLC]**
 - i. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Type UF and Type UF-B Cables: UL CCN YDUX, including UL 493.
4. Standard Features:
 - a. Referenced Standard: Article 340 of NFPA 70.
 - b. Insulation Voltage Rating: 600 V.
 - c. Insulation Temperature Rating:
 - 1) Type UF: 60 deg C.
 - 2) Type UF-B: Individual conductors are rated 90 deg C for multiple conductor ampacity calculations; however, final cable ampacity rating must not exceed value for 60 deg C in Table 310.15(C)(1) of NFPA 70.
 - d. Conductor Material: **[Copper][Aluminum][Copper-clad aluminum]**.
 - e. Conductor Size: **[As indicated on the Drawings.]**
 - 1) Minimum Conductor Size: **[14 AWG][12 AWG][10 AWG]**.
 - f. Cable Covering: Flame retardant, moisture resistant, fungus resistant, corrosion resistant, and suitable for direct burial in the earth.



C. UL TYLZ - Service-Entrance Cable, Type SE, Type USE, and Type USE-2 :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Belden Inc.]**
 - b. **[Cerro Wire LLC]**
 - c. **[Encore Wire Corporation]**
 - d. **[Marmon Industrial Energy & Infrastructure; division of Marmon Electrical; a Berkshire Hathaway company]**
 - e. **[Okonite Company (The)]**
 - f. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - g. **[Republic Wire Inc.]**
 - h. **[Southwire Company, LLC]**
 - i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Belden Inc.]**
 - b. **[Cerro Wire LLC]**
 - c. **[Encore Wire Corporation]**
 - d. **[Marmon Industrial Energy & Infrastructure; division of Marmon Electrical; a Berkshire Hathaway company]**
 - e. **[Okonite Company (The)]**
 - f. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - g. **[Republic Wire Inc.]**
 - h. **[Southwire Company, LLC]**
 - i. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Service-Entrance Cable: UL CCN TYLZ, including UL 854.
4. Standard Features:
 - a. Referenced Standard: Article 338 of NFPA 70.
 - b. Insulation Voltage Rating: 600 V.
 - c. Insulation Temperature Rating: Not in excess of rating for insulation type specified below:
 - 1) Type THWN: 75 deg C, dry and wet locations.
 - 2) Type THWN-2: 90 deg C, dry and wet locations.
 - 3) Type RHW: 75 deg C, dry and wet locations.
 - 4) Type XHHW: 90 deg C, dry and damp locations; 75 deg C, wet locations.
 - 5) Type RHW-2: 90 deg C, dry and wet locations.
 - 6) Type XHHW-2: 90 deg C, dry and wet locations.
 - d. Conductor Material: **[Copper][Aluminum][Copper-clad aluminum].**
 - e. Conductor Size: **[As indicated on the Drawings.]**

- 1) Minimum Conductor Size: **[14 AWG][12 AWG][10 AWG]**.
5. Other Available Features Required by the Project:
 - a. Marked "Style R," indicating that cable assembly includes uninsulated equipment ground conductor with insulated conductors.
 - b. Marked "Style U," indicating that cable assembly includes uninsulated equipment ground conductor helically wrapped over insulated conductors.
 - c. Marked "-HF," indicating that combustible materials are halogen-free when tested in accordance with UL Subject 2885.
 - 1) Marked "-LSHF," indicating that combustible materials are low smoke when also tested in accordance with IEC 61034-2.
- D. UL QPOR - Power and Control Tray Cable, Type TC :
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Alpha Wire; brand of Belden, Inc.]**
 - b. **[Belden Inc.]**
 - c. **[Encore Wire Corporation]**
 - d. **[General Cable; Prysmian Group North America]**
 - e. **[Okonite Company (The)]**
 - f. **[Southwire Company, LLC]**
 - g. **[WESCO]**
 - h. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Alpha Wire; brand of Belden, Inc.]**
 - b. **[Belden Inc.]**
 - c. **[Encore Wire Corporation]**
 - d. **[General Cable; Prysmian Group North America]**
 - e. **[Okonite Company (The)]**
 - f. **[Southwire Company, LLC]**
 - g. **[WESCO]**
 - h. **<Insert manufacturer's name>**
 3. Description: A factory assembly of insulated current-carrying conductors with or without an equipment grounding conductor in a nonmetallic jacket.
 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Power and Control Tray Cable: UL CCN QPOR, including UL 1277.
 5. Standard Features:
 - a. Comply with NEMA WC 57/ICEA S-73-532 for Type TC cables used for control, thermocouple extension, and instrumentation.
 - b. Comply with NEMA WC 70/ICEA S-95-658 for Type TC cables used for power distribution.



- c. Conductors: **[Copper][Aluminum][Copper-clad aluminum]**.
- d. Ground Conductor: **[Bare][Insulated][None]**.
- e. Conductor Insulation: Type XHHW-2. Comply with UL 44.

6. Other Available Features Required by the Project:

- a. Marked "TC-ER," indicating that cable is designed for use with ASDs, with oversized crosslinked polyethylene insulation, **[spiral-wrapped foil plus 85 percent coverage braided shields and insulated full-size ground wire][dual spirally wrapped copper tape shields and three bare symmetrically applied ground wires]**, and sunlight- and oil-resistant outer PVC jacket.
 - 1) Marked "TC-ER-JP," indicating that cable is also suitable for pulling through structural members in accordance with Article 336.10(9) of NFPA 70.
 - 2) Marked "TC-ER-HL," indicating that cable is also suitable for use in hazardous (classified) environments.
- b. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.
- c. Marked "ST1-HF," indicating that combustible materials are halogen-free in accordance with UL Subject 2885.
 - 1) Marked "ST1-LSHF," indicating that combustible materials are low smoke when also tested in accordance with IEC 61034-2.

2.8 CONNECTORS AND SPLICES

A. UL PJOX - Armored and Metal-Clad Cable Fittings :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Installation Products]**
 - b. **[Adalet; division of Scott Fetzer Co.]**
 - c. **[American Fittings Corp. (AMFICO)]**
 - d. **[Arlington Industries, Inc.]**
 - e. **[Bridgeport Fittings Inc.]**
 - f. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - g. **[Halex; division of Scott Fetzer Co.]**
 - h. **[Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - i. **[O-Z/Gedney; brand of Appleton Group]**
 - j. **[Service Wire Co.]**
 - k. **[SIGMA Engineered Solutions]**
 - l. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Installation Products]**
 - b. **[Adalet; division of Scott Fetzer Co.]**
 - c. **[American Fittings Corp. (AMFICO)]**
 - d. **[Arlington Industries, Inc.]**

- e. [Bridgeport Fittings Inc.]
 - f. [Crouse-Hinds; brand of Eaton, Electrical Sector]
 - g. [Halex; division of Scott Fetzer Co.]
 - h. [Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - i. [O-Z/Gedney; brand of Appleton Group]
 - j. [Service Wire Co.]
 - k. [SIGMA Engineered Solutions]
 - l. <Insert manufacturer's name>
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
- a. Type AC and Type MC Cable Connectors: UL CCN PJOX, including UL 514B.
4. Standard Features: For steel and aluminum sheathed cables, designed to connect conductors specified in this Section.
- B. UL PPYT - Mineral-Insulated Metallic-Sheathed Cable Fittings :
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. [TEC International]
 - b. <Insert manufacturer's name>
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [TEC International]
 - b. <Insert manufacturer's name>
 - 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Type MI Cable Fittings: UL CCN PPYT, including UL 514B.
 - 4. Standard Features: For copper sheathed cables, designed to connect conductors specified in this Section.
- C. UL ZMVV - Wire Connectors and Soldering Lugs :
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. [ABB, Installation Products]
 - b. [Amphenol TPC Wire & Cable]
 - c. [Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - d. [Eaton]
 - e. [Fastenal Co.]



- f. [Gardner Bender; brand of ECM Industries LLC; division of nVent Electric plc]
 - g. [Hillsdale Terminal]
 - h. [Ideal Industries, Inc.]
 - i. [ILSCO; brand of ECM Industries LLC; division of nVent Electric plc]
 - j. [Marinco Power Products]
 - k. [Morris Products Inc.]
 - l. [Newark; an Avnet Company]
 - m. [Panduit Corp]
 - n. [Penn-Union Corp.; subsidiary of Nesco, Inc.]
 - o. [TE Connectivity Ltd.]
 - p. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [ABB, Installation Products]
 - b. [Amphenol TPC Wire & Cable]
 - c. [Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - d. [Eaton]
 - e. [Fastenal Co.]
 - f. [Gardner Bender; brand of ECM Industries LLC; division of nVent Electric plc]
 - g. [Hillsdale Terminal]
 - h. [Ideal Industries, Inc.]
 - i. [ILSCO; brand of ECM Industries LLC; division of nVent Electric plc]
 - j. [Marinco Power Products]
 - k. [Morris Products Inc.]
 - l. [Newark; an Avnet Company]
 - m. [Panduit Corp]
 - n. [Penn-Union Corp.; subsidiary of Nesco, Inc.]
 - o. [TE Connectivity Ltd.]
 - p. <Insert manufacturer's name>
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
- a. Wire Connectors and Soldering Lugs: UL CCN ZMVV, including UL 486A-486B or UL 486C.
4. Standard Features:
- a. One piece, seamless, designed to terminate conductors specified in this Section.
 - b. Material: [Copper][Aluminum][Bronze].
 - c. Type: [One][Two] hole with [standard][long] barrels.
 - d. Termination: [Compression][Crimp].

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders:

1. Copper; solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
 2. Copper for feeders smaller than No. 4 AWG; copper, aluminum, or copper-clad aluminum for feeders No. 4 AWG and larger. Conductors must be solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- B. Branch Circuits:
1. Material: **[Copper][Aluminum][Copper-clad aluminum]**.
 - a. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
 - b. Solid for No. 12 AWG and smaller; stranded for No. 10 AWG and larger.
- C. ASD Output Circuits Cable: Extra-flexible stranded for all sizes.
- D. PV Circuits: **[Copper][Aluminum][Copper-clad aluminum]**; Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- 3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS
- A. Service Entrance: **[Type THHN/THWN-2, single conductors in raceway][Type XHHW-2, single conductors in raceway][Type USE, single conductor in raceway][Mineral-insulated, metal-sheathed cable, Type MI][Multiconductor cable, Type SE]**.
 - B. Exposed Feeders: **[Type THHN/THWN-2, single conductors in raceway][Type XHHW-2, single conductors in raceway][Armored cable, Type AC][Metal-clad cable, Type MC][Mineral-insulated, metal-sheathed cable, Type MI][Nonmetallic-sheathed cable, Type NM]**.
 - C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: **[Type THHN/THWN-2, single conductors in raceway][Armored cable, Type AC][Metal-clad cable, Type MC][Mineral-insulated, metal-sheathed cable, Type MI][Nonmetallic-sheathed cable, Type NM]**.
 - D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: **[Type THHN/THWN-2, single conductors in raceway][Type XHHW-2, single conductors in raceway][Underground feeder cable, Type UF]**.
 - E. Feeders Installed below Raised Flooring: **[Type THHN/THWN-2, single conductors in raceway][Armored cable, Type AC][Metal-clad cable, Type MC][Mineral-insulated, metal-sheathed cable, Type MI]**.
 - F. Feeders in Cable Tray: **[Type THHN/THWN-2, single conductors in raceway][Type XHHW-2, single conductors larger than No. 1/0 AWG][Armored cable, Type AC][Metal-clad cable, Type MC][Mineral-insulated, metal-sheathed cable, Type MI][Nonmetallic-sheathed cable, Type NM]**.
 - G. Exposed Branch Circuits, Including in Crawlspace: **[Type THHN/THWN-2, single conductors in raceway][Armored cable, Type AC][Metal-clad cable, Type MC][Mineral-insulated, metal-sheathed cable, Type MI][Nonmetallic-sheathed cable, Type NM]**.
 - H. Branch Circuits Concealed in Ceilings, Walls, and Partitions: **[Type THHN/THWN-2, single conductors in raceway][Armored cable, Type AC][Metal-clad cable, Type MC][Mineral-insulated, metal-sheathed cable, Type MI][Nonmetallic-sheathed cable, Type NM]**.
 - I. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: **[Type THHN/THWN-2, single conductors in raceway][Type XHHW-2, single conductors in raceway][Underground branch-circuit cable, Type UF]**.



- J. Branch Circuits Installed below Raised Flooring: **[Type THHN/THWN-2, single conductors in raceway][Armored cable, Type AC][Metal-clad cable, Type MC][Mineral-insulated, metal-sheathed cable, Type MI]**.
- K. Branch Circuits in Cable Tray: **[Type THHN/THWN-2, single conductors in raceway][Type XHHW-2, single conductors larger than No. 1/0 AWG][Armored cable, Type AC][Metal-clad cable, Type MC][Mineral-insulated, metal-sheathed cable, Type MI][Nonmetallic-sheathed cable, Type NM]**.
- L. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless steel, wire-mesh, strain relief device at terminations to suit application.
- M. ASD Output Circuits: **[Type XHHW-2 in metal conduit][Type TC-ER cable with braided shield][Type TC-ER cable with dual tape shield]**.
- N. PV Circuits, Type USE-2: For PV source circuits rated at 600 V or less.
- O. PV Circuits, Type PV: For PV source circuits rated at **[600][1000][2000]** V.

3.3 INSTALLATION OF LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:
 - 1. Electrical Construction: ICC IBC, ICC IFB, NFPA 1, NFPA 70, and NECA NEIS 1.
 - 2. Electrical Maintenance: NFPA 70B.
 - 3. Electrical Safety: NFPA 70E.
 - 4. Temporary Electric Power Work: NECA NEIS 200.
 - 5. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
 - 6. Work in Confined Spaces: NFPA 350.
 - 7. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
 - 8. Installation of Type AC and Type MC Cables: NECA NEIS 120.
 - 9. Consult Architect for resolution of conflicting requirements.
- C. Special Installation Techniques:
 - 1. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.
 - 2. Complete raceway installation between conductor and cable termination points prior to pulling conductors and cables.
 - 3. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
 - 4. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
 - 5. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
 - 6. Provide support for cables.
 - 7. Complete cable tray systems installation prior to installing conductors and cables.
 - 8. Connections:
 - a. Tighten electrical connectors and terminals in accordance with manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

- b. Make splices, terminations, and taps that are compatible with conductor material[**and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors**].
 - 1) Use oxide inhibitor in each splice, termination, and tap for aluminum conductors.
 - 9. Wiring at Outlets: Install conductor at each outlet, with at least **[6 inch (150 mm)][12 inch (300 mm)]** of slack.
- D. Interfaces with Other Work:
 - 1. Identification:
 - a. Identify and color-code conductors and cables.
 - b. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.
 - 2. Sleeves and Sleeve Seals: Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies.
 - 3. Firestopping: Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly.

3.4 FIELD QUALITY CONTROL

- A. Administrant for Electrical Power Tests and Inspections:
 - 1. **[Owner][Tenant]** will engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
 - 2. Engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
 - 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
 - 4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].
- B. Acceptance Testing Preparation:
 - 1. **<Insert requirements>**.
- C. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.
- D. Tests and Inspections:
 - 1. Perform manufacturer's recommended tests and inspections.
 - 2. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.
 - 3. After installing conductors and cables and before electrical circuitry has been energized, test **[service entrance and feeder conductors][and][conductors]** feeding the following critical equipment and services for compliance with requirements:
 - a. **<Insert, in separate subparagraphs, critical equipment and services to be tested>**.
 - 4. Perform each of the following visual and electrical tests:

- a. Inspect exposed sections of conductor and cable for physical damage and correct connection in accordance with the single-line diagram.
- b. Test bolted connections for high resistance using one or more of the following:
 - 1) A low-resistance ohmmeter.
 - 2) Calibrated torque wrench.
 - 3) Thermographic survey.
- c. Inspect compression-applied connectors for correct cable match and indentation.
- d. Inspect for correct identification.
- e. Inspect cable jacket and condition.
- f. Insulation-resistance test on each conductor for ground and adjacent conductors. Apply a potential of 500 V(dc) for 300 V rated cable and 1000 V(dc) for 600 V rated cable for a one-minute duration.
- g. Continuity test on each conductor and cable.
- h. Uniform resistance of parallel conductors.

E. Nonconforming Work:

- 1. Wire or cable assembly will be considered defective if it does not pass tests and inspections.
- 2. Remove and replace defective units and retest.

F. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

3.5 MAINTENANCE

- A. Infrared Scanning of Splices: Two months after Substantial Completion, perform infrared scan of splices, joints, and connections in conductors 3 AWG and larger. Remove covers so splices, joints, and connections are accessible to portable scanner. Take visible light photographs at same locations and orientations as infrared scans for documentation to ensure follow-on scans match same conditions for valid comparison. Correct deficiencies determined during the scan.
 - 1. Follow-On Infrared Scanning: Perform follow-up infrared scan of splices at 11 months after Substantial Completion.
 - 2. Instrument: Use infrared-scanning device designed to measure temperature or to detect significant deviations from normal values. Provide documentation of device calibration.
 - 3. Field Reports for Infrared Scanning: Prepare certified report that identifies cables splices checked and that describes scanning results. Include notation of deficiencies detected, remedial actions taken, and scanning observations after remedial action.

END OF SECTION 26 05 19 00



Task	Specification	Specification Description
26 05 19 00	26 05 00 00	Sleeves and Sleeve Seals for Electrical Raceways and Cabling
26 05 19 13	26 05 19 00	Low-Voltage Electrical Power Conductors and Cables
26 05 19 13	26 05 39 00	Underfloor Raceways For Electrical Systems
26 05 19 13	26 05 00 00	Sleeves and Sleeve Seals for Electrical Raceways and Cabling
26 05 19 16	26 05 13 00	Medium-Voltage Cables
26 05 19 16	26 05 19 00	Low-Voltage Electrical Power Conductors and Cables
26 05 19 16	26 05 23 00	Control-Voltage Electrical Power Cables
26 05 19 16	26 05 00 00	Sleeves and Sleeve Seals for Electrical Raceways and Cabling
26 05 19 16	27 11 00 00	Communications Equipment Room Fittings
26 05 19 16	27 13 13 00	Communications Copper Backbone Cabling
26 05 19 16	27 15 33 00	Communications Coaxial Horizontal Cabling



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SECTION 26 05 23 00 - CONTROL-VOLTAGE ELECTRICAL POWER CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Backboards.
2. Category 5e balanced twisted pair cable.
3. Category 6 balanced twisted pair cable.
4. Category 6a balanced twisted pair cable.
5. Balanced twisted pair cable hardware.
6. Twin-axial data highway cable.
7. RS-232 cable.
8. RS-485 cable.
9. Control cable.
10. Control-circuit conductors.
11. Fire-alarm wire and cable.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.2 ACTION SUBMITTALS

A. Product Data:

1. Backboards.
2. Category 5e balanced twisted pair cable.
3. Category 6 balanced twisted pair cable.
4. Category 6a balanced twisted pair cable.
5. Balanced twisted pair cable hardware.
6. Twin-axial data highway cable.
7. RS-232 cable.
8. RS-485 cable.
9. Control cable.
10. Control-circuit conductors.
11. Fire-alarm wire and cable.

B. Sustainable Design Submittals:

1. Product Data: For each conductor and cable indicating lead content.
2. Environmental Product Declaration: For each product.
3. Health Product Declaration: For each product.
4. Sourcing of Raw Materials: Corporate sustainability report for each manufacturer.
5. Environmental Product Declaration: For each product.
6. Environmental Product Declaration: For each product.



7. Environmental Product Declaration: For each product.
8. Third-Party Certifications: For each product.
9. Third-Party Certified Life Cycle Assessment: For each product.

1.3 INFORMATIONAL SUBMITTALS

- A. Source quality-control reports.
- B. Field quality-control reports.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Flame Travel and Smoke Density in Plenums: As determined by testing identical products according to NFPA 262, by a qualified testing agency. Identify products for installation in plenums with appropriate markings of applicable testing agency.
 1. Flame Travel Distance: **60 inch (1520 mm)** or less.
 2. Peak Optical Smoke Density: 0.5 or less.
 3. Average Optical Smoke Density: 0.15 or less.
- C. Flame Travel and Smoke Density for Riser Cables in Non-Plenum Building Spaces: As determined by testing identical products according to UL 1666.
- D. Flame Travel and Smoke Density for Cables in Non-Riser Applications and Non-Plenum Building Spaces: As determined by testing identical products according to UL 1685.

2.2 BACKBOARDS

- A. Description: Plywood, **[fire-retardant treated], 3/4 by 48 by 96 inch (19 by 1220 by 2440 mm)**. Comply with requirements for plywood backing panels in Section 061000 "Rough Carpentry."
- B. Painting: Paint plywood on all sides and edges with **[flat][eggshell][black]<Insert color>[latex][alkyd]** paint. Comply with requirements in Section 099123 "Interior Painting."
 1. Lead Content: Less than 300 parts per million.

2.3 CATEGORY 5e BALANCED TWISTED PAIR CABLE

- A. Description: Four-pair, balanced-twisted pair cable, certified to meet transmission characteristics of Category 5e cable at frequencies up to 100 MHz.
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. [AMP NETCONNECT; a TE Connectivity Ltd. company]
2. [Belden Inc.]
3. [Berk-Tek, a Leviton Company]
4. [CommScope, Inc]
5. [General Cable; Prysmian Group North America]
6. [Hitachi Cable America Inc.]
7. [Mohawk; a division of Belden Networking, Inc.]
8. [West Penn Wire; brand of Belden, Inc.]
9. <Insert manufacturer's name>

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

1. [AMP NETCONNECT; a TE Connectivity Ltd. company]
2. [Belden Inc.]
3. [Berk-Tek, a Leviton Company]
4. [CommScope, Inc]
5. [General Cable; Prysmian Group North America]
6. [Hitachi Cable America Inc.]
7. [Mohawk; a division of Belden Networking, Inc.]
8. [West Penn Wire; brand of Belden, Inc.]
9. <Insert manufacturer's name>

D. Standard: Comply with ICEA S-90-661, NEMA WC 63.1, and TIA-568-C.2 for Category 5e cables.

E. Conductors: 100 ohm, No. 24 AWG solid copper.

1. Lead Content: Less than 300 parts per million.

F. Shielding/Screening: [Unshielded twisted pairs (UTP)][Shielded twisted pairs (FTP)][Screened twisted pairs (F/UTP)][Screened and shielded twisted pairs (F/FTP)].

G. Cable Rating: [Riser][Plenum].

H. Jacket: [White][Gray]<Insert color> thermoplastic.

2.4 CATEGORY 6 BALANCED TWISTED PAIR CABLE

A. Description: Four-pair, balanced-twisted pair cable, [with internal spline,] certified to meet transmission characteristics of Category 6 cable at frequencies up to 250 MHz.

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

1. [3M]
2. [AMP NETCONNECT; a TE Connectivity Ltd. company]
3. [Belden Inc.]
4. [Berk-Tek, a Leviton Company]
5. [CommScope, Inc]
6. [General Cable; Prysmian Group North America]
7. [Genesis; Resideo Technologies, Inc.]
8. [Hitachi Cable America Inc.]
9. [Mohawk; a division of Belden Networking, Inc.]
10. [Prysmian Cables and Systems; Prysmian Group North America]

11. **[Superior Essex Inc.; subsidiary of LS Corp.]**
12. **<Insert manufacturer's name>**

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

1. **[3M]**
2. **[AMP NETCONNECT; a TE Connectivity Ltd. company]**
3. **[Belden Inc.]**
4. **[Berk-Tek, a Leviton Company]**
5. **[CommScope, Inc]**
6. **[General Cable; Prysmian Group North America]**
7. **[Genesis; Resideo Technologies, Inc.]**
8. **[Hitachi Cable America Inc.]**
9. **[Mohawk; a division of Belden Networking, Inc.]**
10. **[Prysmian Cables and Systems; Prysmian Group North America]**
11. **[Superior Essex Inc.; subsidiary of LS Corp.]**
12. **<Insert manufacturer's name>**

D. Standard: Comply with NEMA WC 66/ICEA S-116-732 and TIA-568-C.2 for Category 6 cables.

E. Conductors: 100 ohm, No. 23 AWG solid copper.

1. Lead Content: Less than 300 parts per million.

F. Shielding/Screening: **[Unshielded twisted pairs (UTP)][Shielded twisted pairs (FTP)][Screened twisted pairs (F/UTP)][Screened and shielded twisted pairs (F/FTP)]**.

G. Cable Rating: **[Riser][Plenum]**.

H. Jacket: **[White][Gray][Blue][Yellow]<Insert color>** thermoplastic.

2.5 CATEGORY 6a BALANCED TWISTED PAIR CABLE

A. Description: Four-pair, balanced-twisted pair cable, **[with internal spline,]** certified to meet transmission characteristics of Category 6a cable at frequencies up to 500 MHz.

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

1. **[3M]**
2. **[AMP NETCONNECT; a TE Connectivity Ltd. company]**
3. **[Belden Inc.]**
4. **[Berk-Tek, a Leviton Company]**
5. **[CommScope, Inc]**
6. **[General Cable; Prysmian Group North America]**
7. **[Genesis; Resideo Technologies, Inc.]**
8. **[Hitachi Cable America Inc.]**
9. **[Mohawk; a division of Belden Networking, Inc.]**
10. **[Prysmian Cables and Systems; Prysmian Group North America]**
11. **[Superior Essex Inc.; subsidiary of LS Corp.]**
12. **<Insert manufacturer's name>**

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

1. [3M]
2. [AMP NETCONNECT; a TE Connectivity Ltd. company]
3. [Belden Inc.]
4. [Berk-Tek, a Leviton Company]
5. [CommScope, Inc]
6. [General Cable; Prysmian Group North America]
7. [Genesis; Resideo Technologies, Inc.]
8. [Hitachi Cable America Inc.]
9. [Mohawk; a division of Belden Networking, Inc.]
10. [Prysmian Cables and Systems; Prysmian Group North America]
11. [Superior Essex Inc.; subsidiary of LS Corp.]
12. **<Insert manufacturer's name>**

- D. Standard: Comply with TIA-568-C.2 for Category 6a cables.

- E. Conductors: 100 ohm, No. 23 AWG solid copper.

1. Lead Content: Less than 300 parts per million.

- F. Shielding/Screening: [Unshielded twisted pairs (UTP)][Shielded twisted pairs (FTP)][Screened twisted pairs (F/UTP)][Screened and shielded twisted pairs (F/FTP)].

- G. Cable Rating: [Riser][Plenum].

- H. Jacket: [White][Gray][Blue][Yellow]**<Insert color>** thermoplastic.

2.6 BALANCED TWISTED PAIR CABLE HARDWARE

- A. Description: Hardware designed to connect, splice, and terminate balanced twisted pair copper communications cable.

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

1. [3M]
2. [American Technology Systems Industries, Inc]
3. [AMP NETCONNECT; a TE Connectivity Ltd. company]
4. [Belden Inc.]
5. [Berk-Tek, a Leviton Company]
6. [CommScope, Inc]
7. [Dynacom Corporation]
8. [General Cable; Prysmian Group North America]
9. [Genesis; Resideo Technologies, Inc.]
10. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
11. [Leviton Manufacturing Co., Inc.]
12. [Mohawk; a division of Belden Networking, Inc.]
13. [Molex Premise Networks]
14. [Panduit Corp]
15. [Prysmian Cables and Systems; Prysmian Group North America]
16. [Siemon Co. (The)]
17. [Superior Essex Inc.; subsidiary of LS Corp.]



18. <Insert manufacturer's name>
- C. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [3M]
 2. [American Technology Systems Industries, Inc]
 3. [AMP NETCONNECT; a TE Connectivity Ltd. company]
 4. [Belden Inc.]
 5. [Berk-Tek, a Leviton Company]
 6. [CommScope, Inc]
 7. [Dynacom Corporation]
 8. [General Cable; Prysmian Group North America]
 9. [Genesis; Resideo Technologies, Inc.]
 10. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 11. [Leviton Manufacturing Co., Inc.]
 12. [Mohawk; a division of Belden Networking, Inc.]
 13. [Molex Premise Networks]
 14. [Panduit Corp]
 15. [Prysmian Cables and Systems; Prysmian Group North America]
 16. [Siemon Co. (The)]
 17. [Superior Essex Inc.; subsidiary of LS Corp.]
 18. <Insert manufacturer's name>
- D. General Requirements for Balanced Twisted Pair Cable Hardware:
1. Comply with the performance requirements of [Category 5e][Category 6][Category 6a][Category 7].
 2. Comply with TIA-568-C.2, IDC type, with modules designed for punch-down caps or tools.
 3. Cables must be terminated with connecting hardware of same category or higher.
- E. Source Limitations: [Obtain balanced twisted pair cable hardware from single source from single manufacturer][Obtain balanced twisted pair cable hardware from same manufacturer as balanced twisted pair cable, from single source].
- F. Connecting Blocks: [110-style IDC for Category 5e][110-style IDC for Category 6][66-style IDC for Category 5e]. Provide blocks for the number of cables terminated on the block, plus [25]<Insert number> percent spare, integral with connector bodies, including plugs and jacks where indicated.
- G. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.
1. Number of Terminals per Field: [One]<Insert number> for each conductor in assigned cables.
- H. Patch Panel: Modular panels housing numbered jack units with IDC-type connectors at each jack location for permanent termination of pair groups of installed cables.
1. Features:
 - a. Universal T568A and T568B wiring labels.
 - b. Labeling areas adjacent to conductors.
 - c. Replaceable connectors.
 - d. 24 or 48 ports.
 2. Construction: 16-gauge steel and mountable on 19 inch (483 mm) equipment racks.

3. Number of Jacks per Field: One for each four-pair **[cable indicated][conductor group of indicated cables, plus spares and blank positions adequate to suit specified expansion criteria]**.
- I. Patch Cords: Factory-made, four-pair cables in **[36 inch (900 mm)][48 inch (1200 mm)]<Insert length>**lengths; terminated with an eight-position modular plug at each end.
 1. Patch cords must have bend-relief-compliant boots and color-coded icons to ensure performance. Patch cords must have latch guards to protect against snagging.
 2. Patch cords must have color-coded boots for circuit identification.
- J. Plugs and Plug Assemblies:
 1. Male; eight position; color-coded modular telecommunications connector designed for termination of a single four-pair 100 ohm unshielded or shielded balanced twisted pair cable.
 2. Comply with IEC 60603-7-1, IEC 60603-7-2, IEC 60603-7-3, IEC 60603-7-4, and IEC 60603-7.5.
 3. Marked to indicate transmission performance.
- K. Jacks and Jack Assemblies:
 1. Female; eight position; modular; fixed telecommunications connector designed for termination of a single four-pair 100 ohm unshielded or shielded balanced twisted pair cable.
 2. Designed to snap-in to a patch panel or faceplate.
 3. Standards:
 - a. Category 5e, unshielded balanced twisted pair cable must comply with IEC 60603-7-2.
 - b. Category 5e, shielded balanced twisted pair cable must comply with IEC 60603-7-3.
 - c. Category 6, unshielded balanced twisted pair cable must comply with IEC 60603-7-4.
 - d. Category 6, shielded balanced twisted pair cable must comply with IEC 60603-7.5.
 - e. Category 6a, unshielded balanced twisted pair cable must comply with IEC 60603-7-41.
 - f. Category 6a, shielded balanced twisted pair cable must comply with IEC 60603-7.51.
 4. Marked to indicate transmission performance.
- L. Faceplate:
 1. **[Two][Four][Six]** port, vertical single-gang faceplates designed to mount to single-gang wall boxes.
 2. **[Eight][10][12]** port, vertical double-gang faceplates designed to mount to double-gang wall boxes.
 3. Plastic Faceplate: High-impact plastic. Coordinate color with Section 260533.16 "Boxes and Covers for Electrical Systems."
 4. Metal Faceplate: **[Stainless steel][Brass]<Insert description>**, complying with requirements in Section 260533.16 "Boxes and Covers for Electrical Systems."
 5. For use with snap-in jacks accommodating any combination of balanced twisted pair, optical fiber, and coaxial work area cords.
 - a. Flush mounting jacks, positioning the cord at a 45-degree angle.
- M. Legend:
 1. Machine printed, in the field, using adhesive-tape label.
 2. Snap-in, clear-label covers and machine-printed paper inserts.

2.7 TWIN-AXIAL DATA HIGHWAY CABLE

- A. Standard Cable: NFPA 70, Type CM.
1. Paired, <Insert number> pairs, [No. 20][No. 22][No. 24] AWG, stranded [(7x28)][(7x30)][(7x32)] tinned-copper conductors.
 2. Polypropylene insulation.
 3. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
 4. PVC jacket.
 5. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned-copper drain wire.
 6. Flame Resistance: Comply with UL 1685.
 7. Lead Content: Less than 300 parts per million.
- B. Plenum-Rated Cable: NFPA 70, Type CMP.
1. Paired, <Insert number> pairs, [No. 20][No. 22][No. 24] AWG, stranded [(7x28)][(7x30)][(7x32)] tinned-copper conductors.
 2. Plastic insulation.
 3. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
 4. Plastic jacket.
 5. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned-copper drain wire.
 6. Flame Resistance: Comply with NFPA 262.
 7. Lead Content: Less than 300 parts per million.

2.8 RS-232 CABLE

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
1. [Allied Wire & Cable Inc.]
 2. [Belden Inc.]
 3. [General Cable; Prysmian Group North America]
 4. [Genesis; Resideo Technologies, Inc.]
 5. [Southwire Company, LLC]
 6. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [Allied Wire & Cable Inc.]
 2. [Belden Inc.]
 3. [General Cable; Prysmian Group North America]
 4. [Genesis; Resideo Technologies, Inc.]
 5. [Southwire Company, LLC]
 6. <Insert manufacturer's name>
- C. PVC-Jacketed, TIA 232-F:
1. [Three][Nine], No. 22 AWG, stranded (7x30) tinned copper conductors.
 2. Lead Content: Less than 300 parts per million.
 3. Polypropylene insulation.
 4. Aluminum foil-polyester tape shield with 100 percent shield coverage.
 5. PVC jacket.

6. Conductors are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
7. NFPA 70 Type: Type CM.
8. Flame Resistance: Comply with UL 1581.

D. Plenum-Type, TIA 232-F:

1. **[Three][Nine]**, No. 22 AWG, stranded (7x30) tinned copper conductors.
2. Lead Content: Less than 300 parts per million.
3. PE insulation.
4. Aluminum foil-polyester tape shield with 100 percent shield coverage.
5. Fluorinated ethylene propylene jacket.
6. Conductors are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
7. Flame Resistance: Comply with NFPA 262.

2.9 RS-485 CABLE

A. Standard Cable: NFPA 70, Type CMG.

1. Paired, **[one pair][two pairs]**, twisted, No. 22 AWG, stranded (7x30) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with UL 1685.
6. Lead Content: Less than 300 parts per million.

B. Plenum-Rated Cable: NFPA 70, Type CMP.

1. Paired, **[one pair][two pairs]**, No. 22 AWG, stranded (7x30) tinned-copper conductors.
2. Fluorinated ethylene propylene insulation.
3. Unshielded.
4. Fluorinated ethylene propylene jacket.
5. Flame Resistance: NFPA 262.
6. Lead Content: Less than 300 parts per million.

2.10 CONTROL CABLE

A. Paired Cable: NFPA 70, Type CMG.

1. **[One][Multi-]**pair, twisted, **[No. 16 AWG, stranded (19x29)][No. 18 AWG, stranded (19x30)]** tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with UL 1685.
6. Lead Content: Less than 300 parts per million.

B. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.

1. **[One][Multi-]**pair, twisted, **[No. 16 AWG, stranded (19x29)][No. 18 AWG, stranded (19x30)]** tinned-copper conductors.
2. PVC insulation.
3. Unshielded.



4. PVC jacket.
5. Flame Resistance: Comply with NFPA 262.
6. Lead Content: Less than 300 parts per million.

2.11 CONTROL-CIRCUIT CONDUCTORS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
1. **[Encore Wire Corporation]**
 2. **[General Cable; Prysmian Group North America]**
 3. **[Service Wire Co.]**
 4. **[Southwire Company, LLC]**
 5. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Encore Wire Corporation]**
 2. **[General Cable; Prysmian Group North America]**
 3. **[Service Wire Co.]**
 4. **[Southwire Company, LLC]**
 5. **<Insert manufacturer's name>**
- C. Class 1 Control Circuits: Stranded copper, **[Type THHN/THWN-2, complying with UL 83 in raceway][Type THW, complying with UL 83 in raceway][Type XHHW-2, complying with UL 44 in raceway][Type TC, complying with UL 1277 in raceway][Type MC, complying with UL 1569].**
- D. Class 2 Control Circuits: Stranded copper, **[Type THHN/THWN-2, complying with UL 83 in raceway][Type XHHW-2, complying with UL 44 in raceway][power-limited cable, concealed in building finishes][power-limited tray cable, in cable tray].**
- E. Class 3 Remote-Control and Signal Circuits: Stranded copper, **[Type THHN/THWN-2, complying with UL 83 in raceway][Type XHHW-2, complying with UL 44 in raceway][power-limited cable, concealed in building finishes][power-limited tray cable, in cable tray][Type TW or Type TF, complying with UL 83, in raceway].**
- F. Class 2 Control Circuits and Class 3 Remote-Control and Signal Circuits That Supply Critical Circuits: Circuit Integrity (CI) cable.
1. Smoke control signaling and control circuits.
 2. **<Insert list of critical circuits that require CI cable>.**

2.12 FIRE-ALARM WIRE AND CABLE

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
1. **[Allied Wire & Cable Inc.]**
 2. **[CommScope, Inc]**
 3. **[Comtran Corporation]**

4. [Genesis; Resideo Technologies, Inc.]
5. [Prysmian Cables and Systems; Prysmian Group North America]
6. [Radix Wire]
7. [Rockbestos-Suprenant Cable Corp.]
8. [Superior Essex Inc.; subsidiary of LS Corp.]
9. [West Penn Wire; brand of Belden, Inc.]
10. <Insert manufacturer's name>

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

1. [Allied Wire & Cable Inc.]
2. [CommScope, Inc]
3. [Comtran Corporation]
4. [Genesis; Resideo Technologies, Inc.]
5. [Prysmian Cables and Systems; Prysmian Group North America]
6. [Radix Wire]
7. [Rockbestos-Suprenant Cable Corp.]
8. [Superior Essex Inc.; subsidiary of LS Corp.]
9. [West Penn Wire; brand of Belden, Inc.]
10. <Insert manufacturer's name>

C. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.

1. Lead Content: Less than 300 parts per million.

D. Signaling Line Circuits: Twisted, shielded pair, [**not less than**][No. 18 AWG]<Insert wire size>[size as recommended by system manufacturer].

1. Circuit Integrity Cable: Twisted shielded pair, NFPA 70, Article 760, Classification CI, for power-limited fire-alarm signal service Type FPL. NRTL listed and labeled as complying with UL 1424 and UL 2196 for a two-hour rating.

E. Non-Power-Limited Circuits: Solid-copper conductors with 600 V rated, 75 deg C, color-coded insulation, and complying with requirements in UL 2196 for a two-hour rating.

1. Control-Voltage Circuits: No. 16 AWG, minimum, in pathway.
2. Low-Voltage Circuits: No. 12 AWG, minimum, in pathway.
3. Multiconductor Armored Cable: NFPA 70, Type MC, copper conductors, Type TFN/THHN conductor insulation, copper drain wire, copper armor[**with outer jacket**] with red identifier stripe, NTRL listed for fire-alarm and cable tray installation, plenum rated.

2.13 SOURCE QUALITY CONTROL

- A. Testing Agency: [**Owner will engage**][Engage] a qualified testing agency to evaluate cables.
- B. Factory test twisted pair cables according to TIA-568-C.2.
- C. Cable will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

PART 3 - EXECUTION**3.1 EXAMINATION**

- A. Test cables on receipt at Project site.
 - 1. Test each pair of twisted pair cable for open and short circuits.

3.2 INSTALLATION OF RACEWAYS AND BOXES

- A. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems" for raceway selection and installation requirements for conduits as supplemented or modified in this Section.
- B. Comply with requirements in Section 260533.23 "Surface Raceways for Electrical Systems" for raceway selection and installation requirements for wireways as supplemented or modified in this Section.
- C. Comply with requirements in Section 260533.16 "Boxes and Covers for Electrical Systems" for raceway selection and installation requirements for boxes as supplemented or modified in this Section.
 - 1. Outlet boxes must be no smaller than **2 inch (50 mm)** wide, **3 inch (75 mm)** high, and **2-1/2 inch (64 mm)** deep.
 - 2. Outlet boxes for cables must be no smaller than **4 inch (102 mm)** square by **[1-1/2 inch (38 mm)][2-1/8 inch (53 mm)]** deep with extension ring sized to bring edge of ring to within **1/8 inch (3.1 mm)** of the finished wall surface.
 - 3. Flexible metal conduit must not be used.
- D. Comply with TIA-569-D for pull-box sizing and length of conduit and number of bends between pull points.
- E. Install manufactured conduit sweeps and long-radius elbows if possible.
- F. Raceway Installation in Equipment Rooms:
 - 1. Position conduit ends adjacent to a corner on backboard if a single piece of plywood is installed, or in the corner of the room if multiple sheets of plywood are installed around perimeter walls of the room.
 - 2. Install cable trays to route cables if conduits cannot be located in these positions.
 - 3. Secure conduits to backboard if entering the room from overhead.
 - 4. Extend conduits **[3 inch (75 mm)]<Insert dimension>** above finished floor.
 - 5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.
- G. Backboards: Install backboards with **96 inch (2440 mm)** dimension vertical. Butt adjacent sheets tightly and form smooth gap-free corners and joints.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

- A. Comply with NECA 1.
- B. General Requirements for Cabling:

1. Comply with TIA-568-C Series of standards.
2. Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems."
3. Terminate all conductors; cable must not contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
4. Cables may not be spliced and must be continuous from terminal to terminal. Do not splice cable between termination, tap, or junction points.
5. Cables serving a common system may be grouped in a common raceway. Install network cabling and control wiring and cable in separate raceway from power wiring. Do not group conductors from different systems or different voltages.
6. Secure and support cables at intervals not exceeding **30 inch (760 mm)** and not more than **6 inch (150 mm)** from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
7. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems." Install lacing bars and distribution spools.
8. Do not install bruised, kinked, scored, deformed, or abraded cable. Remove and discard cable if damaged during installation and replace it with new cable.
9. Cold-Weather Installation: Bring cable to room temperature before dereeling. Do not use heat lamps for heating.
10. Pulling Cable: Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems." Monitor cable pull tensions.
11. Support: Do not allow cables to lie on removable ceiling tiles.
12. Secure: Fasten securely in place with hardware specifically designed and installed so as to not damage cables.
13. Provide strain relief.
14. Keep runs short. Allow extra length for connecting to terminals. Do not bend cables in a radius less than 10 times the cable OD. Use sleeves or grommets to protect cables from vibration at points where they pass around sharp corners and through penetrations.
15. Ground wire must be copper, and grounding methods must comply with IEEE C2. Demonstrate ground resistance.

C. Balanced Twisted Pair Cable Installation:

1. Comply with TIA-568-C.2.
2. Install termination hardware as specified in Section 271513 "Communications Copper Horizontal Cabling" unless otherwise indicated.
3. Do not untwist balanced twisted pair cables more than **1/2 inch (12 mm)** at the point of termination to maintain cable geometry.

D. Installation of Control-Circuit Conductors:

1. Install wiring in raceways.
2. Use insulated spade lugs for wire and cable connection to screw terminals.

E. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend copper cable not in a wireway or pathway a minimum of **8 inch (200 mm)** above ceilings by cable supports not more than [**30 inch (760 mm)**]**<Insert dimension>** apart.
3. Cable must not be run through or on structural members or in contact with pipes, ducts, or other potentially damaging items. Do not run cables between structural members and corrugated panels.

F. Installation of Cable Routed Exposed under Raised Floors:

1. Install plenum-rated cable only.

2. Install cabling after the flooring system has been installed in raised floor areas.
3. Below each feed point, neatly coil a minimum of **[72 inch (1830 mm)]<Insert dimension>** of cable in a coil not less than **[12 inch (305 mm)]<Insert dimension>** in diameter.

G. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA-569-D recommendations for separating unshielded copper voice and data communications cable from potential EMI sources including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment must be as follows:
 - a. Electrical Equipment or Circuit Rating Less Than 2 kVA: A minimum of **5 inch (127 mm)**.
 - b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of **12 inch (305 mm)**.
 - c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of **24 inch (600 mm)**.
3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment must be as follows:
 - a. Electrical Equipment or Circuit Rating Less Than 2 kVA: A minimum of **2-1/2 inch (64 mm)**.
 - b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of **6 inch (150 mm)**.
 - c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of **12 inch (305 mm)**.
4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures must be as follows:
 - a. Electrical Equipment or Circuit Rating Less Than 2 kVA: No requirement.
 - b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of **3 inch (75 mm)**.
 - c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of **6 inch (150 mm)**.
5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or 5 HP and Larger: A minimum of **48 inch (1200 mm)**.
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of **5 inch (127 mm)**.

3.4 REMOVAL OF CONDUCTORS AND CABLES

- A. Remove abandoned conductors and cables. Abandoned conductors and cables are those installed that are not terminated at equipment and are not identified with a tag for future use.

3.5 CONTROL-CIRCUIT CONDUCTORS

A. Minimum Conductor Sizes:

1. Class 1 remote-control and signal circuits; **[No 14 AWG]<Insert wire size>**.
2. Class 2 low-energy, remote-control, and signal circuits; **[No. 16 AWG]<Insert wire size>**.
3. Class 3 low-energy, remote-control, alarm, and signal circuits; **[No 12 AWG]<Insert wire size>**.

3.6 FIRESTOPPING

- A. Comply with requirements in Section 078413 "Penetration Firestopping."
- B. Comply with TIA-569-D, Annex A, "Firestopping."
- C. Comply with BICSI TDMM, "Firestopping" Chapter.

3.7 GROUNDING

- A. For data communication wiring, comply with TIA-607-B and with BICSI TDMM, "Bonding and Grounding (Earthing)" Chapter.
- B. For control-voltage wiring and cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.8 IDENTIFICATION

- A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Identify data and communications system components, wiring, and cabling according to TIA-606-B; label printers must use label stocks, laminating adhesives, and inks complying with UL 969.
- C. Identify each wire on each end and at each terminal with a number-coded identification tag. Each wire must have a unique tag.

3.9 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. Visually inspect cable jacket materials for UL or third-party certification markings. Inspect cabling terminations to confirm color-coding for pin assignments, and inspect cabling connections to confirm compliance with TIA-568-C.1.
 - 2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
 - 3. Test cabling for direct-current loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination, but not after cross-connection.
 - a. Test instruments must meet or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in its "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in its "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
- B. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.
- C. End-to-end cabling will be considered defective if it does not pass tests and inspections.

26 - Electrical



-
- D. Prepare test and inspection reports.

END OF SECTION 26 05 23 00



Task	Specification	Specification Description
26 05 23 00	26 05 00 00	Sleeves and Sleeve Seals for Electrical Raceways and Cabling



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SECTION 26 05 26 00 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Grounding and bonding conductors.
2. Grounding and bonding clamps.
3. Grounding and bonding bushings.
4. Grounding and bonding hubs.
5. Grounding and bonding connectors.
6. Intersystem bonding bridge grounding connectors.
7. Grounding and bonding busbars.
8. Signal reference grids.
9. Grounding (earthing) electrodes.
10. Grounding electrode enclosures.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. Section 264113 "Lightning Protection for Structures" specifies bonding of lightning protection grounding electrodes to facility grounding electrodes.
5. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs installed by this Section.
6. Section 270528 "Pathways for Communications Systems"[**and Section 271100 "Communications Equipment Room Fittings"**] specifies additional requirements for identification and grounding and bonding of communications equipment, raceways, boxes, and cable trays.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing agency, certifying product's compliance with specified listing criteria.
 - a. If listed manufacturer differs from selling manufacturer, indicate relationship between entities on submittal. Clearly indicate which entity warrants product performance and fitness for purpose.
 - b. Listing criteria identified in approval letter must match specified listing criteria. UL label indicating approval of equipment's enclosure is not considered approval of equipment for intended application.
 - c. Product identification in approval letter must match product branding and model numbers in submittal. Approval letters for discontinued or superseded products are unacceptable for

submitted product.

B. Shop Drawings: Prepare and submit the following:

1. Plans showing dimensioned locations of grounding features described in "Field Quality Control for Grounding and Bonding" Article, including the following:
 - a. Grounding electrode access enclosures.
 - b. Grounding electrodes.
 - c. Grounding arrangements and connections for separately derived systems.
 - d. **<Insert items>**.

C. Sustainable Design Submittals:

1. Product data for sustainable design features for each type of product.

D. Field quality-control reports.

1.3 INFORMATIONAL SUBMITTALS

A. Manufacturer's published instructions.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data:

1. In addition to items specified in Section 260010 "Supplemental Requirements for Electrical," include the following:
 - a. Plans showing locations of grounding features described in "Field Quality Control for Grounding and Bonding" Article, including the following:
 - 1) Grounding electrode access enclosures.
 - 2) Grounding electrodes.
 - 3) Grounding arrangements and connections for separately derived systems.
 - 4) **<Insert items>**.
 - b. Instructions for periodic testing and inspection of grounding features at **[test wells][ring electrodes][grounding connections for separately derived systems]<Insert locations>** based on **[NETA MTS][NFPA 70B]<Insert reference>**.
 - 1) Tests must determine if ground-resistance or impedance values remain within specified maximums, and instructions must recommend corrective action if values do not.
 - 2) Include recommended testing intervals.

1.5 QUALIFICATIONS

- A. Electrical Power Testing (EPT) Technician III: Possessing active NICET EPT Level III certification. Able to manage switching procedures, conduct tests of complex equipment, analyze test and equipment data, plan a job, and lead a team. Has experience performing NFPA 70B, IEEE, and NETA electrical

tests.

- B. Electrical Power Testing (EPT) Technician IV: Possessing active NICET EPT Level IV certification. Able to conduct tests of complex metering and relay systems, evaluate tests, test equipment, test results, and power system performance, recommend actions to maintain or improve system performance, and lead multi-team projects.
- C. Electrical Power Testing and Inspecting Agency: Entities possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
 - 1. On-site electrical testing supervisors must possess active NICET EPT Technician [III][IV] certification.

1.6 SERVICE CONDITIONS FOR ELECTRICAL EQUIPMENT

- A. Soil Resistivity: Grounding (earthing) Work on the Project must account for soil resistivity conditions specified in Section 018116 "Facility Environmental Requirements."
- B. Electrical and ICT Equipment Grounding (Earthing): Do not exceed **[25 Ω][10 Ω]<Insert resistance value>** resistance to ground (earth).
 - 1. Contact Architect for resolution if 25 Ω specified resistance to ground (earth) is not attained after complying with prescriptive requirements in Article 250 of NFPA 70.
 - 2. Contact Architect for resolution if **[10 Ω]<Insert resistance value>** specified resistance to ground (earth) is not attained after second attempt to increase effectiveness of grounding (earthing) electrode.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- B. **<Insert additional performance requirements for the Project>**.

2.2 GROUNDING AND BONDING CONDUCTORS

- A. Equipment Grounding Conductor:
 - 1. Standard Features: 600 V, **[THHN/THWN-2][or][THWN-2]**, **[copper][or][tinned-copper]** wire or cable, green color, in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Isolated Equipment Grounding Conductor:
 - 1. Standard Features: 600 V, **[THHN/THWN-2][or][THWN-2]**, **[copper][or][tinned-copper]** wire or cable, green color with one or more yellow stripes, in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. ASTM - Bare Copper Grounding and Bonding Conductor:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ERICO; brand of nVent Electrical plc]**
 - b. **[Harger Lightning & Grounding; business of Harger, Inc.]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ERICO; brand of nVent Electrical plc]**
 - b. **[Harger Lightning & Grounding; business of Harger, Inc.]**
 - c. **<Insert manufacturer's name>**
3. Standard Features: Complying with one or more of the following:
 - a. Soft or Annealed Copper Wire: ASTM B3.
 - b. Concentric-Lay Stranded Copper Conductor: ASTM B8.
 - c. Tin-Coated Soft or Annealed Copper Wire: ASTM B33.
 - d. 19-Wire Combination Unilay-Stranded Copper Conductor: ASTM B787/B787M.
4. Sustainable Design Features:
 - a. Lead Content for Electrical Wire and Cable: Less than 300 ppm.
 - b. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - c. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - d. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - e. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - f. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

D. UL KDER - Armored Grounding Wire:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[LS Cable & System USA; subsidiary of LS Corp.]**
 - b. **[Southwire Company, LLC]**
 - c. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - d. **[Viakon; brand of Conductores Monterrey S.A. de C.V.; a subsidiary of Xignux]**
 - e. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[LS Cable & System USA; subsidiary of LS Corp.]**
 - b. **[Southwire Company, LLC]**
 - c. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - d. **[Viakon; brand of Conductores Monterrey S.A. de C.V.; a subsidiary of Xignux]**
 - e. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
4. Standard Features: Single corrosion-resistant copper, aluminum, or copper-clad aluminum conductor within helically formed steel armor.
5. Sustainable Design Features:
 - a. Lead Content for Electrical Wire and Cable: Less than 300 ppm.
 - b. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - c. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - d. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - e. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - f. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

E. UL KDSH - Protector Grounding Conductor:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - b. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

- a. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.
- 4. Standard Features:
 - a. Conductors intended to be used for grounding primary protector or metallic members of cable sheath in accordance with Chapters 7 and 8 of NFPA 70.
 - b. Color: **[Light olive gray][or][green]**.
- 5. Sustainable Design Features:
 - a. Lead Content for Electrical Wire and Cable: Less than 300 ppm.
 - b. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - c. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - d. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - e. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - f. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

2.3 GROUNDING AND BONDING CLAMPS

- A. Description: Clamps suitable for attachment of grounding and bonding conductors to grounding electrodes, pipes, tubing, and rebar. Grounding and bonding clamps specified in this article are also suitable for use with communications applications.
- B. UL KDER and KDSH - Hex-Fitting-Type Pipe and Rod Grounding and Bonding Clamp :
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[America Fujikura Ltd. (AFL); Fujikura Ltd.]**
 - c. **[Arlington Industries, Inc.]**
 - d. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - e. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - f. **[ERICO; brand of nVent Electrical plc]**
 - g. **[Galvan Industries, Inc.; Electrical Products Division, LLC]**
 - h. **[Greaves Corp.; Essex Products Group, Inc.]**
 - i. **[Harger Lightning & Grounding; business of Harger, Inc.]**
 - j. **[ILSCO; brand of ECM Industries LLC; division of nVent Electric plc]**
 - k. **[O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group]**
 - l. **[Panduit Corp]**
 - m. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - n. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[America Fujikura Ltd. (AFL); Fujikura Ltd.]**
 - c. **[Arlington Industries, Inc.]**
 - d. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - e. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - f. **[ERICO; brand of nVent Electrical plc]**
 - g. **[Galvan Industries, Inc.; Electrical Products Division, LLC]**
 - h. **[Greaves Corp.; Essex Products Group, Inc.]**
 - i. **[Harger Lightning & Grounding; business of Harger, Inc.]**
 - j. **[ILSCO; brand of ECM Industries LLC; division of nVent Electric plc]**
 - k. **[O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group]**
 - l. **[Panduit Corp]**
 - m. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - n. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
 - b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.
 5. Standard Features:
 - a. Two pieces with **[zinc-plated][stainless steel]** bolts.
 - b. Clamp Material: **[Silicon bronze][Die-cast zinc alloy][Aluminum][Brass][Tinned brass]**.
 - c. Listed for outdoor use.
 6. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
- C. UL KDER and KDSH - U-Bolt-Type Pipe and Rod Grounding and Bonding Clamp :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- a. [ABB, Electrification Business]
 - b. [America Fujikura Ltd. (AFL); Fujikura Ltd.]
 - c. [Arlington Industries, Inc.]
 - d. [Cooper B-line; brand of Eaton, Electrical Sector]
 - e. [Crouse-Hinds; brand of Eaton, Electrical Sector]
 - f. [ERICO; brand of nVent Electrical plc]
 - g. [Galvan Industries, Inc.; Electrical Products Division, LLC]
 - h. [Greaves Corp.; Essex Products Group, Inc.]
 - i. [Harger Lightning & Grounding; business of Harger, Inc.]
 - j. [ILSCO; brand of ECM Industries LLC; division of nVent Electric plc]
 - k. [O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group]
 - l. [Panduit Corp]
 - m. [Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - n. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [ABB, Electrification Business]
 - b. [America Fujikura Ltd. (AFL); Fujikura Ltd.]
 - c. [Arlington Industries, Inc.]
 - d. [Cooper B-line; brand of Eaton, Electrical Sector]
 - e. [Crouse-Hinds; brand of Eaton, Electrical Sector]
 - f. [ERICO; brand of nVent Electrical plc]
 - g. [Galvan Industries, Inc.; Electrical Products Division, LLC]
 - h. [Greaves Corp.; Essex Products Group, Inc.]
 - i. [Harger Lightning & Grounding; business of Harger, Inc.]
 - j. [ILSCO; brand of ECM Industries LLC; division of nVent Electric plc]
 - k. [O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group]
 - l. [Panduit Corp]
 - m. [Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - n. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
 - b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.
5. Standard Features:
 - a. Clamp Material: [Aluminum][Brass][Tinned brass].
 - b. Listed for outdoor use.
6. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide [third-party-verified]corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.

- c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
- D. UL KDER and KDSH - Strap-Type Pipe and Rod Grounding and Bonding Clamp :
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - c. **[ERICO; brand of nVent Electrical plc]**
 - d. **[O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group]**
 - e. **[Panduit Corp]**
 - f. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - c. **[ERICO; brand of nVent Electrical plc]**
 - d. **[O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group]**
 - e. **[Panduit Corp]**
 - f. **<Insert manufacturer's name>**
 - 3. Source Limitations: Obtain products from single manufacturer.
 - 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
 - b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.
 - 5. Standard Features:
 - a. Clamp Material: **[Aluminum][Copper][Tinned copper][Galvanized steel]**.
 - b. Listed for outdoor use.
 - 6. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced

- (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
- d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
- e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

E. UL KDER - Beam Grounding and Bonding Clamp :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[Anderson; brand of Hubbell Utility Solutions; Hubbell Incorporated]**
 - c. **[Panduit Corp]**
 - d. **[Penn-Union Corp.; subsidiary of Nesco, Inc.]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Anderson; brand of Hubbell Utility Solutions; Hubbell Incorporated]**
 - c. **[Panduit Corp]**
 - d. **[Penn-Union Corp.; subsidiary of Nesco, Inc.]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
 - b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.
5. Standard Features: Mechanical-type, terminal, ground wire access from four directions; with dual, tin-plated or silicon bronze bolts.
6. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.

- e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
- F. UL KDER - Exothermically Welded Connection :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[ALLTEC LLC]**
 - c. **[Continental Industries; brand of Hubbell Utility Solutions; Hubbell Incorporated]**
 - d. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - e. **[ERICO; brand of nVent Electrical plc]**
 - f. **[Harger Lightning & Grounding; business of Harger, Inc.]**
 - g. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[ALLTEC LLC]**
 - c. **[Continental Industries; brand of Hubbell Utility Solutions; Hubbell Incorporated]**
 - d. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - e. **[ERICO; brand of nVent Electrical plc]**
 - f. **[Harger Lightning & Grounding; business of Harger, Inc.]**
 - g. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
 - b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.
 5. Standard Features: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
 6. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

G. UL KDER - Raised-Floor Signal Reference Grid Clamp :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Continental Industries; brand of Hubbell Utility Solutions; Hubbell Incorporated]**
 - d. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - e. **[ERICO; brand of nVent Electrical plc]**
 - f. **[Harger Lightning & Grounding; business of Harger, Inc.]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Continental Industries; brand of Hubbell Utility Solutions; Hubbell Incorporated]**
 - d. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - e. **[ERICO; brand of nVent Electrical plc]**
 - f. **[Harger Lightning & Grounding; business of Harger, Inc.]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
 - b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.
5. Standard Features: Mechanical-type, stamped-steel terminal with hex head screw.
6. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

2.4 GROUNDING AND BONDING BUSHINGS

- A. Description: Bonding bushings connect conduit fittings, tubing fittings, threaded metal conduit, and unthreaded metal conduit to metal boxes and equipment enclosures, and have one or more bonding screws intended to provide electrical continuity between bushing and enclosure. Grounding bushings have provision for connection of bonding or grounding conductor and may or may not also have bonding screws.
- B. UL KDER - Bonding Bushing :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[Arlington Industries, Inc.]**
 - c. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - d. **[Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - e. **[O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group]**
 - f. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - g. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Arlington Industries, Inc.]**
 - c. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - d. **[Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - e. **[O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group]**
 - f. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - g. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
 5. Standard Features: Threaded bushing with insulated throat.
 6. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.



- e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

C. UL KDER - Grounding Bushing :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[Arlington Industries, Inc.]**
 - c. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - d. **[Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - e. **[O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group]**
 - f. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Arlington Industries, Inc.]**
 - c. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - d. **[Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - e. **[O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group]**
 - f. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
5. Standard Features: Threaded bushing with insulated throat and mechanical-type wire terminal.
6. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

2.5 GROUNDING AND BONDING HUBS

A. UL KDER - Grounding and Bonding Hub :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[Arlington Industries, Inc.]**
 - c. **[Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - d. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - e. **[Greaves Corp.; Essex Products Group, Inc.]**
 - f. **[O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group]**
 - g. **[Penn-Union Corp.; subsidiary of Nesco, Inc.]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Arlington Industries, Inc.]**
 - c. **[Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - d. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - e. **[Greaves Corp.; Essex Products Group, Inc.]**
 - f. **[O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group]**
 - g. **[Penn-Union Corp.; subsidiary of Nesco, Inc.]**
 - h. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
5. Standard Features: Insulated, gasketed, watertight hub with mechanical-type wire terminal.
6. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

2.6 GROUNDING AND BONDING CONNECTORS

A. UL KDER - Pressure-Type Grounding and Bonding Busbar Cable Connector :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
 - b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.
5. Standard Features: Copper or copper alloy, for compression bonding of one or more conductor directly to copper busbar. Listed for direct burial.
6. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

B. UL KDER - Lay-In Lug Mechanical-Type Grounding and Bonding Busbar Terminal :

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

- a. **[ABB, Electrification Business]**
 - b. **[Chatsworth Products, Inc.]**
 - c. **[Greaves Corp.; Essex Products Group, Inc.]**
 - d. **[ILSCO; brand of ECM Industries LLC; division of nVent Electric plc]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Chatsworth Products, Inc.]**
 - c. **[Greaves Corp.; Essex Products Group, Inc.]**
 - d. **[ILSCO; brand of ECM Industries LLC; division of nVent Electric plc]**
 - e. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
 - b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.
 5. Standard Features: Mechanical-type, **[aluminum][copper rated for direct burial]** terminal with set screw.
 6. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
- C. UL KDER - Crimped Lug Pressure-Type Grounding and Bonding Busbar Terminal :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[Harger Lightning & Grounding; business of Harger, Inc.]**
 - c. **[ILSCO; brand of ECM Industries LLC; division of nVent Electric plc]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert**

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

- a. **[ABB, Electrification Business]**
 - b. **[Harger Lightning & Grounding; business of Harger, Inc.]**
 - c. **[ILSCO; brand of ECM Industries LLC; division of nVent Electric plc]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
 - b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.
 5. Standard Features: Cast silicon bronze, solderless compression-type wire terminals; with long barrel and two holes spaced on **5/8 or 1 inch (16 or 25 mm)** centers for two-bolt connection to busbar.
 6. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

D. UL KDER - Split-Bolt Service-Post Pressure-Type Grounding and Bonding Busbar Terminal :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Panduit Corp]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Panduit Corp]**
 - b. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in

accordance with guide information and standards specified for the following UL product categories:

- a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
 - b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.
5. Standard Features: Bolts that surround cable and bond to cable under compression when nut is tightened after assembly is screwed into busbar opening.
 6. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

E. UL KDER - Crimped Pressure-Type Grounding and Bonding Cable Connector :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[allG Fabrication (formerly ALT)]**
 - c. **[Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - d. **[ILSCO; brand of ECM Industries LLC; division of nVent Electric plc]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[allG Fabrication (formerly ALT)]**
 - c. **[Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - d. **[ILSCO; brand of ECM Industries LLC; division of nVent Electric plc]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
 - b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.

5. Standard Features: Crimp-and-compress connectors that bond to conductor when connector is compressed around conductor.
 - a. **[Copper][Copper alloy][Tinned copper]**, C and H shaped.
 6. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
- F. UL KDER - Split-Bolt Pressure-Type Grounding and Bonding Cable Connector :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[allIG Fabrication (formerly ALT)]**
 - c. **[ERICO; brand of nVent Electrical plc]**
 - d. **[Greaves Corp.; Essex Products Group, Inc.]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[allIG Fabrication (formerly ALT)]**
 - c. **[ERICO; brand of nVent Electrical plc]**
 - d. **[Greaves Corp.; Essex Products Group, Inc.]**
 - e. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
 - b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.
 5. Standard Features: Bolts that surround cable and bond to cable under compression when nut is tightened.

- a. **[Copper][Copper alloy][Tinned copper].**
6. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
- G. UL KDER - Signal Reference Grid Grounding and Bonding Connector :
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[Continental Industries; brand of Hubbell Utility Solutions; Hubbell Incorporated]**
 - c. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - d. **[ERICO; brand of nVent Electrical plc]**
 - e. **[Harger Lightning & Grounding; business of Harger, Inc.]**
 - f. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Continental Industries; brand of Hubbell Utility Solutions; Hubbell Incorporated]**
 - c. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - d. **[ERICO; brand of nVent Electrical plc]**
 - e. **[Harger Lightning & Grounding; business of Harger, Inc.]**
 - f. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
 - b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.
 5. Standard Features: Combination of compression wire connectors, access floor grounding clamps, bronze U-bolt grounding clamps, and copper split-bolt connectors, designed for the purpose.
 6. Sustainable Design Features:

- a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
- b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
- c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
- d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
- e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

2.7 INTERSYSTEM BONDING BRIDGE GROUNDING CONNECTORS

- A. Description: Devices that provide means for connecting communications systems grounding and bonding conductors at service equipment or at disconnecting means for buildings or structures.
- B. UL KDSH - One-Piece Intersystem Bonding Bridge Grounding Connector :
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Galvan Industries, Inc.; Electrical Products Division, LLC]**
 - b. **[Madison Electric Products; business of Southwire Company, LLC]**
 - c. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Galvan Industries, Inc.; Electrical Products Division, LLC]**
 - b. **[Madison Electric Products; business of Southwire Company, LLC]**
 - c. **<Insert manufacturer's name>**
 - 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.
 - 4. Standard Features: Zinc-alloy one-piece construction; six terminating points; gangable.
 - 5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced

- (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
- C. UL KDSH - Two-Piece Intersystem Bonding Bridge Grounding Connector :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - c. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - c. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - d. **<Insert manufacturer's name>**
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.
 4. Standard Features: **[Zinc-alloy][Copper]** body and polycarbonate cover; four terminating points.
 5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

2.8 GROUNDING AND BONDING BUSBARS

- A. Description: Miscellaneous grounding and bonding devices that serve as common connection for multiple grounding and bonding conductors.
- B. UL KDER - Equipment Room Grounding and Bonding Busbar :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[allG Fabrication (formerly ALT)]**
 - b. **[Chatsworth Products, Inc.]**
 - c. **[Continental Industries; brand of Hubbell Utility Solutions; Hubbell Incorporated]**
 - d. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - e. **[ERICO; brand of nVent Electrical plc]**
 - f. **[Harger Lightning & Grounding; business of Harger, Inc.]**
 - g. **[Hoffman; brand of nVent Electrical plc]**
 - h. **[ILSCO; brand of ECM Industries LLC; division of nVent Electric plc]**
 - i. **[Panduit Corp]**
 - j. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[allG Fabrication (formerly ALT)]**
 - b. **[Chatsworth Products, Inc.]**
 - c. **[Continental Industries; brand of Hubbell Utility Solutions; Hubbell Incorporated]**
 - d. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - e. **[ERICO; brand of nVent Electrical plc]**
 - f. **[Harger Lightning & Grounding; business of Harger, Inc.]**
 - g. **[Hoffman; brand of nVent Electrical plc]**
 - h. **[ILSCO; brand of ECM Industries LLC; division of nVent Electric plc]**
 - i. **[Panduit Corp]**
 - j. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
 5. Standard Features:
 - a. Bus: Rectangular bar of annealed copper.
 - b. Mounting Stand-Off Insulators: Lexan or PVC.
 - 1) Comply with UL 891 for use in 600 V switchboards, impulse tested at 5000 V.
 6. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability

- report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
- b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
7. Other Available Features Required by the Project:
- a. Dimensions: **[1/4 by 4 inch (6.3 by 100 mm)]<Insert dimensions>** in cross section; length as indicated on the Drawings.
 - b. Predrilled Hole Pattern: **[Complying with BICSI N3 and TIA-607][9/32 inch (7.14 mm) holes spaced 1-1/8 inch (28 mm) apart][Suitable for installing specified grounding and bonding connectors].**
 - c. Mounting Hardware: Stand-off brackets that provide **[2 inch (50 mm)][4 inch (100 mm)]<Insert dimension>** clearance to access rear of bus. Brackets and bolts must be stainless steel.

C. UL KDER - Rack and Cabinet Bonding Busbar :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Chatsworth Products, Inc.]**
 - b. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - c. **[Harger Lightning & Grounding; business of Harger, Inc.]**
 - d. **[Hoffman; brand of nVent Electrical plc]**
 - e. **[Panduit Corp]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Chatsworth Products, Inc.]**
 - b. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - c. **[Harger Lightning & Grounding; business of Harger, Inc.]**
 - d. **[Hoffman; brand of nVent Electrical plc]**
 - e. **[Panduit Corp]**
 - f. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

5. Standard Features:
 - a. Bus: Rectangular bar of hard-drawn solid copper.
 - b. Horizontal Mounting Dimensions: Designed for mounting in [19 inch (483 mm)][23 inch (584 mm)] wide equipment racks or cabinets.
 - c. Vertical Mounting Dimensions: Designed for mounting in [72 inch (1827 mm)][36 inch (914 mm)] high equipment racks or cabinets.
 - d. Predrilled Hole Pattern: Accepts connectors for grounding and bonding conductor sizes 14 AWG to 2/0 AWG.
 - e. Mounting Hardware: Stainless steel or copper-plated, for attachment to rack.
6. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

2.9 SIGNAL REFERENCE GRIDS

- A. Description: Means for providing low-impedance path to ground over a large area, approximating an equipotential plan, while simultaneously mitigating large current spikes from faults or lightning.
- B. UL KDER - Mesh-Type Signal Reference Grid :
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Continental Industries; brand of Hubbell Utility Solutions; Hubbell Incorporated]**
 - c. **[Harger Lightning & Grounding; business of Harger, Inc.]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Continental Industries; brand of Hubbell Utility Solutions; Hubbell Incorporated]**
 - c. **[Harger Lightning & Grounding; business of Harger, Inc.]**
 - d. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain products from single manufacturer.

4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
5. Standard Features: Conductive metal wire mesh for field-fabrication of grid.
 - a. Wire Size: **[8 AWG][6 AWG][4 AWG][2 AWG]**.
 - b. Wire Material: **[Copper][Copper-clad steel]**.
 - c. Spacing: **[4 inch (102 mm)][8 inch (203 mm)][12 inch (305 mm)][24 inch (610 mm)]**.
 - d. Welded or brazed intersections.
6. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

C. UL KDER - Tape-Type Signal Reference Grid :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Continental Industries; brand of Hubbell Utility Solutions; Hubbell Incorporated]**
 - b. **[ERICO; brand of nVent Electrical plc]**
 - c. **[Harger Lightning & Grounding; business of Harger, Inc.]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Continental Industries; brand of Hubbell Utility Solutions; Hubbell Incorporated]**
 - b. **[ERICO; brand of nVent Electrical plc]**
 - c. **[Harger Lightning & Grounding; business of Harger, Inc.]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

5. Standard Features: Conductive copper tape for field-fabrication of grid.
 - a. Copper Tape Dimensions: **[16 mil (0.4 mm) (26 ga.) thick by 2 inch (51 mm) wide][40 mil (1 mm) (18 ga.) thick by 1.6 inch (40 mm) wide]<Insert dimensions>**.
 - b. Spacing: **[24 inch (610 mm)]<Insert dimension>**.
 - c. Welded or brazed fittings for intersections.
6. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

2.10 GROUNDING (EARTHING) ELECTRODES

A. UL KDER - Rod Electrode :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[allG Fabrication (formerly ALT)]**
 - c. **[Continental Industries; brand of Hubbell Utility Solutions; Hubbell Incorporated]**
 - d. **[ERICO; brand of nVent Electrical plc]**
 - e. **[Galvan Industries, Inc.; Electrical Products Division, LLC]**
 - f. **[Harger Lightning & Grounding; business of Harger, Inc.]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[allG Fabrication (formerly ALT)]**
 - c. **[Continental Industries; brand of Hubbell Utility Solutions; Hubbell Incorporated]**
 - d. **[ERICO; brand of nVent Electrical plc]**
 - e. **[Galvan Industries, Inc.; Electrical Products Division, LLC]**
 - f. **[Harger Lightning & Grounding; business of Harger, Inc.]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in

accordance with guide information and standards specified for the following UL product categories:

- a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
- 5. Standard Features: **[Copper-clad][Zinc-coated][Stainless] steel[, sectional type]; [3/4 inch by 10 ft (19 mm by 3 m)][5/8 inch by 8 ft (16 mm by 2.4 m)]**.
- 6. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

B. UL KDER - Chemically Charged Rod Electrode :

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[allIG Fabrication (formerly ALT)]**
 - b. **[ALLTEC LLC]**
 - c. **[ERICO; brand of nVent Electrical plc]**
 - d. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[allIG Fabrication (formerly ALT)]**
 - b. **[ALLTEC LLC]**
 - c. **[ERICO; brand of nVent Electrical plc]**
 - d. **<Insert manufacturer's name>**
- 3. Source Limitations: Obtain products from single manufacturer.
- 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
- 5. Standard Features: Copper tube, straight or L-shaped, charged electrode enhancement material.
 - a. Termination: Factory-attached 4/0 AWG bare conductor at least **48 inch (1200 mm)** long.
 - b. Backfill Material: Electrode manufacturer's recommended material.

6. Sustainable Design Features:

- a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
- b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
- c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
- d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
- e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

7. Other Available Features Required by the Project:

- a. Electrode Enhancement Material: **[Nonhazardous electrolytic chemical salts]<Insert enhancement material>**.

C. UL KDER - Plate Electrode :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ALLTEC LLC]**
 - b. **[Galvan Industries, Inc.; Electrical Products Division, LLC]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ALLTEC LLC]**
 - b. **[Galvan Industries, Inc.; Electrical Products Division, LLC]**
 - c. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
5. Standard Features: **1/4 inch (6 mm)** thick, hot-dip galvanized.
6. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.

- c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
- d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
- e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

2.11 GROUNDING ELECTRODE ENCLOSURES

- A. Description: Enclosures designed to protect grounding electrodes from damage while providing access for inspection and testing of the grounding system.
- B. Grounding Electrode Access Well Enclosure :
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ERICO; brand of nVent Electrical plc]**
 - b. **[Harger Lightning & Grounding; business of Harger, Inc.]**
 - c. **[Quazite; brand of Hubbell Utility Solutions; Hubbell Incorporated]**
 - d. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ERICO; brand of nVent Electrical plc]**
 - b. **[Harger Lightning & Grounding; business of Harger, Inc.]**
 - c. **[Quazite; brand of Hubbell Utility Solutions; Hubbell Incorporated]**
 - d. **<Insert manufacturer's name>**
 - 3. Source Limitations: Obtain products from single manufacturer.
 - 4. Standard Features:
 - a. Well Material: **[Concrete][HDPE][Schedule 40 PVC]**.
 - b. Cover Material: **[Cast iron][Concrete][HDPE][Plastic][Steel]**.
 - c. Cover Strength: **[Sidewalk or turf use][Driveway use]<Insert rating>**.
 - 5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Material Reuse: Product is salvaged, refurbished, or reused.
 - c. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - d. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - e. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard



- development organization, is publicly available for product.
- f. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
6. Other Available Features Required by the Project:
- a. Round:
 - 1) Nominal Diameter: [8 inch (200 mm)][9 inch (230 mm)][10 inch (250 mm)][12 inch (300 mm)][13 inch (330 mm)]<Insert dimension>.
 - 2) Nominal Height: [10 inch (250 mm)][12 inch (300 mm)][18 inch (450 mm)][24 inch (600 mm)][30 inch (760 mm)][36 inch (910 mm)][48 inch (1220 mm)]<Insert dimension>.
 - 3) Slotted sides for installation after grounding connections made.
 - b. Rectangular:
 - 1) Nominal Width: [2 inch (50 mm)][12 inch (300 mm)][13 inch (330 mm)][17 inch (430 mm)][36 inch (910 mm)]<Insert dimension>.
 - 2) Nominal Length: [10 inch (250 mm)][12 inch (300 mm)][13 inch (330 mm)][17 inch (430 mm)][18 inch (450 mm)][24 inch (600 mm)][36 inch (910 mm)][42 inch (1070 mm)]<Insert dimension>.
 - 3) Nominal Height: [12 inch (300 mm)][18 inch (450 mm)][24 inch (600 mm)][30 inch (760 mm)]<Insert dimension>.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine facility's grounding electrode system and equipment grounding for compliance with requirements for maximum ground-resistance level and other conditions affecting performance of grounding and bonding of electrical system.
- B. Inspect test results of grounding system measured at point of electrical service equipment connection.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
- D. Proceed with connection of electrical service equipment only after unsatisfactory conditions have been corrected.

3.2 SELECTION OF GROUNDING AND BONDING PRODUCTS

- A. Grounding and Bonding Conductors:
 1. Provide solid conductor for [8 AWG]<Insert wire size> and smaller, and stranded conductors for [6 AWG]<Insert wire size> and larger unless otherwise indicated.
 2. Custom-Length Insulated Equipment Bonding Jumpers: 6 AWG, 19-strand, Type THHN.
 3. Bonding Cable: 28 kcmil, 14 strands of 17 AWG conductor, 1/4 inch (6 mm) in diameter.
 4. Bonding Conductor: 4 AWG or 6 AWG, stranded conductor.
 5. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inch (41 mm) wide and 1/16 inch (1.6 mm) thick.

6. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; **1-5/8 inch (41 mm)** wide and **1/16 inch (1.6 mm)** thick.
7. Underground Grounding Conductors: Install bare **[tinned-]**copper conductor, **[2/0 AWG]<Insert wire size>** minimum.

B. Grounding and Bonding Connectors:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

C. Grounding and Bonding Busbars: Provide in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated on the Drawings.

D. Substation Signal Reference Grid:

1. Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with IEEE C2.
 - a. Install **[8 AWG][6 AWG]<Insert wire size from fault calculation>** bonding conductors below grade in a grid pattern on **2 ft (600 mm)** centers. Bond grid conductors with exothermic welds where they cross each other.
 - b. Grid must fill entire area inside equipment yard fence, and extend minimum **6.5 ft (2 m)** outside fence, so someone walking or running outside yard may not touch fence or open gate without first stepping inside grid.
 - c. Bond each metal fence post and gate post to at least two grid conductors.
 - d. Inside grid, bond equipment reinforcing steel inside bases and sidewalks to at least two grid conductors.
 - e. Bond underground metal pipe and conduit passing under grid to nearest grid conductor at both ends.

E. Signal Reference Grid Tape Mesh:

1. Install tape mesh under floor finish with the following features:
 - a. Tape mesh, **2 inch (50 mm)** by **16 mil (0.4 mm)** solid copper, **[12 inch (300 mm)][24 inch (610 mm)]** spacing.

3.3 SELECTION OF GROUNDING AND BONDING PRODUCTS FOR COMMUNICATIONS

- A. Comply with Section 270528 "Pathways for Communications Systems" and Section 271100 "Communications Equipment Room Fittings."

3.4 SELECTION OF GROUNDING AND BONDING PRODUCTS FOR TOWERS AND ANTENNAS

A. Special Techniques:

1. Ring Electrode: Buried at least **30 inch (760 mm)** below grade and at least **24 inch (610 mm)** from base of tower or mounting.
2. Bond each tower base and metallic frame of dish to ring electrode, buried at least **18 inch (460 mm)** below grade.
3. Bond ring electrode and antenna bonding conductors to equipment room PBB or SBB, buried at least **30 inch (760 mm)** below grade.



4. Bond metal fences located within **6 ft (1.8 m)** of towers and antennas to ring electrode, buried at least **18 inch (460 mm)** below grade.
5. Special Requirements for Roof-Mounted Towers:
 - a. Roof Ring: Meet requirements for ring electrode except conductors must comply with NFPA 780.
 - b. Bond tower base footings steel, SBB in equipment room, and antenna support guys to roof ring.
 - c. Connect roof ring to perimeter conductors of lightning protection system.
6. Special Requirements for Waveguides and Coaxial Cable:
 - a. Bond cable shields at point of entry into building to nearest SBB and to cable entrance plate, using 2 AWG bonding conductors.
 - b. Bond coaxial cable surge arrester to ring electrode or roof ring using bonding conductor size recommended by surge-arrester manufacturer.

3.5 INSTALLATION OF GROUNDING AND BONDING

- A. Comply with manufacturer's published instructions.
- B. Reference Standards:
 1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
 2. Electrical Maintenance: NFPA 70B.
 3. Electrical Safety: NFPA 70E.
 4. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
 5. Communications Work: BICSI N1.
 6. Work in ITE Rooms: NFPA 75.
 7. Work in Health Care Facilities: NFPA 99 and Article 517 of NFPA 70.
 8. Emergency and Standby Power Work: NFPA 110, NFPA 111, and NECA NEIS 416.
 9. Work in Confined Spaces: NFPA 350.
 10. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
 11. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.
 12. Consult Architect for resolution of conflicting requirements.
- C. Special Techniques:
 1. Grounding and Bonding Conductors:
 - a. Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
 - b. Underground Grounding Conductors:
 - 1) Bury at least **30 inch (750 mm)** below grade.
 - 2) Duct-Bank Grounding Conductor: Bury **12 inch (300 mm)** above duct bank when indicated as part of duct-bank installation.
 2. Grounding and Bonding Connectors: Make connections so possibility of galvanic action or

electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.

- a. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
 - b. Make connections with clean, bare metal at points of contact.
 - c. Make aluminum-to-steel connections with stainless steel separators and mechanical clamps.
 - d. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
 - e. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.
 - f. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
 - 1) Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate adjacent parts.
 - 2) Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
 - 3) Use exothermic-welded connectors for outdoor locations; if disconnect-type connection is required, use bolted clamp.
 - g. Grounding and Bonding for Piping:
 - 1) Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use bolted clamp connector or bolt lug-type connector to pipe flange by using one of lug bolts of flange. Where dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
 - 2) Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with bolted connector.
 - 3) Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
 - h. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install **[tinned]** bonding jumper to bond across flexible duct connections to achieve continuity.
 - i. Grounding for Steel Building Structure: Install driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than **60 ft (18 m)** apart.
3. Grounding and Bonding Busbars:
- a. Install busbar horizontally, on insulated spacers **2 inch (50 mm)** minimum from wall, **6 inch (150 mm)** above finished floor unless otherwise indicated.
 - b. Where busbars are indicated on both sides of doorways, route bonding conductor up to top of door frame, across top of doorway, and down; connect to continuation of horizontal busbar.
4. Electrodes:
- a. Ground Rods: Drive rods until tops are **2 inch (50 mm)** below finished floor or final grade unless otherwise indicated.
 - 1) Interconnect ground rods with grounding electrode conductor below grade and as

- otherwise indicated. Make connections without exposing steel or damaging coating if any.
- 2) Use exothermic welds for below-grade connections.
- b. For grounding electrode system, install at least **[three]<Insert number>** rods spaced at least one-rod length from each other and located at least same distance from other grounding electrodes, and connect to service grounding electrode conductor.
 - c. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Section 260543 "Underground Ducts and Raceways for Electrical Systems," and must be at least **12 inch (300 mm)** deep, with cover.
 - 1) Install at least one test well for each service unless otherwise indicated. Install at ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.
 - d. Ring Electrode: Install grounding conductor, electrically connected to each building structure ground rod and to each **[steel column][indicated item]**, extending around perimeter of **[building][area or item indicated]**.
 - 1) Install tinned-copper conductor not less than **[2/0 AWG]<Insert wire size>** for ring electrode and for taps to building steel.
 - 2) Bury ring electrode not less than **[24 inch (600 mm)]<Insert dimension>** from building's foundation.
 - e. Concrete-Encased Electrode (Ufer Ground):
 - 1) Fabricate in accordance with NFPA 70; use minimum of **[20 ft (6 m)]<Insert dimension>** of bare copper conductor not smaller than **[4 AWG]<Insert wire size>**.
 - a) If concrete foundation is less than **[20 ft (6 m)]<Insert dimension>** long, coil excess conductor within base of foundation.
 - b) Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building's grounding grid or to grounding electrode external to concrete.
 - 2) Fabricate in accordance with NFPA 70; using electrically conductive coated steel reinforcing bars or rods, at least **20 ft (6.0 m)** long. If reinforcing is in multiple pieces, connect together by usual steel tie wires or exothermic welding to create required length.
5. Grounding at Service:
 - a. Equipment grounding conductors and grounding electrode conductors must be connected to ground busbar. Install main bonding jumper between neutral and ground buses.
 6. Grounding Separately Derived Systems:
 - a. Permanent Generators: Install grounding electrode(s) at location of permanent generators having switched neutral connections. Electrode must be connected to equipment grounding conductor and to frame of generator.
 7. Grounding Underground Distribution System Components:
 - a. Duct-Bank Grounding Conductor: Bury **12 inch (300 mm)** above duct bank when indicated as part of duct-bank installation.

- b. Comply with IEEE C2 grounding requirements.
 - c. Grounding Manholes and Handholes: Install driven ground rod through manhole or handhole floor, close to wall, and set rod depth so **4 inch (100 mm)** will extend above finished floor. If necessary, install ground rod before manhole is placed and provide 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from **2 inch (50 mm)** above to **6 inch (150 mm)** below concrete. Seal floor opening with waterproof, nonshrink grout.
 - d. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields in accordance with manufacturer's published instructions with splicing and termination kits.
 - e. Pad-Mounted Transformers and Switches: Install two ground rods and ring electrode around pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than 2 AWG for ring electrode and for taps to equipment grounding terminals. Bury ring electrode not less than **6 inch (150 mm)** from foundation.
8. Equipment Grounding and Bonding:
- a. Install insulated equipment grounding conductors with feeders and branch circuits.
 - b. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
 - 1) Feeders and branch circuits.
 - 2) Lighting circuits.
 - 3) Receptacle circuits.
 - 4) Single-phase motor and appliance branch circuits.
 - 5) Three-phase motor and appliance branch circuits.
 - 6) Flexible raceway runs.
 - 7) Armored and metal-clad cable runs.
 - 8) Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
 - 9) X-Ray Equipment Circuits: Install insulated equipment grounding conductor in circuits supplying x-ray equipment.
 - c. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.
 - d. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.
 - e. Isolated Grounding Receptacle Circuits: Install insulated equipment grounding conductor connected to receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of applicable derived system or service unless otherwise indicated.
 - f. Isolated Equipment Enclosure Circuits: For designated equipment supplied by branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install separate insulated equipment grounding conductor. Isolate conductor from raceway

and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of applicable derived system or service unless otherwise indicated.

- g. Poles Supporting Outdoor Lighting Fixtures: Bond insulated equipment grounding conductor to equipment grounding terminal inside pole base.
- h. Metallic Fences: Comply with requirements of IEEE C2.

- 1) Grounding Conductor: Bare[, **tinned**] copper, not less than **[8 AWG]<Insert wire size>**.
- 2) Gates: Must be bonded to grounding conductor with flexible bonding jumper.
- 3) Barbed Wire: Strands must be bonded to grounding conductor.

9. Fence Grounding:

- a. Grounding Method: At each grounding location, drive grounding rod vertically until top is **6 inch (150 mm)** below finished grade. Connect rod to fence with 6 AWG conductor. Connect conductor to each fence component at grounding location.
- b. Fences greater than **100 ft (30 m)** of Buildings, Structures, Walkways, and Roadways: Ground fence at maximum intervals of **[1500 ft (450 m)]<Insert lesser distance if grounding resistance is high>**.
- c. Fences within **100 ft (30 m)** of Buildings, Structures, Walkways, and Roadways: Ground fence at maximum intervals of **[750 ft (225 m)]<Insert lesser distance if grounding resistance is high>**.
- 1) Gates and Other Fence Openings: Ground fence on each side of opening.
 - a) Bond metal gates to gate posts by connecting bonding jumper between gate post and gate frame.
 - b) Bond across openings, with and without gates, except at openings indicated as intentional fence discontinuities. Use 2 AWG wire and bury it at least **18 inch (460 mm)** below finished grade.
- d. Protection at Crossings of Overhead Electrical Power Lines: Ground fence at location of power line crossing and at maximum distance of **150 ft (45 m)** on each side of crossing.
- e. Bonding to Lightning-Protection System: If fence terminates at lightning-protected building or structure, ground fence and bond fence grounding conductor to lightning-protection down conductor or lightning-protection grounding conductor, complying with NFPA 780.

3.6 FIELD QUALITY CONTROL FOR GROUNDING AND BONDING

A. Administrant for Electrical Power Tests and Inspections:

- 1. **[Owner][Tenant]** will engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
- 2. Engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
- 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
- 4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].

B. Acceptance Testing Preparation:

- 1. **<Insert requirements>**.

- C. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.
- D. Tests and Inspections:
1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with calibrated torque wrench in accordance with manufacturer's published instructions.
 3. Test completed grounding system at each location where maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal[, **at ground test wells**][, **and at individual ground rods**]. Make tests at ground rods before conductors are connected.
 - a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
 - b. Perform tests by fall-of-potential method in accordance with IEEE Std 81.
 - c. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.
 4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to record of tests and observations. Include number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.
- E. Nonconforming Work:
1. Grounding system will be considered defective if it does not pass tests and inspections.
 2. Remove and replace defective components and retest.
- F. Collect, assemble, and submit test and inspection reports.
1. Report measured ground resistances that exceed the following values:
 - a. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: **[10 Ω]<Insert ohms>**.
 - b. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: **[5 Ω]<Insert ohms>**.
 - c. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: **[3 Ω]<Insert ohms>**.
 - d. Power Distribution Units or Panelboards Serving Electronic Equipment: **[1 Ω][3 Ω]<Insert ohms>**.
 - e. Substations and Pad-Mounted Equipment: **[5 Ω]<Insert ohms>**.
 - f. Manhole Grounds: **[10 Ω]<Insert ohms>**.
 - g. **<Insert application and maximum ground-resistance>**.

3.7 PROTECTION

- A. After installation, protect grounding and bonding cables and equipment from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.



26 - Electrical

END OF SECTION 26 05 26 00



Task	Specification	Specification Description
26 05 26 00	26 05 00 00	Sleeves and Sleeve Seals for Electrical Raceways and Cabling



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SECTION 26 05 29 00 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Support systems.
2. Mounting, anchoring, and attachment components.
3. Installation of fabricated metal supports.
4. Installation of concrete bases.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. Section 033000 "Cast-in-Place Concrete" specifies concrete materials, reinforcement, and placement requirements referenced by this Section.
5. Section 055000 "Metal Fabrications" specifies site-fabricated metal supports referenced by this Section.
6. **[Section 099113 "Exterior Painting"]****[Section 099123 "Interior Painting"]****[and]****[Section 099600 "High-Performance Coatings"]** specify cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal referenced by this Section.
7. Section 260548 "Vibration and Seismic Controls for Electrical Systems" specifies vibration controls, seismic restraints, and wind restraints referenced by this Section.

1.2 DELEGATED DESIGN SERVICES

- A. Delegated Design Professionals: Engage qualified structural professional engineer to design hangers and supports for electrical systems.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:
 - a. Slotted support systems, hardware, and accessories.
 - b. Clamps.
 - c. Hangers.
 - d. Sockets.
 - e. Eye nuts.

- f. Fasteners.
- g. Anchors.
- h. Saddles.
- i. Brackets.
- j. <Insert product type>.

2. Include rated capacities and furnished specialties and accessories.

B. Shop Drawings: For fabrication and installation details for electrical hangers and support systems.

- 1. Hangers. Include product data for components.
- 2. Slotted support systems.
- 3. Equipment supports.
- 4. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Delegated Design Submittals: For hangers and supports for electrical systems.

- 1. Include design calculations and details of hangers.
- 2. Include design calculations for seismic restraints.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.5 REGULATORY AGENCY APPROVALS

A. Delegated design submittals and shop drawings requiring approval by authorities having jurisdiction must be signed by qualified structural professional engineer responsible for their preparation. **[Obtain approval by authorities having jurisdiction prior to submitting for action by Architect.]****[Submit for action by Architect prior to submitting for approval by authorities having jurisdiction.]**

1.6 QUALIFICATIONS

A. Structural Professional Engineer: Professional engineer possessing active qualifications specified in Section 014000 "Quality Requirements," with expertise in structural engineering, including design of seismic and wind controls, equipment hangers and supports, and concrete foundations.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Prepare design calculations in accordance with criteria specified in Section 260010 "Supplemental Requirements for Electrical" and Section 018123 "Facility Seismic and Wind Criteria."
- B. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame Rating: Class 1.
2. Self-extinguishing according to ASTM D635.

2.2 SUPPORT SYSTEMS

A. Steel Slotted Support Systems :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[Allied Tube & Conduit; Atkore International]**
 - c. **[Atkore Unistrut]**
 - d. **[CADDY; brand of nVent Electrical plc]**
 - e. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - f. **[Flex-Strut Inc.]**
 - g. **[G-Strut]**
 - h. **[Gripple Inc.]**
 - i. **[Haydon Corporation]**
 - j. **[Metal Ties Innovation]**
 - k. **[MIRO Industries Inc.]**
 - l. **[Rocket Rack; Robroy Industries]**
 - m. **[Wesanco/ZSi-Foster; an Ideal Tridon Group Company]**
 - n. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Allied Tube & Conduit; Atkore International]**
 - c. **[Atkore Unistrut]**
 - d. **[CADDY; brand of nVent Electrical plc]**
 - e. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - f. **[Flex-Strut Inc.]**
 - g. **[G-Strut]**
 - h. **[Gripple Inc.]**
 - i. **[Haydon Corporation]**
 - j. **[Metal Ties Innovation]**
 - k. **[MIRO Industries Inc.]**
 - l. **[Rocket Rack; Robroy Industries]**
 - m. **[Wesanco/ZSi-Foster; an Ideal Tridon Group Company]**
 - n. **<Insert manufacturer's name>**
3. Standard Features: Preformed steel channels and angles with minimum **13/32 inch (10 mm)** diameter holes at a maximum of **8 inch (200 mm)** on center in at least one surface.
 - a. Referenced Standard: MFMA-4 factory-fabricated components for field assembly.
 - b. Material for Channel, Fittings, and Accessories: **[Galvanized steel][Plain steel][Stainless steel, Type 304][Stainless steel, Type 316]**.
 - c. Channel Width: **[Selected for applicable load criteria][1-5/8 inch (41.25 mm)][1-1/4 inch (31.75 mm)][13/16 inch (20.64 mm)]<Insert dimension>**.
 - d. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.

- e. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
- f. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
- g. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

B. Aluminum Slotted Support Systems :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[Atkore Unistrut]**
 - c. **[Eaton]**
 - d. **[Flex-Strut Inc.]**
 - e. **[Haydon Corporation]**
 - f. **[MKT Metal Manufacturing]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Atkore Unistrut]**
 - c. **[Eaton]**
 - d. **[Flex-Strut Inc.]**
 - e. **[Haydon Corporation]**
 - f. **[MKT Metal Manufacturing]**
 - g. **<Insert manufacturer's name>**
3. Standard Features: Extruded-aluminum channels and angles with minimum **13/32 inch (10 mm)** diameter holes at a maximum of **8 inch (200 mm)** on center in at least one surface.
 - a. Referenced Standard: MFMA-4 factory-fabricated components for field assembly.
 - b. Channel Material: 6063-T5 aluminum alloy.
 - c. Fittings and Accessories Material: 5052-H32 aluminum alloy.
 - d. Channel Width: **[Selected for applicable load criteria][1-5/8 inch (41.25 mm)][1-1/4 inch (31.75 mm)][13/16 inch (20.64 mm)]<Insert dimension>**.
 - e. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
 - f. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 - g. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

C. Nonmetallic Slotted Support Systems :

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

- b. [Atkore Unistrut]
 - c. [Champion Fiberglass, Inc]
 - d. [Cooper B-line; brand of Eaton, Electrical Sector]
 - e. [Fabco Plastics Wholesale Limited]
 - f. [G-Strut]
 - g. [Haydon Corporation]
 - h. [Seasafe, Inc.; AMICO, a Gibraltar Industries Company]
 - i. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Allied Tube & Conduit; Atkore International]
 - b. [Atkore Unistrut]
 - c. [Champion Fiberglass, Inc]
 - d. [Cooper B-line; brand of Eaton, Electrical Sector]
 - e. [Fabco Plastics Wholesale Limited]
 - f. [G-Strut]
 - g. [Haydon Corporation]
 - h. [Seasafe, Inc.; AMICO, a Gibraltar Industries Company]
 - i. <Insert manufacturer's name>
3. Standard Features: Structural-grade, factory-formed, glass-fiber-resin channels and angles with minimum **13/32 inch (10 mm)** diameter holes at a maximum of **8 inch (200 mm)** on center, in at least one surface.
 - a. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
 - b. Channel Width: [Selected for applicable load criteria][1-5/8 inch (41.25 mm)][1-1/4 inch (31.75 mm)][13/16 inch (20.64 mm)]<Insert dimension>.
 - c. Fittings and Accessories: Products provided by channel and angle manufacturer and designed for use with those items.
 - d. Fitting and Accessory Materials: Same as those for channels and angles[, **except metal items may be stainless steel**].
 - e. Rated Strength: Selected to suit applicable load criteria.
 - f. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- D. Conduit and Cable Support Devices:
 1. Standard Features: [Steel][Steel and malleable-iron][Stainless steel][Glass-fiber-resin] hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- E. Support for Conductors in Vertical Conduit:
 1. Standard Features: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored electrical conductors or cables in riser conduits. Plugs must have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body must be made of malleable iron.
- F. Structural Steel for Fabricated Supports and Restraints:
 1. Standard Features: ASTM A36/A36M steel plates, shapes, and bars; black and galvanized.

2.3 MOUNTING, ANCHORING, AND ATTACHMENT COMPONENTS

A. Powder-Actuated Fasteners :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Hilti, Inc.]**
 - b. **[ITW Ramset/Red Head; Illinois Tool Works, Inc.]**
 - c. **[MKT Fastening, LLC]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Hilti, Inc.]**
 - b. **[ITW Ramset/Red Head; Illinois Tool Works, Inc.]**
 - c. **[MKT Fastening, LLC]**
 - d. **<Insert manufacturer's name>**
3. Standard Features: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

B. Mechanical-Expansion Anchors :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - b. **[Empire Industries, Inc.]**
 - c. **[Hilti, Inc.]**
 - d. **[ITW Ramset/Red Head; Illinois Tool Works, Inc.]**
 - e. **[MKT Fastening, LLC]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - b. **[Empire Industries, Inc.]**
 - c. **[Hilti, Inc.]**
 - d. **[ITW Ramset/Red Head; Illinois Tool Works, Inc.]**
 - e. **[MKT Fastening, LLC]**
 - f. **<Insert manufacturer's name>**
3. Standard Features: Insert-wedge-type, **[zinc-coated][stainless]** steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

- C. Concrete Inserts:
 - 1. Standard Features: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
- D. Clamps for Attachment to Steel Structural Elements:
 - 1. Standard Features: MSS SP-58 units are suitable for attached structural element.
- E. Through Bolts:
 - 1. Standard Features: Structural type, hex head, and high strength. Comply with ASTM F3125/F3125M, **Grade A325 (Grade A325M)**.
- F. Toggle Bolts:
 - 1. Standard Features: **[All][Stainless]** steel springhead type.
- G. Hanger Rods:
 - 1. Standard Features: Threaded steel.

PART 3 - EXECUTION

3.1 SELECTION OF HANGERS AND SUPPORTS

- A. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, IMC, and ERM as **[required by][scheduled in NECA NEIS 1, where its Table 1 lists maximum spacings that are less than those stated in]** NFPA 70. Minimum rod size must be **1/4 inch (6 mm)** in diameter.
- B. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted **[or other]** support system, sized so capacity can be increased by at least **[25]<Insert number>** percent in future without exceeding specified design load limits.
 - 1. Secure raceways and cables to these supports with **[two-bolt conduit clamps][single-bolt conduit clamps][single-bolt conduit clamps using spring friction action for retention in support channel]**.
- C. Spring-steel clamps designed for supporting single conduits without bolts may be used for **1-1/2 inch (38 mm)** and smaller raceways serving branch circuits and communication systems above suspended ceilings, and for fastening raceways to trapeze supports.

3.2 INSTALLATION OF HANGERS AND SUPPORTS

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:
 - 1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
 - 2. Hot Work: NFPA 51B.

3. Work in Confined Spaces: NFPA 350.
4. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
5. Installation of Steel Conduit: NECA NEIS 101.
6. Installation of Aluminum Conduit: NECA NEIS 102.
7. Installation of Metal Cable Tray Systems: NECA NEIS 105.
8. Installation of Nonmetallic Cable Tray Systems: NECA NEIS 111.
9. Consult Architect for resolution of conflicting requirements.

C. Special Installation Techniques:

1. Raceway Support Methods: In addition to methods described in NECA NEIS 1, **[EMT][IMC][and][ERMC]** may be supported by openings through structure members, in accordance with NFPA 70.
2. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination must be weight of supported components plus **200 lb (90 kg)**.
3. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
 - a. To Wood: Fasten with lag screws or through bolts.
 - b. To New Concrete: Bolt to concrete inserts.
 - c. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 - d. To Existing Concrete: Expansion anchor fasteners.
 - e. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete **4 inch (100 mm)** thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than **4 inch (100 mm)** thick.
 - f. To Steel: **[Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts][Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69][Spring-tension clamps]**.
 - g. To Light Steel: Sheet metal screws.
 - h. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate **[by means that comply with seismic-restraint strength and anchorage requirements]**.
4. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

D. Interfaces with Other Work:

1. Provide **[vibration][and][seismic]** controls with hangers and supports.
2. Touchup Finishes:
 - a. Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1) Apply paint by brush or spray to provide minimum dry film thickness of **2.0 mils (0.05 mm)**.
 - b. Cleaning and touchup painting of field welds, bolted connections, and abraded areas of

- shop paint on miscellaneous metal.
 - c. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780.
- 3. Installation of Fabricated Metal Supports:
 - a. Provide site-fabricated metal supports.
 - b. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
 - c. Field Welding: Comply with AWS D1.1/D1.1M. Submit welding certificates.
- 4. Installation of Concrete Bases:
 - a. Provide concrete bases of dimensions indicated, but not less than **4 inch (100 mm)** larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.
 - b. Use **[3000 psi (20.7 MPa)]<Insert value>**, 28-day compressive-strength concrete.
 - c. Anchor equipment to concrete base as follows:
 - 1) Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 2) Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 3) Install anchor bolts according to anchor-bolt manufacturer's written instructions.

END OF SECTION 26 05 29 00



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SECTION 26 05 29 00A - VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Vibration controls.
2. Seismic and wind controls.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. Section 260529 "Hangers and Supports for Electrical Systems" specifies hangers and supports referenced by this Section.

1.2 DEFINITIONS

- A. Designated Seismic System: An architectural, electrical, or mechanical system and its components for which the component importance factor is greater than 1.0 when determined in accordance with Section 018123 "Facility Seismic and Wind Criteria."
- B. OSHPD: Office of Statewide Health Planning and Development (for the State of California owned and regulated medical facilities).

1.3 DELEGATED DESIGN SERVICES

- A. Delegated Design Professionals: Engage qualified structural professional engineer to design seismic and wind controls.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Prepare and submit catalog cuts, brochures, [**diagrams**,] [**schedules**,] and performance data illustrating size, physical appearance, and other characteristics of product.
 - a. Include rated load capacity for each seismic- and wind-restraint device.
 - b. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic- and wind-restraint component used.
 - c. Annotate types and sizes of seismic restraints and accessories, complete with listing markings or report numbers and load rating in tension and compression as evaluated by

[ICC-ES product listing][UL product listing][FM Approvals][an evaluation service member of ICC-ES][OSHPD][an agency acceptable to authorities having jurisdiction].

- d. Annotate to indicate application of each product submitted and compliance with requirements.

B. Shop Drawings:

1. Detail fabrication and assembly of equipment bases.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
3. Show coordination of seismic and wind bracing for components with other systems and equipment in the vicinity, including other supports and seismic restraints.

C. Delegated Design Submittals:

1. For each seismic-restraint device, including **[restraint - rigid and cable type],[restraint accessory],[and][concrete anchor and insert]** that is required by this Section or is indicated on the Drawings, submit the following:
 - a. Seismic Restraints: Select seismic restraints complying with performance requirements, design criteria, and analysis data.
 - b. Post-Installed Concrete Anchors and Inserts: Include calculations showing anticipated seismic criteria. Include certification that device is approved by qualified testing laboratory for seismic reinforcement use.
 - c. Seismic Design Calculations: Submit input data and loading calculations.
2. For each wind-restraint device, including **[restraint - rigid and cable type],[restraint accessory],[and][concrete anchor and insert]** that is required by this Section or is indicated on the Drawings, submit the following:
 - a. Wind Restraint: Select wind restraints complying with performance requirements, design criteria, and analysis data.
 - b. Post-Installed Concrete Anchors and Inserts: Include calculations showing anticipated wind criteria. Include certification that device is approved by qualified testing laboratory for reinforcement use.
 - c. Wind Design Calculations: Submit static and dynamic loading calculations.
3. Seismic- and Wind-Restraint Detail Drawings:
 - a. Design Analysis: To support selection and arrangement of seismic and wind restraints. Include calculations of combined tensile and shear loads.
 - b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
 - c. Coordinate seismic-restraint details with wind details required for equipment mounted outdoors.
4. Product Listing, Preapproval, and Evaluation Documentation: By **[an evaluation service member of ICC-ES][UL][FM Approvals][OSHPD][an agency acceptable to authorities having jurisdiction]**, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

D. Field quality-control reports.

1.5 REGULATORY AGENCY APPROVALS

- A. Delegated design submittals and shop drawings requiring approval by authorities having jurisdiction must be signed by qualified structural professional engineer responsible for their preparation. **[Obtain approval by authorities having jurisdiction prior to submitting for action by Architect.][Submit for action by Architect prior to submitting for approval by authorities having jurisdiction.]**

1.6 QUALIFICATIONS

- A. Structural Professional Engineer: Professional engineer possessing active qualifications specified in Section 014000 "Quality Requirements," with expertise in structural engineering, including design of seismic and wind controls, equipment hangers and supports, and concrete foundations.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Prepare design calculations in accordance with criteria specified in Section 260010 "Supplemental Requirements for Electrical" and Section 018123 "Facility Seismic and Wind Criteria."
- B. Seismic and Wind Restraint Device Ratings: Devices must be tested and rated in accordance with applicable code requirements and authorities having jurisdiction. Devices must be listed by a nationally recognized third party that requires periodic follow-up inspections and has a listing directory available to the public. Provide third-party listing by one or more of the following: **[ICC-ES product listing][UL product listing][FM Approvals][an evaluation service member of ICC-ES][an agency acceptable to authorities having jurisdiction]**.
- C. Consequential Damage: Provide additional seismic and wind restraints for suspended components or anchorage of floor-, roof-, or wall-mounted components so that failure of a non-essential or essential component will not cause failure of any other essential building component.
- D. Fire/Smoke Resistance: Seismic- and wind-restraint devices that are not constructed of ferrous metals must have a maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested by qualified testing laboratory in accordance with ASTM E84 or UL 723, and be so labeled.
- E. Component Supports:
 - 1. Load ratings, features, and applications of reinforcement components must be based on testing standards of qualified testing laboratory.

2.2 VIBRATION CONTROLS

- A. Elastomeric Isolation Pads :
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Ace Mountings Co., Inc.]**
 - b. **[CADDY; brand of nVent Electrical plc]**

- c. [California Dynamics Corporation]
 - d. [Isolation Technology, Inc]
 - e. [Kinetics Noise Control, Inc]
 - f. [Korfund]
 - g. [Mason Industries, Inc.]
 - h. [NOVIA; a division of Carpenter & Paterson]
 - i. [Vibration Eliminator Co., Inc]
 - j. [Vibration Isolation]
 - k. [Vibration Management Corp.]
 - l. [VMC GROUP]
 - m. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. [Ace Mountings Co., Inc.]
 - b. [CADDY; brand of nVent Electrical plc]
 - c. [California Dynamics Corporation]
 - d. [Isolation Technology, Inc]
 - e. [Kinetics Noise Control, Inc]
 - f. [Korfund]
 - g. [Mason Industries, Inc.]
 - h. [NOVIA; a division of Carpenter & Paterson]
 - i. [Vibration Eliminator Co., Inc]
 - j. [Vibration Isolation]
 - k. [Vibration Management Corp.]
 - l. [VMC GROUP]
 - m. <Insert manufacturer's name>
3. Standard Features:
- a. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
 - b. Size: Factory or field cut to match requirements of supported equipment.
 - c. Pad Material: Oil and water resistant with elastomeric properties. Neoprene rubber, silicone rubber, or other elastomeric material.
 - d. Surface Pattern: Smooth, ribbed, or waffle pattern.
 - e. Infused nonwoven cotton or synthetic fibers.
 - f. Load-bearing metal plates adhered to pads.
 - g. Sandwich-Core Material: [**Resilient**][**and**][**elastomeric**]**<Insert compound>**.
- 1) Surface Pattern: Smooth, ribbed, or waffle pattern.
 - 2) Infused nonwoven cotton or synthetic fibers.

2.3 SEISMIC AND WIND CONTROLS

A. Restraints - Rigid Type :

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

- a. [Atkore Unistrut]
 - b. [CADDY; brand of nVent Electrical plc]
 - c. [California Dynamics Corporation]
 - d. [Cooper B-line; brand of Eaton, Electrical Sector]
 - e. [Hilti, Inc.]
 - f. [Isolation Technology, Inc]
 - g. [TOLCO Incorporated]
 - h. [VMC GROUP]
 - i. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Atkore Unistrut]
 - b. [CADDY; brand of nVent Electrical plc]
 - c. [California Dynamics Corporation]
 - d. [Cooper B-line; brand of Eaton, Electrical Sector]
 - e. [Hilti, Inc.]
 - f. [Isolation Technology, Inc]
 - g. [TOLCO Incorporated]
 - h. [VMC GROUP]
 - i. <Insert manufacturer's name>
3. Standard Features: Shop- or field-fabricated bracing assembly made of ANSI/AISI S110-07-S1 slotted steel channels, ANSI/ASTM A53/A53M steel pipe, or other rigid steel brace member. Includes accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

B. Restraints - Cable Type :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [CADDY; brand of nVent Electrical plc]
 - b. [Cooper B-line; brand of Eaton, Electrical Sector]
 - c. [Gripple Inc.]
 - d. [Loos & Co. Inc.]
 - e. [VMC GROUP]
 - f. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [CADDY; brand of nVent Electrical plc]
 - b. [Cooper B-line; brand of Eaton, Electrical Sector]
 - c. [Gripple Inc.]
 - d. [Loos & Co. Inc.]
 - e. [VMC GROUP]
 - f. <Insert manufacturer's name>
3. Standard Features:

- a. Seismic- and Wind-Restraint Cables: **[ASTM A1023/A1023M galvanized or ASTM A603 galvanized-steel][ASTM A492 stainless steel]** cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for seismic-restraining cable service; with fittings attached by means of poured socket, swaged socket, or mechanical (Flemish eye) loop.
- b. Restraint cable assembly and cable fittings must comply with ASCE/SEI 19. Cable fittings and complete cable assembly must maintain the minimum cable breaking force. U-shaped cable clips and wedge-type end fittings do not comply and are unacceptable.

C. Restraint Accessories :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Atkore Unistrut]**
 - b. **[CADDY; brand of nVent Electrical plc]**
 - c. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - d. **[Hilti, Inc.]**
 - e. **[Loos & Co. Inc.]**
 - f. **[Mason Industries, Inc.]**
 - g. **[TOLCO Incorporated]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Atkore Unistrut]**
 - b. **[CADDY; brand of nVent Electrical plc]**
 - c. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - d. **[Hilti, Inc.]**
 - e. **[Loos & Co. Inc.]**
 - f. **[Mason Industries, Inc.]**
 - g. **[TOLCO Incorporated]**
 - h. **<Insert manufacturer's name>**
3. Standard Features:
 - a. Hanger-Rod Stiffener: **[Steel tube or steel slotted-support-system sleeve with internally bolted connections][Reinforcing steel angle clamped]** to hanger rod. Non-metallic stiffeners are unacceptable.
 - b. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to **[rigid channel bracings][and][restraint cables]**.
 - c. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.
 - d. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.
 - e. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

D. Mechanical Anchor Bolts :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Atkore Unistrut]**
 - b. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - c. **[Hilti, Inc.]**
 - d. **[Mason Industries, Inc.]**
 - e. **[Powers Fasteners]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Atkore Unistrut]**
 - b. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - c. **[Hilti, Inc.]**
 - d. **[Mason Industries, Inc.]**
 - e. **[Powers Fasteners]**
 - f. **<Insert manufacturer's name>**
3. Standard Features:
 - a. Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength for anchor and as tested according to ASTM E488/E488M.
 - b. Prequalify post-installed anchors in concrete in accordance with ACI 355.2 or other approved qualification testing procedures.
 - c. Prequalify post-installed anchors in masonry in accordance with approved qualification procedures.

E. Adhesive Anchor Bolts :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Atkore Unistrut]**
 - b. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - c. **[Hilti, Inc.]**
 - d. **[Mason Industries, Inc.]**
 - e. **[Powers Fasteners]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Atkore Unistrut]**
 - b. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - c. **[Hilti, Inc.]**
 - d. **[Mason Industries, Inc.]**
 - e. **[Powers Fasteners]**

f. **<Insert manufacturer's name>**

3. Standard Features

- a. Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488/E488M.
- b. Prequalify post-installed anchors in concrete in accordance with ACI 355.2 or other approved qualification testing procedures.
- c. Prequalify post-installed anchors in masonry in accordance with approved qualification procedures.

F. Concrete Inserts :

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

- a. **[Atkore Unistrut]**
- b. **[Cooper B-line; brand of Eaton, Electrical Sector]**
- c. **[Hilti, Inc.]**
- d. **[Mason Industries, Inc.]**
- e. **[Powers Fasteners]**
- f. **<Insert manufacturer's name>**

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

- a. **[Atkore Unistrut]**
- b. **[Cooper B-line; brand of Eaton, Electrical Sector]**
- c. **[Hilti, Inc.]**
- d. **[Mason Industries, Inc.]**
- e. **[Powers Fasteners]**
- f. **<Insert manufacturer's name>**

3. Standard Features:

- a. Provide preset concrete inserts that are seismically prequalified in accordance with ICC-ES AC446 testing.
- b. Comply with MSS SP-58.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and equipment to receive seismic and wind control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for reinforcement and cast-in-place anchors to verify actual locations before

installation.

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

3.2 SELECTION OF VIBRATION AND SEISMIC CONTROLS

- A. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by **[an evaluation service member of ICC-ES][OSHPD][an agency acceptable to authorities having jurisdiction]**.
- B. Hanger-Rod Stiffeners: Install where indicated or scheduled on the Drawings to receive them and where required to prevent buckling of hanger rods caused by seismic forces.
- C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry static, wind, and seismic loads within specified loading limits.

3.3 INSTALLATION OF SEISMIC AND WIND CONTROLS

- A. Provide seismic and wind control devices for systems and equipment where indicated in Equipment Schedules or Seismic and Wind Controls Schedule, where indicated on the Drawings, where the Specifications indicate they must be installed on specific equipment and systems, and where required by applicable codes.
 - 1. Install equipment and devices to withstand the effects of earthquake motions and high wind events.
- B. Coordinate location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."
- C. Installation of seismic and wind restraints must not cause any stresses, misalignment, or change of position of equipment or conduits.
- D. Equipment Restraints:
 - 1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds **0.125 inch (3.2 mm)**.
 - 2. Install seismic-restraint and wind-restraint devices using methods approved by **[an evaluation service member of ICC-ES][OSHPD][an agency acceptable to authorities having jurisdiction]** that provides required submittals for component.
- E. Raceway, Cable, Wireway, Cable Tray, and Busway Support and Hanger Restraints:
 - 1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds **0.125 inch (3.2 mm)**.
 - 2. Install seismic-restraint and wind-restraint devices using methods approved by **[an evaluation service member of ICC-ES][OSHPD][an agency acceptable to authorities having jurisdiction]** that provides required submittals for component.
 - 3. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds **0.125 inch (3.2 mm)**.
 - 4. Install seismic-restraint devices using methods approved by **[an evaluation service member of ICC-ES][OSHPD][an agency acceptable to authorities having jurisdiction]** providing required submittals for component.

- F. Install cables so they do not bend across edges of adjacent equipment or building structure.
- G. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
- H. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.
- I. Post-Installed Concrete Anchors:
 - 1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
 - 2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
 - 3. Mechanical-Type Anchor Bolts: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors must be installed with sleeve fully engaged in the structural element to which anchor will be fastened.
 - 4. Adhesive-Type Anchor Bolts: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
 - 5. Set anchors to manufacturer's recommended torque using a torque wrench.
 - 6. Install zinc-coated steel anchors for interior and stainless steel anchors for exterior applications.
- J. Accommodation of Differential Seismic Motion: Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where connection is terminated to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

3.4 FIELD QUALITY CONTROL

- A. Field tests must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.
- B. Special Structural Tests and Inspections:
 - 1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
 - 2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
 - 3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
 - 4. Test no fewer than **[four]<Insert number>** of each type and size of installed anchors and fasteners selected by Architect.
 - 5. Test to 90 percent of rated proof load of device.
- C. Nonconforming Work:
 - 1. Seismic controls will be considered defective if they do not pass tests and inspections.
 - 2. Remove and replace malfunctioning units and retest as specified above.



- D. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

END OF SECTION 26 05 29 00A



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Task	Specification	Specification Description
26 05 29 00	05 40 00 00	Cold-Formed Metal Framing
26 05 29 00	05 50 00 00	Metal Fabrications
26 05 29 00	26 05 00 00	Sleeves and Sleeve Seals for Electrical Raceways and Cabling
26 05 33 00	26 05 00 00	Sleeves and Sleeve Seals for Electrical Raceways and Cabling



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SECTION 26 05 33 13 - CONDUITS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Type EMT duct raceways and elbows.
2. Type ENT duct raceways and fittings.
3. Type HDPE and Type EPEC duct raceways and fittings.
4. Type ERMC duct raceways, elbows, couplings, and nipples.
5. Type FMC duct raceways.
6. Type FMT duct raceways.
7. Type IMC duct raceways.
8. Type LFMC duct raceways.
9. Type LFNC duct raceways.
10. Type PVC duct raceways and fittings.
11. Type RTRC duct raceways and fittings.
12. Fittings for conduit, tubing, and cable.
13. Joint compounds.
14. Solvent cements.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies temperature, humidity, acoustical, and other field conditions applicable to the Work specified in this Section.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies seismic hazard, wind hazard, other structural load design conditions applicable to the Work specified in this Section.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional coordination, scheduling, sequencing, submittal, and installation requirements applicable to the Work for electrical, communications, and electronic safety and security systems on the Project, including wiring methods.
4. Section 078413 "Penetration Firestopping" specifies firestopping referenced by this Section.
5. Section 260519 "Low-Voltage for Electrical Power Conductors and Cables" specifies nonmetallic underground conduit with conductors (Type NUCC).
6. Section 260529 "Hangers and Supports for Electrical Systems" specifies conduit hangers and supports referenced by this Section.
7. Section 260543 "Underground Ducts and Raceways for Electrical Systems" specifies exterior duct banks, manholes, and underground utility construction.
8. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels.
9. Section 270528 "Pathways for Communications Systems" **and Section 271100 "Communications Equipment Room Fittings"** specifies additional requirements for installation of conduits for communications cabling.

1.2 REFERENCES

A. Abbreviations and Acronyms for Electrical Raceway Types:

1. EMT: Electrical metallic tubing.
2. EMT-A: Aluminum electrical metallic tubing.
3. EMT-S: Steel electrical metallic tubing.

4. EMT-SS: Stainless steel electrical metallic tubing.
5. ENT: Electrical nonmetallic tubing.
6. EPEC: Electrical HDPE underground conduit (thin wall).
7. EPEC-A: Type A electrical HDPE underground conduit.
8. EPEC-B: Type B electrical HDPE underground conduit.
9. ERMCM: Electrical rigid metal conduit.
10. ERMCM-A: Aluminum electrical rigid metal conduit.
11. ERMCM-S: Steel electrical rigid metal conduit.
12. ERMCM-S-G: Galvanized-steel electrical rigid metal conduit.
13. ERMCM-S-PVC: PVC-coated-steel electrical rigid metal conduit.
14. ERMCM-SS: Stainless steel electrical rigid metal conduit.
15. FMC: Flexible metal conduit.
16. FMC-A: Aluminum flexible metal conduit.
17. FMC-S: Steel flexible metal conduit.
18. FMT: Steel flexible metallic tubing.
19. FNMC: Flexible nonmetallic conduit. See "LFNC."
20. HDPE: HDPE underground conduit (thick wall).
21. HDPE-40: Schedule 40 HDPE underground conduit.
22. HDPE-80: Schedule 80 HDPE underground conduit.
23. IMC: Steel electrical intermediate metal conduit.
24. LFMC: Liquidtight flexible metal conduit.
25. LFMC-A: Aluminum liquidtight flexible metal conduit.
26. LFMC-S: Steel liquidtight flexible metal conduit.
27. LFMC-SS: Stainless steel liquidtight flexible metal conduit.
28. LFNC: Liquidtight flexible nonmetallic conduit.
29. LFNC-A: Layered (Type A) liquidtight flexible nonmetallic conduit.
30. LFNC-B: Integral (Type B) liquidtight flexible nonmetallic conduit.
31. LFNC-C: Corrugated (Type C) liquidtight flexible nonmetallic conduit.
32. PVC: Rigid PVC conduit.
33. PVC-40: Schedule 40 rigid PVC conduit.
34. PVC-80: Schedule 80 rigid PVC Conduit.
35. PVC-A: Type A rigid PVC concrete-encased conduit.
36. PVC-EB: Type EB rigid PVC concrete-encased underground conduit.
37. RGS: See ERMCM-S-G.
38. RMC: See ERMCM.
39. RTRC: Reinforced thermosetting resin conduit.
40. RTRC-AG: Low-halogen, aboveground reinforced thermosetting resin conduit.
41. RTRC-AG-HW: Heavy wall, low-halogen, aboveground reinforced thermosetting resin conduit.
42. RTRC-AG-SW: Standard wall, low-halogen, aboveground reinforced thermosetting resin conduit.
43. RTRC-AG-XW: Extra heavy wall, low-halogen, aboveground reinforced thermosetting resin conduit.
44. RTRC-BG: Low-halogen, belowground reinforced thermosetting resin conduit.

B. Definitions:

1. Conduit: A structure containing one or more duct raceways.
2. Direct Buried: Installed underground without encasement in concrete or other protective material.
3. Duct Bank: An arrangement of conduit providing one or more continuous duct raceways between two points.
4. Duct Raceway: A single enclosed raceway for conductors or cable.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.

B. Sustainable Design Submittals:

1. Product data for sustainable design features for each type of product.

C. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

A. Manufacturer's published instructions.

1.5 QUALIFICATIONS

- A. Electrical Power Testing (EPT) Technician III: Possessing active NICET EPT Level III certification. Able to manage switching procedures; conduct tests of complex equipment; analyze test and equipment data; plan a job; and lead a team. Has experience performing NFPA 70B, IEEE, and NETA electrical tests.
- B. Electrical Power Testing (EPT) Technician IV: Possessing active NICET EPT Level IV certification. Able to conduct tests of complex metering and relay systems; evaluate tests, test equipment, test results, and power system performance; recommend actions to maintain or improve system performance; and lead multi-team projects.
- C. Electrical Power Testing and Inspecting Agency: Entities possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
 1. On-site electrical testing supervisors must possess active NICET EPT Technician [III][IV] certification.
- D. ERM-C-S-PVC Installers: Installer possessing active qualifications specified in Section 014000 "Quality Requirements," and able to present unexpired certified Installer credentials issued by ERM-C-S-PVC manufacturer prior to starting installation.
- E. Communications Testing and Inspecting Agency: Entity possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
 1. On-site communications testing supervisor must have **[BICSI Technician (TECH)]<Insert certification program>** certification and documented training, and be experienced with testing communications equipment in accordance with **[BICSI]<Insert code enforced by authorities having jurisdiction>** testing standards.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- B. **<Insert additional performance requirements for the Project>**.

2.2 TYPE EMT DUCT RACEWAYS AND ELBOWS

A. UL FJMX - Aluminum Electrical Metal Tubing (EMT-A) and Elbows:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[American Conduit; Norsk Hydro ASA, Hydro Extrusion USA LLC]**
 - b. **[Patriot Aluminum Products, LLC]**
 - c. **[Penn Aluminum Conduit & EMT; Penn Aluminum International LLC; Berkshire Hathaway]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Conduit; Norsk Hydro ASA, Hydro Extrusion USA LLC]**
 - b. **[Patriot Aluminum Products, LLC]**
 - c. **[Penn Aluminum Conduit & EMT; Penn Aluminum International LLC; Berkshire Hathaway]**
 - d. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN FJMX; including UL 797A.
4. Standard Features:
 - a. Material: Aluminum.
 - b. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)][Metric designator 21 (trade size 3/4)]**.
5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
6. Other Available Features Required by the Project:

- a. Colors: As indicated on the Drawings.
- B. UL FJMX - Stainless Steel Electrical Metal Tubing (EMT-SS) and Elbows:
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Calconduit; Atkore International]**
 - b. **[Rymco USA brand; manufactured and listed by subsidiary Conduit S.A. de C.V]**
 - c. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Calconduit; Atkore International]**
 - b. **[Rymco USA brand; manufactured and listed by subsidiary Conduit S.A. de C.V]**
 - c. **<Insert manufacturer's name>**
 - 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN FJMX; including UL 797A.
 - 4. Standard Features:
 - a. Material: Stainless steel.
 - b. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)][Metric designator 21 (trade size 3/4)]**.
 - 5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
 - 6. Other Available Features Required by the Project:
 - a. Colors: As indicated on the Drawings.
- C. UL FJMX - Steel Electrical Metal Tubing (EMT-S) and Elbows:
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the**

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

- a. **[Allied Tube & Conduit; Atkore International]**
 - b. **[Calconduit; Atkore International]**
 - c. **[Emerson Electric Co., Automation Solutions]**
 - d. **[Picoma; Zekelman Industries]**
 - e. **[Republic Conduit; Nucor Corporation, Nucor Tubular Products]**
 - f. **[Topaz Lighting & Electric]**
 - g. **[Western Tube; Zekelman Industries]**
 - h. **[Wheatland Tube; Zekelman Industries]**
 - i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[Allied Tube & Conduit; Atkore International]**
 - b. **[Calconduit; Atkore International]**
 - c. **[Emerson Electric Co., Automation Solutions]**
 - d. **[Picoma; Zekelman Industries]**
 - e. **[Republic Conduit; Nucor Corporation, Nucor Tubular Products]**
 - f. **[Topaz Lighting & Electric]**
 - g. **[Western Tube; Zekelman Industries]**
 - h. **[Wheatland Tube; Zekelman Industries]**
 - i. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
- a. UL CCN FJMX; including UL 797.
4. Standard Features:
- a. Material: Steel.
 - b. Exterior Coating: **[Zinc][Alternate corrosion-resistant coating]**.
 - c. Interior Coating: **[Zinc with organic top coating][Zinc][Organic coating]**.
 - d. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)][Metric designator 21 (trade size 3/4)]**.
5. Sustainable Design Features:
- a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.

- e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
- 6. Other Available Features Required by the Project:
 - a. Colors: As indicated on the Drawings.

2.3 TYPE ENT DUCT RACEWAYS AND FITTINGS

A. UL FKHU - Electrical Nonmetallic Tubing (ENT) and Fittings:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[Cantex Inc.]**
 - c. **[JM Eagle]**
 - d. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Cantex Inc.]**
 - c. **[JM Eagle]**
 - d. **<Insert manufacturer's name>**
- 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN FKHU; including UL 1653.
- 4. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
- 5. Other Available Features Required by the Project:
 - a. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)][Metric designator 21 (trade**



- size 3/4)].
- b. Fittings:
 - 1) Mechanically Attached Fittings: UL 1653.
 - 2) Solvent-Attached Fittings: UL 651.

2.4 TYPE HDPE AND TYPE EPEC DUCT RACEWAYS AND FITTINGS

A. UL EAZX - Schedule 40 Electrical HDPE Underground Conduit (HDPE-40):

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Blue Diamond Industries, LLC]**
 - b. **[JM Eagle]**
 - c. **[Petroflex North America]**
 - d. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - e. **[Southwire Company, LLC]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Blue Diamond Industries, LLC]**
 - b. **[JM Eagle]**
 - c. **[Petroflex North America]**
 - d. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - e. **[Southwire Company, LLC]**
 - f. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN EAZX; including UL 651A.
4. Standard Features:
 - a. Dimensional Specifications: Schedule 40.
5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute

- standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
- e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
6. Other Available Features Required by the Project:
- a. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)][Metric designator 21 (trade size 3/4)]**.
- B. UL EAZX - Schedule 80 Electrical HDPE Underground Conduit (HDPE-80):
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Blue Diamond Industries, LLC]**
 - b. **[JM Eagle]**
 - c. **[Petroflex North America]**
 - d. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - e. **[Southwire Company, LLC]**
 - f. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Blue Diamond Industries, LLC]**
 - b. **[JM Eagle]**
 - c. **[Petroflex North America]**
 - d. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - e. **[Southwire Company, LLC]**
 - f. **<Insert manufacturer's name>**
 - 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN EAZX; including UL 651A.
 - 4. Standard Features:
 - a. Dimensional Specifications: Schedule 80.
 - 5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute

- standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
- e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
6. Other Available Features Required by the Project:
- a. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)][Metric designator 21 (trade size 3/4)]**.
- C. UL EAZX - Type A Electrical HDPE Underground Conduit (EPEC-A):
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **<Insert manufacturer's name>**
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN EAZX; including UL 651A.
 4. Standard Features:
 - a. Dimensional Specifications: Type A.
 5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
 6. Other Available Features Required by the Project:
 - a. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)][Metric designator 21 (trade size 3/4)]**.

D. UL EAZX - Type B Electrical HDPE Underground Conduit (EPEC-B):

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN EAZX; including UL 651A.
4. Standard Features:
 - a. Dimensional Specifications: Type B.
5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
6. Other Available Features Required by the Project:
 - a. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)][Metric designator 21 (trade size 3/4)]**.

2.5 TYPE ERMCDUCT RACEWAYS, ELBOWS, COUPLINGS, AND NIPPLES

A. UL DYWIDAG - Aluminum Electrical Rigid Metal Conduit (ERMCD-A), Elbows, Couplings, and Nipples:

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

- a. [ABB, Electrification Business]
 - b. [Allied Tube & Conduit; Atkore International]
 - c. [American Conduit; Norsk Hydro ASA, Hydro Extrusion USA LLC]
 - d. [Appleton; Emerson Electric Co., Automation Solutions]
 - e. [Calconduit; Atkore International]
 - f. [Crouse-Hinds; brand of Eaton, Electrical Sector]
 - g. [Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - h. [Patriot Aluminum Products, LLC]
 - i. [Penn Aluminum Conduit & EMT; Penn Aluminum International LLC; Berkshire Hathaway]
 - j. [Republic Conduit; Nucor Corporation, Nucor Tubular Products]
 - k. [Rymco USA brand; manufactured and listed by subsidiary Conduit S.A. de C.V.]
 - l. [Topaz Lighting & Electric]
 - m. [Western Tube; Zekelman Industries]
 - n. [Wheatland Tube; Zekelman Industries]
 - o. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [ABB, Electrification Business]
 - b. [Allied Tube & Conduit; Atkore International]
 - c. [American Conduit; Norsk Hydro ASA, Hydro Extrusion USA LLC]
 - d. [Appleton; Emerson Electric Co., Automation Solutions]
 - e. [Calconduit; Atkore International]
 - f. [Crouse-Hinds; brand of Eaton, Electrical Sector]
 - g. [Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - h. [Patriot Aluminum Products, LLC]
 - i. [Penn Aluminum Conduit & EMT; Penn Aluminum International LLC; Berkshire Hathaway]
 - j. [Republic Conduit; Nucor Corporation, Nucor Tubular Products]
 - k. [Rymco USA brand; manufactured and listed by subsidiary Conduit S.A. de C.V.]
 - l. [Topaz Lighting & Electric]
 - m. [Western Tube; Zekelman Industries]
 - n. [Wheatland Tube; Zekelman Industries]
 - o. <Insert manufacturer's name>
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN DYWV; including UL 6A.
4. Standard Features:
 - a. Material: Aluminum.
 - b. Protective Coating: Provide protective coating for [use in concrete][direct burial][use in severely corrosive environment].
 - c. Minimum Trade Size: [Metric designator 16 (trade size 1/2)][Metric designator 21 (trade size 3/4)].
5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide [third-party-verified]corporate sustainability

- report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
- b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
6. Other Available Features Required by the Project:
- a. Colors: As indicated on the Drawings.
- B. UL DYWV - Stainless Steel Electrical Rigid Metal Conduit (ERMC-SS), Elbows, Couplings, and Nipples:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[Allied Tube & Conduit; Atkore International]**
 - c. **[Calconduit; Atkore International]**
 - d. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - e. **[Patriot Aluminum Products, LLC]**
 - f. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Allied Tube & Conduit; Atkore International]**
 - c. **[Calconduit; Atkore International]**
 - d. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - e. **[Patriot Aluminum Products, LLC]**
 - f. **<Insert manufacturer's name>**
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN DYWV; including UL 6A.
 4. Standard Features:
 - a. Material: Stainless steel.
 - b. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)][Metric designator 21 (trade size 3/4)]**.
 5. Sustainable Design Features:

- a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
6. Other Available Features Required by the Project:
- a. Colors: As indicated on the Drawings.
- C. UL DYIX - Galvanized-Steel Electrical Rigid Metal Conduit (ERMC-S-G), Elbows, Couplings, and Nipples:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Allied Tube & Conduit; Atkore International]**
 - b. **[Calconduit; Atkore International]**
 - c. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - d. **[Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - e. **[Patriot Aluminum Products, LLC]**
 - f. **[Republic Conduit; Nucor Corporation, Nucor Tubular Products]**
 - g. **[Rymco USA brand; manufactured and listed by subsidiary Conduit S.A. de C.V.]**
 - h. **[Topaz Lighting & Electric]**
 - i. **[Western Tube; Zekelman Industries]**
 - j. **[Wheatland Tube; Zekelman Industries]**
 - k. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Allied Tube & Conduit; Atkore International]**
 - b. **[Calconduit; Atkore International]**
 - c. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - d. **[Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - e. **[Patriot Aluminum Products, LLC]**
 - f. **[Republic Conduit; Nucor Corporation, Nucor Tubular Products]**
 - g. **[Rymco USA brand; manufactured and listed by subsidiary Conduit S.A. de C.V.]**
 - h. **[Topaz Lighting & Electric]**
 - i. **[Western Tube; Zekelman Industries]**
 - j. **[Wheatland Tube; Zekelman Industries]**
 - k. **<Insert manufacturer's name>**
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in

accordance with guide information and standards specified for the following UL product categories:

- a. UL CCN DYIX; including UL 6.
4. Standard Features:
 - a. Exterior Coating: Zinc.
 - b. Interior Coating: **[Zinc with organic top coating][Zinc][Organic coating]**.
 - c. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)][Metric designator 21 (trade size 3/4)]**.
5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
6. Other Available Features Required by the Project:
 - a. Colors: As indicated on the Drawings.
- D. UL DYIX - PVC-Coated-Steel Electrical Rigid Metal Conduit (ERMC-S-PVC), Elbows, Couplings, and Nipples:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[Bluesteel Services LLC]**
 - c. **[Calbond; Atkore International]**
 - d. **[KorKap; Robroy Industries]**
 - e. **[Perma-Cote; Robroy Industries]**
 - f. **[Plasti-Bond; Robroy Industries]**
 - g. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Bluesteel Services LLC]**
 - c. **[Calbond; Atkore International]**
 - d. **[KorKap; Robroy Industries]**

- e. **[Perma-Cote; Robroy Industries]**
 - f. **[Plasti-Bond; Robroy Industries]**
 - g. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
- a. UL CCN DYIX; including UL 6.
4. Standard Features:
- a. Exterior Coating: PVC complying with NEMA RN 1.
 - b. Interior Coating: **[Zinc with organic top coating][Zinc][Organic coating]**.
 - c. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)][Metric designator 21 (trade size 3/4)]**.
5. Sustainable Design Features:
- a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
6. Other Available Features Required by the Project:
- a. Colors: As indicated on the Drawings.
 - b. Conduit Fittings for Hazardous (Classified) Locations: UL 1203.
 - c. Expansion and Deflection Fittings: UL 651 with flexible bonding jumper.

2.6 TYPE FMC DUCT RACEWAYS

A. UL DXUZ - Steel Flexible Metal Conduit (FMC-S):

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
- a. **[ABB, Electrification Business]**
 - b. **[Anaconda Sealtite; Anamet Electrical, Inc]**
 - c. **[Electri-Flex Company]**
 - d. **[International Metal Hose Co.]**
 - e. **[Penn Aluminum Conduit & EMT; Penn Aluminum International LLC; Berkshire Hathaway]**

- f. **[Topaz Lighting & Electric]**
 - g. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Anaconda Sealtite; Anamet Electrical, Inc]**
 - c. **[Electri-Flex Company]**
 - d. **[International Metal Hose Co.]**
 - e. **[Penn Aluminum Conduit & EMT; Penn Aluminum International LLC; Berkshire Hathaway]**
 - f. **[Topaz Lighting & Electric]**
 - g. **<Insert manufacturer's name>**
 - 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN DXUZ; including UL 1.
 - 4. Standard Features:
 - a. Material: Steel.
 - b. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)][Metric designator 21 (trade size 3/4)]**.
 - 5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
 - 6. Other Available Features Required by the Project:
 - a. Colors: As indicated on the Drawings.
- B. UL DXUZ - Aluminum Flexible Metal Conduit (FMC-A):
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**



- b. [Anaconda Sealtite; Anamet Electrical, Inc]
 - c. [Electri-Flex Company]
 - d. [Topaz Lighting & Electric]
 - e. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [ABB, Electrification Business]
 - b. [Anaconda Sealtite; Anamet Electrical, Inc]
 - c. [Electri-Flex Company]
 - d. [Topaz Lighting & Electric]
 - e. <Insert manufacturer's name>
- 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN DXUZ; including UL 1.
- 4. Standard Features:
 - a. Material: Aluminum.
 - b. Minimum Trade Size: [Metric designator 16 (trade size 1/2)][Metric designator 21 (trade size 3/4)].
- 5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide [third-party-verified]corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
- 6. Other Available Features Required by the Project:
 - a. Colors: As indicated on the Drawings.

2.7 TYPE FMT DUCT RACEWAYS

A. UL ILJW - Steel Flexible Metallic Tubing (FMT):

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

following]:

- a. **[Electri-Flex Company]**
 - b. **[International Metal Hose Co]**
 - c. **[Liquid Tight Connector Co.]**
 - d. **[Southwire Company, LLC]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Electri-Flex Company]**
 - b. **[International Metal Hose Co]**
 - c. **[Liquid Tight Connector Co.]**
 - d. **[Southwire Company, LLC]**
 - e. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN ILJW; including UL Subject 1652.
4. Standard Features:
 - a. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)][Metric designator 21 (trade size 3/4)]**.
5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
6. Other Available Features Required by the Project:
 - a. Colors: As indicated on the Drawings.

2.8 TYPE IMC DUCT RACEWAYS

A. UL DYBY - Steel Intermediate Metal Conduit (IMC):

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering**

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

- a. **[ABB, Electrification Business]**
 - b. **[Allied Tube & Conduit; Atkore International]**
 - c. **[Calconduit; Atkore International]**
 - d. **[Republic Conduit; Nucor Corporation, Nucor Tubular Products]**
 - e. **[Rymco USA brand; manufactured and listed by subsidiary Conduit S.A. de C.V]**
 - f. **[Topaz Lighting & Electric]**
 - g. **[Western Tube; Zekelman Industries]**
 - h. **[Wheatland Tube; Zekelman Industries]**
 - i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[ABB, Electrification Business]**
 - b. **[Allied Tube & Conduit; Atkore International]**
 - c. **[Calconduit; Atkore International]**
 - d. **[Republic Conduit; Nucor Corporation, Nucor Tubular Products]**
 - e. **[Rymco USA brand; manufactured and listed by subsidiary Conduit S.A. de C.V]**
 - f. **[Topaz Lighting & Electric]**
 - g. **[Western Tube; Zekelman Industries]**
 - h. **[Wheatland Tube; Zekelman Industries]**
 - i. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
- a. UL CCN DYBY; including UL 1242.
4. Standard Features:
- a. Exterior Coating: **[Zinc][Alternative corrosion-resistant coating]**.
 - b. Interior Coating: **[Zinc with organic top coating][Zinc][Organic coating]**.
 - c. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)][Metric designator 21 (trade size 3/4)]**.
5. Sustainable Design Features:
- a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

6. Other Available Features Required by the Project:

- a. Colors: As indicated on the Drawings.

2.9 TYPE LFMC DUCT RACEWAYS

A. UL DXHR - Steel Liquidtight Flexible Metal Conduit (LFMC-S):

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[Anaconda Sealtite; Anamet Electrical, Inc]**
 - c. **[Electri-Flex Company]**
 - d. **[International Metal Hose Co]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Anaconda Sealtite; Anamet Electrical, Inc]**
 - c. **[Electri-Flex Company]**
 - d. **[International Metal Hose Co]**
 - e. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN DXHR; including UL 360.
4. Standard Features:
 - a. Material: Steel.
 - b. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)][Metric designator 21 (trade size 3/4)]**.
5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate

scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

6. Other Available Features Required by the Project:

- a. Colors: As indicated on the Drawings.

B. UL DXHR - Stainless Steel Liquidtight Flexible Metal Conduit (LFMC-SS):

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[Anaconda Sealtite; Anamet Electrical, Inc]**
 - c. **[Electri-Flex Company]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Anaconda Sealtite; Anamet Electrical, Inc]**
 - c. **[Electri-Flex Company]**
 - d. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN DXHR; including UL 360.
4. Standard Features:
 - a. Material: Stainless steel.
 - b. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)][Metric designator 21 (trade size 3/4)]**.
5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

6. Other Available Features Required by the Project:

- a. Colors: As indicated on the Drawings.

2.10 TYPE LFNC DUCT RACEWAYS

A. UL DXOQ - Layered (Type A) Liquidtight Flexible Nonmetallic Conduit (LFNC-A):

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[AFC Cable Systems; Atkore International]**
 - b. **[Electri-Flex Company]**
 - c. **[Topaz Lighting & Electric]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[AFC Cable Systems; Atkore International]**
 - b. **[Electri-Flex Company]**
 - c. **[Topaz Lighting & Electric]**
 - d. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN DXOQ; including UL 1660.
4. Standard Features:
 - a. Type A conduit with smooth seamless inner core and cover bonded together with one or more reinforcement layers between core and cover.
 - b. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)][Metric designator 21 (trade size 3/4)]**.
 - c. Markings: **[80 deg C dry][90 deg C dry][105 deg C dry][70 deg C oil resistant][Sunlight resistant][Outdoor][Direct burial][Complies with flame test in cable trays]**.
5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.

- e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
6. Other Available Features Required by the Project:
 - a. Colors: As indicated on the Drawings.
- B. UL DXOQ - Integral (Type B) Liquidtight Flexible Nonmetallic Conduit (LFNC-B):
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[Cambridge Resources]**
 - c. **[Electri-Flex Company]**
 - d. **[Superflex Ltd.]**
 - e. **[Topaz Lighting & Electric]**
 - f. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Cambridge Resources]**
 - c. **[Electri-Flex Company]**
 - d. **[Superflex Ltd.]**
 - e. **[Topaz Lighting & Electric]**
 - f. **<Insert manufacturer's name>**
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN DXOQ; including UL 1660.
 4. Standard Features:
 - a. Type B conduit with smooth inner surface with integral reinforcement within conduit wall.
 - b. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)][Metric designator 21 (trade size 3/4)]**.
 - c. Markings: **[80 deg C dry][90 deg C dry][105 deg C dry][70 deg C oil resistant][Sunlight resistant][Outdoor][Direct burial][Complies with flame test in cable trays]**.
 5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project

- site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
 6. Other Available Features Required by the Project:
 - a. Colors: As indicated on the Drawings.
- C. UL DXOQ - Corrugated (Type C) Liquidtight Flexible Nonmetallic Conduit (LFNC-C):
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[HellermannTyton]**
 - c. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[HellermannTyton]**
 - c. **<Insert manufacturer's name>**
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN DXOQ; including UL 1660.
 4. Standard Features:
 - a. Type C conduit with corrugated internal and external surfaces without integral reinforcement within conduit wall.
 - b. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)][Metric designator 21 (trade size 3/4)]**.
 - c. Markings: **[80 deg C dry][90 deg C dry][105 deg C dry][70 deg C oil resistant][Sunlight resistant][Outdoor][Direct burial][Complies with flame test in cable trays]**.
 5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute

- standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
- e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

6. Other Available Features Required by the Project:

- a. Colors: As indicated on the Drawings.

2.11 TYPE PVC DUCT RACEWAYS AND FITTINGS

A. UL DZYZR - Schedule 40 Rigid PVC Conduit (PVC-40) and Fittings:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[Calconduit; Atkore International]**
 - c. **[JM Eagle]**
 - d. **[NAPCO; Westlake Chemical Corp.]**
 - e. **[National Pipe and Plastic, Inc. (Oldcastle)]**
 - f. **[Opti-Com Manufacturing Network, Inc (OMNI)]**
 - g. **[Topaz Lighting & Electric]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Calconduit; Atkore International]**
 - c. **[JM Eagle]**
 - d. **[NAPCO; Westlake Chemical Corp.]**
 - e. **[National Pipe and Plastic, Inc. (Oldcastle)]**
 - f. **[Opti-Com Manufacturing Network, Inc (OMNI)]**
 - g. **[Topaz Lighting & Electric]**
 - h. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN DZYZR; including UL 651.
4. Standard Features:
 - a. Dimensional Specifications: Schedule 40.
 - b. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)][Metric designator 21 (trade size 3/4)]**.
 - c. Markings: **[For use with maximum 90 deg C wire][For directional boring applications]**.
5. Sustainable Design Features:

- a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
- B. UL DZYZR - Schedule 80 Rigid PVC Conduit (PVC-80) and Fittings:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[Calconduit; Atkore International]**
 - c. **[JM Eagle]**
 - d. **[National Pipe and Plastic, Inc. (Oldcastle)]**
 - e. **[Opti-Com Manufacturing Network, Inc (OMNI)]**
 - f. **[Topaz Lighting & Electric]**
 - g. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Calconduit; Atkore International]**
 - c. **[JM Eagle]**
 - d. **[National Pipe and Plastic, Inc. (Oldcastle)]**
 - e. **[Opti-Com Manufacturing Network, Inc (OMNI)]**
 - f. **[Topaz Lighting & Electric]**
 - g. **<Insert manufacturer's name>**
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN DZYZR; including UL 651.
 4. Standard Features:
 - a. Dimensional Specifications: Schedule 80.
 - b. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)][Metric designator 21 (trade size 3/4)]**.
 - c. Markings: **[For use with maximum 90 deg C wire][For directional boring applications]**.
 5. Sustainable Design Features:

- a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
- b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
- c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
- d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
- e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

C. UL DZYZR - Type A Rigid PVC Concrete-Encased Conduit (PVC-A) and Fittings:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Southern Pipe, Inc.]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Southern Pipe, Inc.]**
 - b. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN DZYZR; including UL 651.
4. Standard Features:
 - a. Dimensional Specifications: Type A.
 - b. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)][Metric designator 21 (trade size 3/4)]**.
5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard

- development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
- D. UL DZYZR - Type EB Rigid PVC Concrete-Encased Underground Conduit (PVC-EB) and Fittings:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[JM Eagle]**
 - b. **[Southern Pipe, Inc.]**
 - c. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[JM Eagle]**
 - b. **[Southern Pipe, Inc.]**
 - c. **<Insert manufacturer's name>**
 - 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN DZYZR; including UL 651.
 - 4. Standard Features:
 - a. Dimensional Specifications: Type EB.
 - b. Minimum Trade Size: **[Metric designator 53 (trade size 2)][Metric designator 78 (trade size 3)][Metric designator 103 (trade size 4)]**.
 - 5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

2.12 TYPE RTRC DUCT RACEWAYS AND FITTINGS

- A. UL DZKT - Heavy Wall, Low-Halogen, Aboveground Reinforced Thermosetting Resin Conduit (RTRC-AG-HW) and Fittings:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Champion Fiberglass, Inc]**
 - b. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Champion Fiberglass, Inc]**
 - b. **<Insert manufacturer's name>**
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN DZKT; including UL 2515.
 4. Standard Features:
 - a. Additional Characteristics: Type AG-HW.
 - b. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)][Metric designator 21 (trade size 3/4)]**.
 5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
- B. UL DZKT - Standard Wall, Low-Halogen, Aboveground Reinforced Thermosetting Resin Conduit (RTRC-AG-SW) and Fittings:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Champion Fiberglass, Inc]**
 - b. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert**

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

- a. **[Champion Fiberglass, Inc]**
 - b. **<Insert manufacturer's name>**
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN DZKT; including UL 2515.
 4. Standard Features:
 - a. Additional Characteristics: Type SW.
 - b. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)][Metric designator 21 (trade size 3/4)]**.
 5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
- C. UL DZKT - Extra Heavy Wall, Low-Halogen, Aboveground Reinforced Thermosetting Resin Conduit (RTRC-AG-XW) and Fittings:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Champion Fiberglass, Inc]**
 - b. **[FRE Composites]**
 - c. **[United Fiberglass of America (UFA)]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Champion Fiberglass, Inc]**
 - b. **[FRE Composites]**
 - c. **[United Fiberglass of America (UFA)]**
 - d. **<Insert manufacturer's name>**

3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN DZKT; including UL 2515 and UL 2515A.
 4. Standard Features:
 - a. Additional Characteristics: Type AG-XW.
 - b. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)][Metric designator 21 (trade size 3/4)]**.
 5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
- D. UL DZKT - Low-Halogen, Belowground Reinforced Thermosetting Resin Conduit (RTRC-BG) and Fittings:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Champion Fiberglass, Inc]**
 - b. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Champion Fiberglass, Inc]**
 - b. **<Insert manufacturer's name>**
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN DZKT; including UL 2420.
 4. Standard Features:
 - a. Additional Characteristics: Type BG.

- b. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)][Metric designator 21 (trade size 3/4)]**.
- 5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

2.13 FITTINGS FOR CONDUIT, TUBING, AND CABLE

A. UL EBMB - Duct Fittings for Hazardous (Classified) Locations:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - b. **[Power Feed-Thru Systems and Connectors LLC]**
 - c. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - b. **[Power Feed-Thru Systems and Connectors LLC]**
 - c. **<Insert manufacturer's name>**
- 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN EBMB; including UL 1203.
- 4. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project

- site. Identify percentage of product's travel that is by rail or water.
- d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
- e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

B. UL DWTT - Fittings for Type ERMCM, Type IMC, Type PVC, Type HDPE, Type EPEC, and Type RTRC Duct Raceways:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[Appleton; Emerson Electric Co., Automation Solutions]**
 - c. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - d. **[Konkore Fittings; Atkore International]**
 - e. **[O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group]**
 - f. **[Penn Aluminum Conduit & EMT; Penn Aluminum International LLC; Berkshire Hathaway]**
 - g. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - h. **[Southwire Company, LLC]**
 - i. **[Topaz Lighting & Electric]**
 - j. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Appleton; Emerson Electric Co., Automation Solutions]**
 - c. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - d. **[Konkore Fittings; Atkore International]**
 - e. **[O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group]**
 - f. **[Penn Aluminum Conduit & EMT; Penn Aluminum International LLC; Berkshire Hathaway]**
 - g. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - h. **[Southwire Company, LLC]**
 - i. **[Topaz Lighting & Electric]**
 - j. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN DWTT; including UL 514B.
4. Standard Features:
 - a. Material: **[Steel][Die cast]**.
 - b. Coupling Method: **[Compression coupling][Raintight compression coupling with distinctive color gland nut][Setscrew coupling. Setscrew couplings with only single screw per conduit are unacceptable]**.

- c. Expansion and Deflection Fittings: UL 651 with flexible bonding jumper.
5. Sustainable Design Features:
- a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
- C. UL FKA V - Fittings for Type EMT Duct Raceways:
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[Allied Tube & Conduit; Atkore International]**
 - c. **[Appleton; Emerson Electric Co., Automation Solutions]**
 - d. **[Calconduit; Atkore International]**
 - e. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - f. **[O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group]**
 - g. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - h. **[Southwire Company, LLC]**
 - i. **[Topaz Lighting & Electric]**
 - j. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Allied Tube & Conduit; Atkore International]**
 - c. **[Appleton; Emerson Electric Co., Automation Solutions]**
 - d. **[Calconduit; Atkore International]**
 - e. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - f. **[O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group]**
 - g. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - h. **[Southwire Company, LLC]**
 - i. **[Topaz Lighting & Electric]**
 - j. **<Insert manufacturer's name>**
 - 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN FKA V; including UL 514B.

4. Standard Features:
 - a. Material: **[Steel][Die cast]**.
 - b. Coupling Method: **[Compression coupling][Raintight compression coupling with distinctive color gland nut][Setscrew coupling. Setscrew couplings with only single screw per conduit are unacceptable]**.
 - c. Expansion and Deflection Fittings: UL 651 with flexible bonding jumper.
5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

D. UL ILNR - Fittings for Type FMC Duct Raceways:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American Fittings Corp. (AMFICO)]**
 - b. **[Liquid Tight Connector Co.]**
 - c. **[Southwire Company, LLC]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Fittings Corp. (AMFICO)]**
 - b. **[Liquid Tight Connector Co.]**
 - c. **[Southwire Company, LLC]**
 - d. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN ILNR; including UL 514B.
4. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts

- of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
- E. UL DXAS - Fittings for Type LFMC and Type LFNC Duct Raceways:
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Arlington Industries, Inc.]**
 - b. **[Liquid Tight Connector Co.]**
 - c. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arlington Industries, Inc.]**
 - b. **[Liquid Tight Connector Co.]**
 - c. **<Insert manufacturer's name>**
 - 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN DXAS; including UL 514B.
 - 4. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

2.14 JOINT COMPOUNDS

- A. UL FOIZ - Electrically Conductive Corrosion-Resistant Compound for Threaded Conduit:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **<Insert manufacturer's name>**
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN FOIZ; including UL Subject 2419.
 4. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

2.15 SOLVENT CEMENTS

- A. UL VBEW - Solvent Cements for Nonmetallic Duct Raceways and Fittings:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the

following:

- a. <Insert manufacturer's name>
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Solvent Cements: UL CCN VBEW; including UL 340.
 - b. Solvent Cement Compatibility with PVC Conduit Fittings: UL CCN DWTT; including UL 514B. Follow solvent manufacturer's published instructions.
 - c. Solvent Cement Compatibility with Rigid PVC Conduit: UL CCN DZYR; including UL 651. Follow solvent manufacturer's published instructions.
 - d. Solvent Cement Compatibility with Rigid EPEC and HDPE Underground Conduit: UL CCN EAZX; including UL 651A. Follow solvent manufacturer's published instructions.
4. Sustainable Design Features:
 - a. Solvent cements for use with nonmetallic raceways and covers have VOC content less than **[510][490]** g/L.
 - b. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - c. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - d. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - e. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - f. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

PART 3 - EXECUTION

3.1 SELECTION OF CONDUITS FOR ELECTRICAL SYSTEMS

- A. Unless more stringent requirements are specified in the Contract Documents or manufacturer's published instructions, comply with NFPA 70 for selection of duct raceways. Consult Architect for resolution of conflicting requirements.
- B. Special Instructions Regarding HDPE Conduits: Although Article 353 of NFPA 70 permits use of HDPE conduits where encased in concrete aboveground, UL CCN EAZX listing requirements state that HDPE[**and EPEC**] underground conduits are intended only for use where direct buried with or without being encased in concrete. Specified Type HDPE[**and Type EPEC**] underground conduits are not permitted to be used aboveground on the Project.
- C. Outdoors:
 1. Exposed and Subject to Severe Physical Damage: **[ERMC][IMC]**.
 2. Exposed and Subject to Physical Damage: **[ERMC][IMC][Corrosion-resistant EMT]**.
 3. Exposed and Not Subject to Physical Damage: **[ERMC][IMC][Corrosion-resistant EMT][PVC-80][RTRC-AG]**.



4. Concealed Aboveground: [ERMC][IMC][EMT][PVC-80][PVC-40][RTRC-AG].
5. Direct Buried: [PVC-80][PVC-40][HDPE-80][HDPE-40][RTRC-BG].
6. Concrete Encased Not in Trench: [PVC-80][PVC-40][PVC-A][RTRC-BG].
7. Concrete Encased in Trench: [PVC-80][PVC-40][PVC-A][PVC-EB][HDPE-80][HDPE-40][EPEC-A][EPEC-B][RTRC-BG].
8. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): [LFMC][LFNC-A][LFNC-B].

D. Indoors:

1. Hazardous Classified Locations: [ERMC][IMC].
2. Exposed and Subject to Severe Physical Damage: [ERMC][IMC].
3. Exposed and Subject to Physical Damage: [ERMC][IMC][EMT].
4. Exposed and Not Subject to Physical Damage: [ERMC][IMC][EMT][PVC-80][RTRC-AG].
5. Concealed in Ceilings and Interior Walls and Partitions: [ERMC][IMC][EMT][PVC-80][PVC-40][RTRC-AG].
6. Damp or Wet Locations: [ERMC][IMC][RTRC-AG][Corrosion-resistant EMT].
7. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): [LFMC][FMC][LFNC-A][LFNC-B].
8. Circuits Operating Above 60 Hz: [EMT-A][ERMC-A][RTRC-AG]. Provide nonmetallic sleeve where aluminum duct raceways pass through concrete.

E. Duct Fittings: Select fittings in accordance with NEMA FB 2.10 guidelines.

1. ERM and IMC: Provide threaded-type fittings unless otherwise indicated.

3.2 INSTALLATION OF CONDUITS FOR ELECTRICAL SYSTEMS

A. Comply with manufacturer's published instructions.

B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:

1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
2. Electrical Safety: NFPA 70E.
3. Commissioning of Active and Passive Fire Protection Features: NFPA 3 and NFPA 4.
4. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
5. Communications Work: BICSI N1.
6. Life Safety and Means of Egress Work: NFPA 101.
7. Emergency and Standby Power Work: NFPA 110, NFPA 111, and NECA NEIS 416.
8. Work in Confined Spaces: NFPA 350.
9. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
10. Type EMT-A: Article 358 of NFPA 70 and NECA NEIS 102.
11. Type EMT-SS: Article 358 of NFPA 70 and NECA NEIS 101.
12. Type EMT-S: Article 358 of NFPA 70 and NECA NEIS 101.
13. Type ENT: Article 362 of NFPA 70 and NECA NEIS 102.
14. Type HDPE and Type EPEC: Article 353 of NFPA 70 and NECA NEIS 111.
15. Type ERM-A: Article 344 of NFPA 70 and NECA NEIS 102.
16. Type ERM-SS: Article 344 of NFPA 70 and NECA NEIS 101.
17. Type ERM-S: Article 344 of NFPA 70 and NECA NEIS 101.
18. Type FMC-S: Article 348 of NFPA 70 and NECA NEIS 101.
19. Type FMC-A: Article 348 of NFPA 70 and NECA NEIS 102.
20. Type FMT: Article 360 of NFPA 70 and NECA NEIS 101.
21. Type IMC: Article 342 of NFPA 70 and NECA NEIS 101.

22. Type LFMC: Article 350 of NFPA 70 and NECA NEIS 101.
23. Type LFNC: Article 342 of NFPA 70 and NECA NEIS 111.
24. Type PVC: Article 356 of NFPA 70 and NECA NEIS 111.
25. Type RTRC: Article 355 of NFPA 70 and NECA NEIS 111.
26. Expansion Fittings: NEMA FB 2.40.
27. Consult Architect for resolution of conflicting requirements.

C. Special Installation Techniques:

1. General Requirements for Installation of Duct Raceways:

- a. Complete duct raceway installation before starting conductor installation.
- b. Provide stub-ups through floors with coupling threaded inside for plugs, set flush with finished floor. Plug coupling until conduit is extended above floor to final destination or a minimum of **2 ft (0.6 m)** above finished floor.
- c. Install no more than equivalent of three 90-degree bends in conduit run[**except for control wiring conduits, for which no more than equivalent of two 90-degree fewer bends are permitted**]. Support within **12 inch (300 mm)** of changes in direction.
- d. Make bends in duct raceway using large-radius preformed ells except for parallel bends. Field bending must be in accordance with NFPA 70 minimum radii requirements. Provide only equipment specifically designed for material and size involved.
- e. Conceal conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- f. Support conduit within **12 inch (300 mm)** of enclosures to which attached.
- g. Install duct sealing fittings at accessible locations in accordance with NFPA 70 and fill them with listed sealing compound. For concealed duct raceways, install fitting in flush steel box with blank cover plate having finish similar to that of adjacent plates or surfaces. Install duct sealing fittings in accordance with NFPA 70.
- h. Install devices to seal duct raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal interior of duct raceways at the following points:
 - 1) Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 - 2) Where an underground service duct raceway enters a building or structure.
 - 3) Conduit extending from interior to exterior of building.
 - 4) Conduit extending into pressurized duct raceway and equipment.
 - 5) Conduit extending into pressurized zones that are automatically controlled to maintain different pressure set points.
 - 6) Where otherwise required by NFPA 70.
- i. Do not install duct raceways or electrical items on "explosion-relief" walls or rotating equipment.
- j. Do not install conduits within **2 inch (50 mm)** of the bottom side of a metal deck roof.
- k. Keep duct raceways at least **6 inch (150 mm)** away from parallel runs of flues and steam or hot-water pipes. Install horizontal duct raceway runs above water and steam piping.
- l. Cut conduit perpendicular to the length. For conduits metric designator 53 (trade size 2) and larger, use roll cutter or a guide to make cut straight and perpendicular to the length. Ream inside of conduit to remove burrs.
- m. Install pull wires in empty duct raceways. Provide polypropylene or monofilament plastic line with not less than **200 lb (90 kg)** tensile strength. Leave at least **12 inch (300 mm)** of slack at both ends of pull wire. Cap underground duct raceways designated as spare above grade alongside duct raceways in use.
- n. Install duct raceways square to the enclosure and terminate at enclosures without hubs with locknuts on both sides of enclosure wall. Install locknuts hand tight, plus one-quarter turn more.

- 1) Termination fittings with shoulders do not require two locknuts.
- o. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to metric designator 35 (trade size 1-1/4) and insulated throat metal bushings on metric designator 41 (trade size 1-1/2) and larger conduits terminated with locknuts. [**Install insulated throat metal grounding bushings on service conduits**].
2. Types EMT-A, ERMCA, and FMC-A: Do not install aluminum duct raceways or fittings in contact with concrete or earth.
3. Types ERMCA and IMC:
 - a. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound that maintains electrical conductivity to threads of duct raceway and fittings before making up joints. Follow compound manufacturer's published instructions.
4. Type ERMCA-S-PVC:
 - a. Follow manufacturer's installation instructions for clamping, cutting, threading, bending, and assembly.
 - b. Provide PVC-coated sealing locknut for exposed male threads transitioning into female NPT threads that do not have sealing sleeves, including transitions from PVC couplings/female adapters to Type ERMCA-S-PVC elbows in direct-burial applications. PVC-coated sealing locknuts must not be used in place of conduit hub. PVC-coated sealing locknut must cover exposed threads on Type ERMCA-S-PVC duct raceway.
 - c. Coat field-cut threads on PVC-coated duct raceway with manufacturer-approved corrosion-preventing conductive compound prior to assembly.
5. Types FMC, LFMC, and LFNC:
 - a. Provide a maximum of [**36 inch (915 mm)**][**72 inch (1830 mm)**] of flexible conduit for [**recessed and semirecessed luminaires**], equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
6. Types PVC, HDPE, and EPEC:
 - a. Do not install Type PVC, Type HDPE, or Type EPEC conduit where ambient temperature exceeds [**122 deg F (50 deg C)**][**Insert temperature**]. Conductor ratings must be limited to 75 deg C except where installed in a trench outside buildings with concrete encasement, where 90 deg C conductors are permitted.
 - b. Comply with manufacturer's published instructions for solvent welding and fittings.
 - c. Join joints with solvent cement in accordance with manufacturer's published instructions and allowed to cure before handling. Joints to be bent, pushed, or pulled must set for minimum 24 h after joining.
7. Type RTRC: Do not install Type RTRC conduit where ambient temperature exceeds [**230 deg F (110 deg C)**][**Insert temperature**].
8. Duct Raceways Embedded in Slabs:
 - a. [**Run duct raceways larger than metric designator 27 (trade size 1) below concrete slab**][**Run duct raceways larger than metric designator 27 (trade size) parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place duct raceway close to slab support. Secure duct raceways to reinforcement at maximum 10 ft (3 m) intervals**].
 - b. Arrange duct raceways to cross building expansion joints with expansion fittings at right

- angles to the joint.
 - c. Arrange duct raceways to ensure that each is surrounded by minimum of **[1 inch (25 mm)][2 inch (50 mm)]<Insert dimension>** of concrete without voids.
 - d. Do not embed threadless fittings in concrete unless locations have been specifically approved by Architect.
 - e. Change from ENT to **[PVC-80][PVC-40][ERMC][or][IMC]** before rising above floor.
9. Stub-ups to Above Recessed Ceilings:
- a. Provide EMT, IMC, or ERMC for duct raceways.
 - b. Provide a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
10. Duct Raceway Terminations at Locations Subject to Moisture or Vibration:
- a. Provide insulating bushings to protect conductors, including conductors smaller than 4 AWG. **[Install insulated throat metal grounding bushings on service conduits].**
11. Duct Fittings: Install fittings in accordance with NEMA FB 2.10 guidelines.
- a. ERMC-S-PVC: Provide only fittings listed for use with this type of conduit. Patch and seal joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Provide sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
 - b. EMT: Provide **[setscrew][compression]**, **[steel][cast-metal]** fittings. Comply with NEMA FB 2.10.
 - c. Flexible Conduit: Provide only fittings listed for use with flexible conduit type. Comply with NEMA FB 2.20.
12. Expansion-Joint Fittings:
- a. Install in runs of aboveground PVC that are located where environmental temperature change may exceed **30 deg F (17 deg C)** and that have straight-run length that exceeds **25 ft (7.6 m)**. Install in runs of aboveground ERMC **[and EMT]** conduit that are located where environmental temperature change may exceed **100 deg F (55 deg C)** and that have straight-run length that exceeds **100 ft (30 m)**.
 - b. Install type and quantity of fittings that accommodate temperature change listed for the following locations:
 - 1) Outdoor Locations Not Exposed to Direct Sunlight: **[125 deg F (70 deg C)]<Insert temperature>** temperature change.
 - 2) Outdoor Locations Exposed to Direct Sunlight: **[155 deg F (86 deg C)]<Insert temperature>** temperature change.
 - 3) Indoor Spaces Connected with Outdoors without Physical Separation: **[125 deg F (70 deg C)]<Insert temperature>** temperature change.
 - 4) Attics: **[135 deg F (75 deg C)]<Insert temperature>** temperature change.
 - 5) **<Insert location and corresponding temperature change>**.
 - c. Install fitting(s) that provide expansion and contraction for at least **0.00041 inch per foot of length of straight run per deg F (0.06 mm per meter of length of straight run per deg C)** of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least **0.000078 inch per foot of length of straight run per deg F (0.0115 mm per meter of length of straight run per deg C)** of temperature change for metal conduits.
 - d. Install expansion fittings at locations where conduits cross building or structure expansion joints.

- e. Install expansion-joint fitting with position, mounting, and piston setting selected in accordance with manufacturer's published instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.
- 13. Duct Raceways Penetrating Rooms or Walls with Acoustical Requirements: Seal duct raceway openings on both sides of rooms or walls with acoustically rated putty[**or firestopping**].
- 14. Identification: Provide labels for conduit assemblies, duct raceways, and associated electrical equipment.
 - a. Provide warning signs.
- 15. **<Insert more stringent installation requirements that supplement or supersede listed standards and manufacturer's published instructions>.**

D. Interfaces with Other Work:

- 1. Firestop penetrations of fire-rated floor and wall assemblies.
- 2. Provide conduit hangers and supports.
- 3. Coordinate installation of new products for **<Insert system or product family/category>** with existing conditions.
 - a. **<Insert requirements for transition between new and existing>.**
- 4. Coordinate with **<Insert Section number and title>** for **<Insert description of interfacing related Work>.**
 - a. **<Insert requirements for transition between this Section and related Work>.**

3.3 FIELD QUALITY CONTROL OF CONDUITS FOR ELECTRICAL SYSTEMS

A. Administrant for Electrical Power Tests and Inspections:

- 1. **[Owner][Tenant]** will engage qualified medium-voltage electrical testing and inspecting agency to administer and perform tests and inspections.
- 2. Engage qualified medium-voltage electrical testing and inspecting agency to administer and perform tests and inspections.
- 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
- 4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].

B. Administrant for Communications Tests and Inspections:

- 1. **[Owner][Tenant]** will engage qualified communications testing and inspecting agency to administer and perform tests and inspections.
- 2. Engage qualified communications testing and inspecting agency to administer and perform tests and inspections.
- 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
- 4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].

C. Acceptance Testing Preparation:

1. <Insert requirements>.
 - D. Field tests and inspections must be witnessed by [Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>.
 - E. Tests and Inspections:
 1. Perform manufacturer's recommended tests and inspections.
 2. Pull solid aluminum or wood test mandrel through duct to prove joint integrity and adequate bend radii, and test for out-of-round duct. Provide minimum **12 inch (300 mm)** long mandrel equal to duct size minus **1/4 inch (6 mm)**. If obstructions are indicated, remove obstructions and retest.
 3. Conduit Placement:
 - a. Verify that center-line location and offsets are in accordance with the Drawings.
 - b. Verify that hangers and supports for conduits are attached to structure **[in accordance with the Drawings][as directed by qualified structural engineer]**.
 - c. Verify that nuts on bolts or hanger rods are secure.
 - d. Verify that space between raceways and cored holes are filled with non-shrinking grout or other approved material indicated on the Drawings and the Specifications.
 - e. Verify that expansion devices are installed at locations indicated on the Drawings and the Specifications.
 - f. Verify that ends are cut square to provide flush-butting surfaces when spliced and inside edges are free of burrs that could impede installation of cables.
 - g. Verify minimum separation of utilities, or that approved mechanical protection has been provided to surrounding conduit(s) where minimum separation cannot be achieved.
 4. Document all changes on Record Drawings.
 - F. Nonconforming Work:
 1. Conduit will be considered defective if it does not pass tests and inspections.
 2. Remove and replace defective units and retest.
 - G. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.
- 3.4 CLEANING
- A. Verify that bentonite or other drilling fluids are contained and removed, and site is restored to its original or improved condition.
- 3.5 PROTECTION
- A. Protect coatings, finishes, and cabinets from damage and deterioration.
 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

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Task	Specification	Specification Description
26 05 33 13	26 05 19 00	Low-Voltage Electrical Power Conductors and Cables
26 05 33 13	26 05 00 00	Sleeves and Sleeve Seals for Electrical Raceways and Cabling
26 05 33 13	27 11 00 00	Communications Equipment Room Fittings
26 05 33 13	27 13 13 00	Communications Copper Backbone Cabling
26 05 33 13	27 15 33 00	Communications Coaxial Horizontal Cabling



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SECTION 26 05 33 16 - BOXES AND COVERS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metallic outlet boxes, device boxes, rings, and covers.
2. Nonmetallic outlet boxes, device boxes, rings, and covers.
3. Junction boxes and pull boxes.
4. Cover plates for device boxes.
5. Hoods for outlet boxes.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies temperature, humidity, acoustical, and other field conditions applicable to the Work specified in this Section.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies seismic hazard, wind hazard, other structural load design conditions applicable to the Work specified in this Section.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional coordination, scheduling, sequencing, submittal, and installation requirements applicable to the Work for electrical, communications, and electronic safety and security systems on the Project, including wiring methods.
4. Section 078413 "Penetration Firestopping" specifies materials and methods for sealing penetrations of rated walls and partitions referenced by this Section.
5. Section 260526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding referenced by this Section.
6. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs installed by this Section.
7. Section 260573 "Power System Studies" specifies arc-flash hazard analysis and warning labels referenced by this Section.
8. Section 270528 "Pathways for Communications Systems"[and **Section 271100 "Communications Equipment Room Fittings"**] specifies additional requirements for identification of communications equipment and cabling.

1.2 DEFINITIONS

- A. Communications Outlet: One or more communications jacks, or cables and plugs, mounted in a box or ring, with a suitable protective cover.
- B. Enclosure: The case or housing of an apparatus, or the fence or wall(s) surrounding an installation, to prevent personnel from accidentally contacting energized parts or to protect the equipment from physical damage. Types of enclosures and enclosure covers include the following:
1. Cabinet: An enclosure that is designed for either surface mounting or flush mounting and is provided with a frame, mat, or trim in which a swinging door or doors are or can be hung.
 2. Concrete Box: A box intended for use in poured concrete.
 3. Conduit Body: A means for providing access to the interior of a conduit or tubing system through one or more removable covers at a junction or terminal point. In the United States, conduit bodies are listed in accordance with outlet box requirements.
 4. Conduit Box: A box having threaded openings or knockouts for conduit, EMT, or fittings.

5. Cover Plate: A cover designed for protecting wiring devices installed in flush-mounted device boxes while permitting their safe operation; also called a faceplate or wallplate.
6. Cutout Box: An enclosure designed for surface mounting that has swinging doors or covers secured directly to and telescoping with the walls of the enclosure.
7. Device Box: A box with provisions for mounting a wiring device directly to the box.
8. Extension Ring: A ring intended to extend the sides of an outlet box or device box to increase the box depth, volume, or both.
9. Floor Box: A box mounted in the floor intended for use with a floor box cover and other components to complete the floor box enclosure.
10. Floor-Mounted Enclosure: A floor box and floor box cover assembly with means to mount in the floor that is sealed against the entrance of scrub water at the floor level.
11. Floor Nozzle: An enclosure used on a wiring system, intended primarily as a housing for a receptacle, provided with a means, such as a collar, for surface-mounting on a floor, which may or may not include a stem to support it above the floor level, and is sealed against the entrance of scrub water at the floor level.
12. Junction Box: A box with a blank cover that joins different runs of raceway or cable and provides space for connection and branching of the enclosed conductors.
13. Outlet Box: A box that provides access to a wiring system having pryout openings, knockouts, threaded entries, or hubs in either the sides or the back, or both, for the entrance of conduit, conduit or cable fittings, or cables, with provisions for mounting an outlet box cover, but without provisions for mounting a wiring device directly to the box.
14. Pedestal Floor Box Cover: A floor box cover that, when installed as intended, provides a means for typically vertical or near-vertical mounting of receptacle outlets above the floor's finished surface.
15. Pull Box: A box with a blank cover that joins different runs of raceway and provides access for pulling or replacing the enclosed cables or conductors.
16. Raised-Floor Box: A floor box intended for use in raised floors.
17. Recessed Access Floor Box: A floor box with provisions for mounting wiring devices below the floor surface.
18. Recessed Access Floor Box Cover: A floor box cover with provisions for passage of cords to recessed wiring devices mounted within a recessed floor box.
19. Ring: A sleeve, which is not necessarily round, used for positioning a recessed wiring device flush with the plaster, concrete, drywall, or other wall surface.
20. Ring Cover: A box cover, with raised center portion to accommodate a specific wall or ceiling thickness, for mounting wiring devices or luminaires flush with the surface.
21. Termination Box: An enclosure designed for installation of termination base assemblies consisting of bus bars, terminal strips, or terminal blocks with provision for wire connectors to accommodate incoming or outgoing conductors, or both.

C. Receptacle: A fixed connecting device arranged for insertion of a power cord plug. Also called a power jack.

D. Receptacle Outlet: One or more receptacles mounted in a box with a suitable protective cover.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples: For each type of product requiring samples for source quality control.

C. Shop Drawings: Prepare and submit the following:

1. Shop Drawings for Floor Boxes: Show that floor boxes are located to avoid interferences and are structurally allowable. Indicate floor thickness **[at location]** where boxes are embedded in

concrete floors and underfloor clearances where boxes are installed in raised floors.

D. Sustainable Design Submittals:

1. Product data for sustainable design features for each type of product.

1.4 INFORMATIONAL SUBMITTALS

A. Manufacturer's published instructions.

1.5 QUALIFICATIONS

- A. Electrical Power Testing (EPT) Technician III: Possessing active NICET EPT Level III certification. Able to manage switching procedures; conduct tests of complex equipment; analyze test and equipment data; plan a job; and lead a team. Has experience performing NFPA 70B, IEEE, and NETA electrical tests.
- B. Electrical Power Testing (EPT) Technician IV: Possessing active NICET EPT Level IV certification. Able to conduct tests of complex metering and relay systems; evaluate tests, test equipment, test results, and power system performance; recommend actions to maintain or improve system performance; and lead multi-team projects.
- C. Inspection and Testing of Fire-Alarm Systems (I&TFAS) Technician I: Possessing active NICET I&TFAS Level I certification. Able to perform periodic inspections and tests of basic fire-alarm systems and prepare related records and reports.
- D. Inspection and Testing of Fire-Alarm Systems (I&TFAS) Technician II: Possessing active NICET I&TFAS Level II certification. Able to plan, perform, and coordinate periodic inspections and tests of complex fire-alarm systems (including one or more of suppression interfaces, networked control units, smoke control interfaces, air sampling systems, multi-zone voice evacuation systems, or high-rise applications) and prepare related records and reports.
- E. Electrical Power Testing and Inspecting Agency: Entities possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
1. On-site electrical testing supervisors must possess active NICET EPT Technician [III][IV] certification.
- F. Communications Testing and Inspecting Agency: Entity possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
1. On-site communications testing supervisor must have **[BICSI Technician (TECH)]<Insert certification program>** certification and documented training, and be experienced with testing communications equipment in accordance with **[BICSI]<Insert code enforced by authorities having jurisdiction>** testing standards.
- G. Security Testing and Inspecting Agency: Entity possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
1. On-site security testing supervisor must have **[ASIS][PSP]<Insert organization>** certification and documented training and experience with testing security equipment in accordance with **[ASIS]<Insert organization>** testing standards.



- H. Fire-Alarm Testing Agency: Entity possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
 - 1. On-site fire-alarm testing supervisor must possess active NICET I&TFAS Technician [I][II] certification.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- B. **<Insert additional performance requirements for the Project>.**

2.2 METALLIC OUTLET BOXES, DEVICE BOXES, RINGS, AND COVERS

- A. Source Quality Control:
 - 1. Samples:
 - a. Floor Box Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors and flooring inserts for each type of floor box.
 - b. Raised Floor Box Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors and flooring inserts for each type of floor box.
 - c. Recessed Access-Floor Box Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors and flooring inserts for each type of floor box.
 - d. Concrete Box Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors and flooring inserts for each type of floor box.
- B. UL QCIT - Metallic Outlet Boxes and Covers:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[Appleton; Emerson Electric Co., Automation Solutions]**
 - c. **[Arlington Industries, Inc.]**
 - d. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - e. **[Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - f. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - g. **[Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - h. **[MonoSystems, Inc]**
 - i. **[O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group]**
 - j. **[Pass & Seymour; Legrand North America, LLC]**
 - k. **[Patriot Aluminum Products, LLC]**
 - l. **[Plasti-Bond; Robroy Industries]**

- m. [Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - n. [Spring City Electrical Manufacturing Company]
 - o. [Topaz Lighting & Electric]
 - p. [Wiremold; Legrand North America, LLC]
 - q. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [ABB, Electrification Business]
 - b. [Appleton; Emerson Electric Co., Automation Solutions]
 - c. [Arlington Industries, Inc.]
 - d. [Crouse-Hinds; brand of Eaton, Electrical Sector]
 - e. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - f. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - g. [Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - h. [MonoSystems, Inc]
 - i. [O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group]
 - j. [Pass & Seymour; Legrand North America, LLC]
 - k. [Patriot Aluminum Products, LLC]
 - l. [Plasti-Bond; Robroy Industries]
 - m. [Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - n. [Spring City Electrical Manufacturing Company]
 - o. [Topaz Lighting & Electric]
 - p. [Wiremold; Legrand North America, LLC]
 - q. <Insert manufacturer's name>
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN QCIT; including UL 514A.
4. Standard Features:
 - a. Box having pryout openings, knockouts, threaded entries, or hubs in either the sides or the back, or both, for entrance of conduit, conduit or cable fittings, or cables, with provisions for mounting outlet box cover, but without provisions for mounting wiring device directly to box.
 - b. Material: [Sheet steel][Sheet aluminum][Cast metal].
 - c. Sheet Metal Depth: Minimum [1.5 inch (38 mm)][2 inch (50 mm)][2.5 inch (65 mm)][2.8 inch (70 mm)][3.5 inch (90 mm)].
 - d. Cast-Metal Depth: Minimum [1.8 inch (44.5 mm)][2.4 inch (60.3 mm)].
5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide [third-party-verified]corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.



- d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
- e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

6. Other Available Features Required by the Project:

- a. Luminaire Outlet Boxes and Covers: Nonadjustable, listed and labeled for attachment of luminaire weighing **[up to 50 lb (23 kg)][more than 50 lb (23 kg) and marked with maximum allowable weight]**.
- b. Paddle Fan Outlet Boxes and Covers: Nonadjustable, designed for attachment of paddle fan weighing up to **70 lb (32 kg)**.

C. UL QCIT - Metallic Conduit Bodies:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[Appleton; Emerson Electric Co., Automation Solutions]**
 - c. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - d. **[Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - e. **[O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group]**
 - f. **[Pass & Seymour; Legrand North America, LLC]**
 - g. **[Patriot Aluminum Products, LLC]**
 - h. **[Plasti-Bond; Robroy Industries]**
 - i. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - j. **[Topaz Lighting & Electric]**
 - k. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Appleton; Emerson Electric Co., Automation Solutions]**
 - c. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - d. **[Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - e. **[O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group]**
 - f. **[Pass & Seymour; Legrand North America, LLC]**
 - g. **[Patriot Aluminum Products, LLC]**
 - h. **[Plasti-Bond; Robroy Industries]**
 - i. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - j. **[Topaz Lighting & Electric]**
 - k. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN QCIT; including UL 514A.

4. Standard Features: Means for providing access to interior of conduit or tubing system through one or more removable covers at junction or terminal point. In the United States, conduit bodies are listed in accordance with outlet box requirements.
5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

D. UL QCIT - Metallic Device Boxes:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[Appleton; Emerson Electric Co., Automation Solutions]**
 - c. **[Arlington Industries, Inc.]**
 - d. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - e. **[Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - f. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - g. **[Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - h. **[O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group]**
 - i. **[Patriot Aluminum Products, LLC]**
 - j. **[Plasti-Bond; Robroy Industries]**
 - k. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - l. **[Topaz Lighting & Electric]**
 - m. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Appleton; Emerson Electric Co., Automation Solutions]**
 - c. **[Arlington Industries, Inc.]**
 - d. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - e. **[Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - f. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - g. **[Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - h. **[O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group]**

- i. **[Patriot Aluminum Products, LLC]**
 - j. **[Plasti-Bond; Robroy Industries]**
 - k. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - l. **[Topaz Lighting & Electric]**
 - m. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
- a. UL CCN QCIT; including UL 514A.
4. Standard Features:
- a. Box with provisions for mounting wiring device directly to box.
 - b. Material: **[Sheet steel][Sheet aluminum][Cast metal]**.
 - c. Sheet Metal Depth: minimum **[1.5 inch (38 mm)][2 inch (50 mm)][2.5 inch (65 mm)][2.8 inch (70 mm)][3.5 inch (90 mm)]**.
 - d. Cast-Metal Depth: minimum **[1.8 inch (44.5 mm)][2.4 inch (60.3 mm)]**.
5. Sustainable Design Features:
- a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
- E. UL QCIT - Metallic Extension Rings:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
- a. **[ABB, Electrification Business]**
 - b. **[Appleton; Emerson Electric Co., Automation Solutions]**
 - c. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - d. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - e. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - f. **[O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group]**
 - g. **[Pass & Seymour; Legrand North America, LLC]**
 - h. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - i. **[Topaz Lighting & Electric]**
 - j. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Appleton; Emerson Electric Co., Automation Solutions]**
 - c. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - d. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - e. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - f. **[O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group]**
 - g. **[Pass & Seymour; Legrand North America, LLC]**
 - h. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - i. **[Topaz Lighting & Electric]**
 - j. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN QCIT; including UL 514A.
4. Standard Features: Ring intended to extend sides of outlet box or device box to increase box depth, volume, or both.
5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

F. UL QCIT - Metallic Floor Boxes and Floor Box Covers:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[AFC Cable Systems; Atkore International]**
 - c. **[Arlington Industries, Inc.]**
 - d. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - e. **[FSR Inc.]**
 - f. **[Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - g. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**

- h. **[Leviton Manufacturing Co., Inc.]**
 - i. **[Pass & Seymour; Legrand North America, LLC]**
 - j. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - k. **[Wiremold; Legrand North America, LLC]**
 - l. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[ABB, Electrification Business]**
 - b. **[AFC Cable Systems; Atkore International]**
 - c. **[Arlington Industries, Inc.]**
 - d. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - e. **[FSR Inc.]**
 - f. **[Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - g. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - h. **[Leviton Manufacturing Co., Inc.]**
 - i. **[Pass & Seymour; Legrand North America, LLC]**
 - j. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - k. **[Wiremold; Legrand North America, LLC]**
 - l. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
- a. UL CCN QCIT; including UL 514A.
4. Standard Features: Box mounted in floor with floor box cover and other components to complete floor box enclosure.
5. Sustainable Design Features:
- a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
- G. UL QCIT - Metallic Raised-Floor Boxes and Floor Box Covers:
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

- a. **[ABB, Electrification Business]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Wiremold; Legrand North America, LLC]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Wiremold; Legrand North America, LLC]**
 - d. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN QCIT; including UL 514A.
4. Standard Features: Box mounted in raised-floor with floor box cover and other components to complete floor box enclosure.
5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
- H. UL QCIT - Metallic Recessed Access-Floor Boxes and Recessed Floor Box Covers:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[FSR Inc.]**
 - c. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - d. **[Wiremold; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the

following:

- a. **[ABB, Electrification Business]**
 - b. **[FSR Inc.]**
 - c. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - d. **[Wiremold; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
- a. UL CCN QCIT; including UL 514A.
4. Standard Features: Floor box with provisions for mounting wiring devices below floor surface and floor box cover with provisions for passage of cords to recessed wiring devices mounted within floor box.
5. Sustainable Design Features:
- a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

I. UL QCIT - Metallic Concrete Boxes and Covers:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - c. **[Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - d. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - e. **[Topaz Lighting & Electric]**
 - f. **[Wiremold; Legrand North America, LLC]**
 - g. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**

- b. [Crouse-Hinds; brand of Eaton, Electrical Sector]
 - c. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - d. [Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - e. [Topaz Lighting & Electric]
 - f. [Wiremold; Legrand North America, LLC]
 - g. <Insert manufacturer's name>
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
- a. UL CCN QCIT; including UL 514A.
4. Standard Features: Box intended for use in poured concrete.
5. Sustainable Design Features:
- a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

2.3 NONMETALLIC OUTLET BOXES, DEVICE BOXES, RINGS, AND COVERS

A. Source Quality Control:

1. Samples:

- a. Floor Box Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors and flooring inserts for each type of floor box.
- b. Raised Floor Box Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors and flooring inserts for each type of floor box.
- c. Recessed Access-Floor Box Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors and flooring inserts for each type of floor box.
- d. Concrete Box Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors and flooring inserts for each type of floor box.

B. UL QCMZ - Nonmetallic Outlet Boxes and Covers:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. [ABB, Electrification Business]
 - b. [Allied Tube & Conduit; Atkore International]

- c. [Appleton; Emerson Electric Co., Automation Solutions]
 - d. [Arlington Industries, Inc.]
 - e. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - f. [Cantex Inc.]
 - g. [Crouse-Hinds; brand of Eaton, Electrical Sector]
 - h. [Ericson Manufacturing Company]
 - i. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - j. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - k. [Intermatic, Inc]
 - l. [JM Eagle]
 - m. [Leviton Manufacturing Co., Inc.]
 - n. [Panduit Corp]
 - o. [Pass & Seymour; Legrand North America, LLC]
 - p. [Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - q. [Topaz Lighting & Electric]
 - r. [Wiremold; Legrand North America, LLC]
 - s. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [ABB, Electrification Business]
 - b. [Allied Tube & Conduit; Atkore International]
 - c. [Appleton; Emerson Electric Co., Automation Solutions]
 - d. [Arlington Industries, Inc.]
 - e. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - f. [Cantex Inc.]
 - g. [Crouse-Hinds; brand of Eaton, Electrical Sector]
 - h. [Ericson Manufacturing Company]
 - i. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - j. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - k. [Intermatic, Inc]
 - l. [JM Eagle]
 - m. [Leviton Manufacturing Co., Inc.]
 - n. [Panduit Corp]
 - o. [Pass & Seymour; Legrand North America, LLC]
 - p. [Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - q. [Topaz Lighting & Electric]
 - r. [Wiremold; Legrand North America, LLC]
 - s. <Insert manufacturer's name>
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
- a. UL CCN QCMZ; including UL 514C.
4. Standard Features: Box having pryout openings, knockouts, threaded entries, or hubs in either the sides or the back, or both, for entrance of conduit, conduit or cable fittings, or cables, with provisions for mounting outlet box cover, but without provisions for mounting wiring device directly

to box.

5. Sustainable Design Features:

- a. Solvent cements for use with nonmetallic raceways and covers have VOC content less than **[510][490]** g/L.
- b. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
- c. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
- d. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
- e. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
- f. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

C. UL QCMZ - Nonmetallic Conduit Bodies:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[Allied Tube & Conduit; Atkore International]**
 - c. **[Arlington Industries, Inc.]**
 - d. **[Cantex Inc.]**
 - e. **[JM Eagle]**
 - f. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - g. **[Topaz Lighting & Electric]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Allied Tube & Conduit; Atkore International]**
 - c. **[Arlington Industries, Inc.]**
 - d. **[Cantex Inc.]**
 - e. **[JM Eagle]**
 - f. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - g. **[Topaz Lighting & Electric]**
 - h. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN QCMZ; including UL 514C.
4. Standard Features: Means for providing access to interior of conduit or tubing system through one or more removable covers at junction or terminal point. In the United States, conduit bodies

are listed in accordance with outlet box requirements.

5. Sustainable Design Features:

- a. Solvent cements for use with nonmetallic raceways and covers have VOC content less than **[510][490]** g/L.
- b. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
- c. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
- d. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
- e. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
- f. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

D. UL QCMZ - Nonmetallic Device Boxes:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[Allied Tube & Conduit; Atkore International]**
 - c. **[Arlington Industries, Inc.]**
 - d. **[Cantex Inc.]**
 - e. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - f. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - g. **[Pass & Seymour; Legrand North America, LLC]**
 - h. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Allied Tube & Conduit; Atkore International]**
 - c. **[Arlington Industries, Inc.]**
 - d. **[Cantex Inc.]**
 - e. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - f. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - g. **[Pass & Seymour; Legrand North America, LLC]**
 - h. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - i. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

- a. UL CCN QCMZ; including UL 514C.
4. Standard Features: Box with provisions for mounting wiring device directly to box.
5. Sustainable Design Features:
 - a. Solvent cements for use with nonmetallic raceways and covers have VOC content less than **[510][490]** g/L.
 - b. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - c. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - d. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - e. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - f. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
- E. UL QCMZ - Nonmetallic Extension Rings:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[Allied Tube & Conduit; Atkore International]**
 - c. **[Arlington Industries, Inc.]**
 - d. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - e. **[Cantex Inc.]**
 - f. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - g. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - h. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Allied Tube & Conduit; Atkore International]**
 - c. **[Arlington Industries, Inc.]**
 - d. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - e. **[Cantex Inc.]**
 - f. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - g. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - h. **<Insert manufacturer's name>**
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

- a. UL CCN QCMZ; including UL 514C.
4. Standard Features: Ring intended to extend sides of outlet box or device box to increase box depth, volume, or both.
5. Sustainable Design Features:
 - a. Solvent cements for use with nonmetallic raceways and covers have VOC content less than **[510][490]** g/L.
 - b. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - c. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - d. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - e. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - f. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
- F. UL QCMZ - Nonmetallic Floor Boxes and Floor Box Covers:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[Allied Tube & Conduit; Atkore International]**
 - c. **[Arlington Industries, Inc.]**
 - d. **[Cantex Inc.]**
 - e. **[JM Eagle]**
 - f. **[Pass & Seymour; Legrand North America, LLC]**
 - g. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - h. **[Wiremold; Legrand North America, LLC]**
 - i. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Allied Tube & Conduit; Atkore International]**
 - c. **[Arlington Industries, Inc.]**
 - d. **[Cantex Inc.]**
 - e. **[JM Eagle]**
 - f. **[Pass & Seymour; Legrand North America, LLC]**
 - g. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - h. **[Wiremold; Legrand North America, LLC]**
 - i. **<Insert manufacturer's name>**
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product

categories:

- a. UL CCN QCMZ; including UL 514C.
4. Standard Features: Box mounted in floor with floor box cover and other components to complete floor box enclosure.
5. Sustainable Design Features:
 - a. Solvent cements for use with nonmetallic raceways and covers have VOC content less than **[510][490]** g/L.
 - b. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - c. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - d. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - e. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - f. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

G. UL QCMZ - Nonmetallic Raised-Floor Boxes and Floor Box Covers:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN QCMZ; including UL 514C.
4. Standard Features: Box mounted in raised-floor with floor box cover and other components to complete floor box enclosure.
5. Sustainable Design Features:
 - a. Solvent cements for use with nonmetallic raceways and covers have VOC content less than **[510][490]** g/L.
 - b. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - c. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.

- d. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
- e. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
- f. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

H. UL QCMZ - Nonmetallic Recessed Access-Floor Boxes and Recessed Floor Box Covers:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - c. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - d. **[Leviton Manufacturing Co., Inc.]**
 - e. **[Pass & Seymour; Legrand North America, LLC]**
 - f. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - g. **[Wiremold; Legrand North America, LLC]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - c. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - d. **[Leviton Manufacturing Co., Inc.]**
 - e. **[Pass & Seymour; Legrand North America, LLC]**
 - f. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - g. **[Wiremold; Legrand North America, LLC]**
 - h. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN QCMZ; including UL 514C.
4. Standard Features: Floor box with provisions for mounting wiring devices below floor surface and floor box cover with provisions for passage of cords to recessed wiring devices mounted within floor box.
5. Sustainable Design Features:
 - a. Solvent cements for use with nonmetallic raceways and covers have VOC content less than **[510][490]** g/L.
 - b. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts

- c. of extraction operations and activities associated with product and its supply chain.
- d. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
- e. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
- f. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
- f. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

I. UL QCMZ - Nonmetallic Floor Nozzles:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN QCMZ; including UL 514C.
4. Standard Features: Enclosure intended primarily as housing for receptacle, provided with means, such as collar, for surface-mounting on floor, which may or may not include stem to support it above floor level, and is sealed against the entrance of scrub water at floor level.
5. Sustainable Design Features:
 - a. Solvent cements for use with nonmetallic raceways and covers have VOC content less than **[510][490]** g/L.
 - b. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - c. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - d. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - e. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - f. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

J. UL QCMZ - Nonmetallic Concrete Boxes and Covers:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[Allied Tube & Conduit; Atkore International]**
 - c. **[Arlington Industries, Inc.]**
 - d. **[Cantex Inc.]**
 - e. **[JM Eagle]**
 - f. **[Leviton Manufacturing Co., Inc.]**
 - g. **[Wiremold; Legrand North America, LLC]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Allied Tube & Conduit; Atkore International]**
 - c. **[Arlington Industries, Inc.]**
 - d. **[Cantex Inc.]**
 - e. **[JM Eagle]**
 - f. **[Leviton Manufacturing Co., Inc.]**
 - g. **[Wiremold; Legrand North America, LLC]**
 - h. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN QCMZ; including UL 514C.
4. Standard Features: Box intended for use in poured concrete.
5. Sustainable Design Features:
 - a. Solvent cements for use with nonmetallic raceways and covers have VOC content less than **[510][490]** g/L.
 - b. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - c. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - d. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - e. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - f. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

2.4 JUNCTION BOXES AND PULL BOXES

A. UL BGUZ - Indoor Sheet Metal Junction and Pull Boxes:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Adalet; division of Scott Fetzer Co.]**
 - b. **[Appleton; Emerson Electric Co., Automation Solutions]**
 - c. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - d. **[FSR Inc.]**
 - e. **[Hoffman; brand of nVent Electrical plc]**
 - f. **[Hubbell Industrial Controls; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - g. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - h. **[Milbank Manufacturing Company]**
 - i. **[N J Sullivan Company]**
 - j. **[O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group]**
 - k. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - l. **[Spring City Electrical Manufacturing Company]**
 - m. **[Square D; Schneider Electric USA]**
 - n. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Adalet; division of Scott Fetzer Co.]**
 - b. **[Appleton; Emerson Electric Co., Automation Solutions]**
 - c. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - d. **[FSR Inc.]**
 - e. **[Hoffman; brand of nVent Electrical plc]**
 - f. **[Hubbell Industrial Controls; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - g. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - h. **[Milbank Manufacturing Company]**
 - i. **[N J Sullivan Company]**
 - j. **[O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group]**
 - k. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - l. **[Spring City Electrical Manufacturing Company]**
 - m. **[Square D; Schneider Electric USA]**
 - n. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN BGUZ; including UL 50 and UL 50E.
4. Standard Features:
 - a. Box with a blank cover that serves the purpose of joining different runs of raceway or



- cable.
- b. Degree of Protection: **[Type 1][Type 2][Type 5][Type 12][Type 12K][Type 13]**.

5. Sustainable Design Features:

- a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
- b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
- c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
- d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
- e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

B. UL BGUZ - Indoor Cast-Metal Junction and Pull Boxes:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Adalet; division of Scott Fetzer Co.]**
 - b. **[Appleton; Emerson Electric Co., Automation Solutions]**
 - c. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - d. **[O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Adalet; division of Scott Fetzer Co.]**
 - b. **[Appleton; Emerson Electric Co., Automation Solutions]**
 - c. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - d. **[O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group]**
 - e. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN BGUZ; including UL 50 and UL 50E.
4. Standard Features:
 - a. Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
 - b. Degree of Protection: **[Type 1][Type 2][Type 5][Type 12][Type 12K][Type 13]**.
5. Sustainable Design Features:

- a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
- b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
- c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
- d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
- e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

C. UL BGUZ - Indoor Polymeric Junction and Pull Boxes:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[Allied Tube & Conduit; Atkore International]**
 - c. **[Cantex Inc.]**
 - d. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - e. **[JM Eagle]**
 - f. **[Robroy Enclosures; Robroy Industries]**
 - g. **[Topaz Lighting & Electric]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Allied Tube & Conduit; Atkore International]**
 - c. **[Cantex Inc.]**
 - d. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - e. **[JM Eagle]**
 - f. **[Robroy Enclosures; Robroy Industries]**
 - g. **[Topaz Lighting & Electric]**
 - h. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN BGUZ; including UL 50 and UL 50E.
4. Standard Features:
 - a. Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
 - b. Degree of Protection: **[Type 1][Type 2][Type 5][Type 12][Type 12K][Type 13]**.

5. Sustainable Design Features:

- a. Solvent cements for use with nonmetallic raceways and covers have VOC content less than **[510][490]** g/L.
- b. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
- c. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
- d. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
- e. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
- f. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

D. UL BGUZ - Outdoor Sheet Metal Junction and Pull Boxes:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Adalet; division of Scott Fetzer Co.]**
 - b. **[Appleton; Emerson Electric Co., Automation Solutions]**
 - c. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - d. **[FSR Inc.]**
 - e. **[Hoffman; brand of nVent Electrical plc]**
 - f. **[Hubbell Industrial Controls; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - g. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - h. **[Milbank Manufacturing Company]**
 - i. **[N J Sullivan Company]**
 - j. **[O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group]**
 - k. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - l. **[Spring City Electrical Manufacturing Company]**
 - m. **[Square D; Schneider Electric USA]**
 - n. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Adalet; division of Scott Fetzer Co.]**
 - b. **[Appleton; Emerson Electric Co., Automation Solutions]**
 - c. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - d. **[FSR Inc.]**
 - e. **[Hoffman; brand of nVent Electrical plc]**
 - f. **[Hubbell Industrial Controls; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - g. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**

- h. [Milbank Manufacturing Company]
 - i. [N J Sullivan Company]
 - j. [O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group]
 - k. [Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - l. [Spring City Electrical Manufacturing Company]
 - m. [Square D; Schneider Electric USA]
 - n. <Insert manufacturer's name>
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN BGUZ; including UL 50 and UL 50E.
 4. Standard Features:
 - a. Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
 - b. Degree of Protection: [Type 3][Type 3X][Type 3R][Type 3RX][Type 3S][Type 3SX][Type 4][Type 4X][Type 6][Type 6P].
 5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide [third-party-verified]corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
- E. UL BGUZ - Outdoor Cast-Metal Junction and Pull Boxes:
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Adalet; division of Scott Fetzer Co.]
 - b. [Appleton; Emerson Electric Co., Automation Solutions]
 - c. [Crouse-Hinds; brand of Eaton, Electrical Sector]
 - d. [O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group]
 - e. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Adalet; division of Scott Fetzer Co.]
 - b. [Appleton; Emerson Electric Co., Automation Solutions]

- c. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - d. **[O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group]**
 - e. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
- a. UL CCN BGUZ; including UL 50 and UL 50E.
4. Standard Features:
- a. Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
 - b. Degree of Protection: **[Type 3][Type 3X][Type 3R][Type 3RX][Type 3S][Type 3SX][Type 4][Type 4X][Type 6][Type 6P]**.
5. Sustainable Design Features:
- a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

F. UL BGUZ - Outdoor Polymeric Junction and Pull Boxes:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
- a. **[ABB, Electrification Business]**
 - b. **[Allied Tube & Conduit; Atkore International]**
 - c. **[Cantex Inc.]**
 - d. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - e. **[JM Eagle]**
 - f. **[Robroy Enclosures; Robroy Industries]**
 - g. **[Topaz Lighting & Electric]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[ABB, Electrification Business]**

- b. **[Allied Tube & Conduit; Atkore International]**
 - c. **[Cantex Inc.]**
 - d. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - e. **[JM Eagle]**
 - f. **[Robroy Enclosures; Robroy Industries]**
 - g. **[Topaz Lighting & Electric]**
 - h. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
- a. UL CCN BGUZ; including UL 50 and UL 50E.
4. Standard Features:
- a. Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
 - b. Degree of Protection: **[Type 3][Type 3X][Type 3R][Type 3RX][Type 3S][Type 3SX][Type 4][Type 4X][Type 6][Type 6P]**.
5. Sustainable Design Features:
- a. Solvent cements for use with nonmetallic raceways and covers have VOC content less than **[510][490]** g/L.
 - b. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - c. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - d. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - e. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - f. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

2.5 COVER PLATES FOR DEVICE BOXES

A. UL QCIT or QCMZ - Metallic Cover Plates for Device Boxes:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[Appleton; Emerson Electric Co., Automation Solutions]**
 - c. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - d. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - e. **[Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**

- f. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - g. [Intermatic, Inc]
 - h. [Leviton Manufacturing Co., Inc.]
 - i. [O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group]
 - j. [Panduit Corp]
 - k. [Pass & Seymour; Legrand North America, LLC]
 - l. [Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - m. [Topaz Lighting & Electric]
 - n. [Wiremold; Legrand North America, LLC]
 - o. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [ABB, Electrification Business]
 - b. [Appleton; Emerson Electric Co., Automation Solutions]
 - c. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - d. [Crouse-Hinds; brand of Eaton, Electrical Sector]
 - e. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - f. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - g. [Intermatic, Inc]
 - h. [Leviton Manufacturing Co., Inc.]
 - i. [O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group]
 - j. [Panduit Corp]
 - k. [Pass & Seymour; Legrand North America, LLC]
 - l. [Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - m. [Topaz Lighting & Electric]
 - n. [Wiremold; Legrand North America, LLC]
 - o. <Insert manufacturer's name>
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN QCIT or UL CCN QCMZ; including UL 514D.
4. Standard Features:
 - a. Cover plate-Securing Screws: Metal with head color to match cover plate finish.
 - b. Damp and Wet Locations: Listed, labeled, and marked for location and use. Provide gaskets and accessories necessary for compliance with listing.
 - c. Cover Plate Material: [0.032 inch (0.8 mm) thick, Type 302/304 non-magnetic stainless steel with brushed finish][0.040 inch (1.0 mm) thick aluminum, anodized or lacquered to prevent corrosion][0.04 inch (1 mm) thick, brushed brass with factory polymer finish][Steel with white baked enamel, suitable for field painting][0.04 inch (1 mm) thick steel with chrome-plated finish][Galvanized steel][Cast aluminum][As indicated on architectural Drawings].
5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide [third-party-verified]corporate sustainability

report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.

- b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
- c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
- d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
- e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

B. UL QCIT or QCMZ - Nonmetallic Cover Plates for Device Boxes:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[Appleton; Emerson Electric Co., Automation Solutions]**
 - c. **[Arlington Industries, Inc.]**
 - d. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - e. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - f. **[Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - g. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - h. **[Intermatic, Inc]**
 - i. **[Leviton Manufacturing Co., Inc.]**
 - j. **[O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group]**
 - k. **[Panduit Corp]**
 - l. **[Pass & Seymour; Legrand North America, LLC]**
 - m. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - n. **[Topaz Lighting & Electric]**
 - o. **[Wiremold; Legrand North America, LLC]**
 - p. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Appleton; Emerson Electric Co., Automation Solutions]**
 - c. **[Arlington Industries, Inc.]**
 - d. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - e. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - f. **[Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - g. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - h. **[Intermatic, Inc]**
 - i. **[Leviton Manufacturing Co., Inc.]**
 - j. **[O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group]**
 - k. **[Panduit Corp]**

- l. **[Pass & Seymour; Legrand North America, LLC]**
 - m. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - n. **[Topaz Lighting & Electric]**
 - o. **[Wiremold; Legrand North America, LLC]**
 - p. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN QCIT or UL CCN QCMZ; including UL 514D.
 4. Standard Features:
 - a. Cover Plate-Securing Screws: Metal with head color to match cover plate finish.
 - b. Damp and Wet Locations: Listed, labeled, and marked for location and use. Provide gaskets and accessories necessary for compliance with listing.
 - c. Cover Plate Material: **[0.060 inch (1.5 mm) thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device][As indicated on architectural Drawings]**.
 - d. Color: **[Ivory][White][Gray][Brown][Black][Red][Orange][in accordance with NEMA WD 1][Blue][Office White][Almond][Light Almond][As indicated on architectural Drawings]**.
 5. Sustainable Design Features:
 - a. Solvent cements for use with nonmetallic raceways and covers have VOC content less than **[510][490]** g/L.
 - b. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - c. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - d. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - e. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - f. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
- C. UL QCIT or QCMZ - Illuminating Cover Plates for Device Boxes:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Leviton Manufacturing Co., Inc.]**
 - b. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[Leviton Manufacturing Co., Inc.]**
- b. **<Insert manufacturer's name>**
- 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN QCIT or UL CCN QCMZ; including UL 514D.
- 4. Standard Features:
 - a. Cover Plate-Securing Screws: Metal with head color to match cover plate finish.
 - b. Damp and Wet Locations: Listed, labeled, and marked for location and use. Provide gaskets and accessories necessary for compliance with listing.
 - c. Cover Plate Material: **[0.060 inch (1.5 mm) thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device][As indicated on architectural Drawings]**.
 - d. Color: **[Ivory][White][Gray][Brown][Black][Red][Orange][in accordance with NEMA WD 1][Blue][Office White][Almond][Light Almond][As indicated on architectural Drawings]**.
- 5. Sustainable Design Features:
 - a. Solvent cements for use with nonmetallic raceways and covers have VOC content less than **[510][490]** g/L.
 - b. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - c. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - d. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - e. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - f. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

2.6 HOODS FOR OUTLET BOXES

A. UL QCIT or QCMZ - Retractable or Reattachable Hoods for Outlet Boxes:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[ABB, Electrification Business]**
 - b. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
- a. UL CCN QCIT or UL CCN QCMZ; including UL 514D.
 - b. Receptacle, Hood, Cover Plate, Gaskets, and Seals: UL 498 Supplement SA when mated with box or enclosure complying with UL 514A, UL 514C, or UL 50E.
4. Standard Features:
- a. Mounts to box using fasteners different from wiring device.
 - b. Provides **[clear][gray][white]**, weatherproof, "while-in-use" cover.
5. Sustainable Design Features:
- a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - d. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

B. UL QCIT or QCMZ - Extra-Duty, While-in-Use Hoods for Outlet Boxes:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
- a. **[ABB, Electrification Business]**
 - b. **[Allied Tube & Conduit; Atkore International]**
 - c. **[Appleton; Emerson Electric Co., Automation Solutions]**
 - d. **[Arlington Industries, Inc.]**
 - e. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - f. **[Intermatic, Inc]**
 - g. **[Leviton Manufacturing Co., Inc.]**
 - h. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[ABB, Electrification Business]**
 - b. **[Allied Tube & Conduit; Atkore International]**
 - c. **[Appleton; Emerson Electric Co., Automation Solutions]**
 - d. **[Arlington Industries, Inc.]**

- e. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - f. [Intermatic, Inc]
 - g. [Leviton Manufacturing Co., Inc.]
 - h. [Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - i. <Insert manufacturer's name>
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
- a. UL CCN QCIT or UL CCN QCMZ; including UL 514D.
 - b. Receptacle, Hood, Cover Plate, Gaskets, and Seals: UL 498 Supplement SA when mated with box or enclosure complying with UL 514A, UL 514C, or UL 50E.
4. Standard Features:
- a. Mounts to box using fasteners different from wiring device.
 - b. Marked "Extra-Duty" in accordance with UL 514D.
 - c. Provides [clear][gray][white], weatherproof, "while-in-use" cover.
 - d. Manufacturer may combine nonmetallic device box with hood as extra-duty rated assembly.
5. Sustainable Design Features:
- a. Corporate Sustainability Report: Provide [third-party-verified]corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

PART 3 - EXECUTION

3.1 SELECTION OF BOXES AND COVERS FOR ELECTRICAL SYSTEMS

- A. Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with NFPA 70 for selection of boxes and enclosures. Consult Architect for resolution of conflicting requirements.
- B. Degree of Protection:
 - 1. Outdoors:
 - a. [Type 3][Type 3R][Type 4] unless otherwise indicated.
 - b. Locations Exposed to Hosedown: [Type 4][Type 4X][Type 6][Type 6P].
 - c. Locations Subject to Potential Flooding: Type 6P.
 - d. Locations Aboveground Where Mechanism Must Operate When Ice Covered: Type 3S.

- e. Locations in-Ground or Exposed to Corrosive Agents: **[Type 4X][Type 6P][Type 3RX]**.
- f. Locations in-Ground or Exposed to Corrosive Agents Where Mechanism Must Operate When Ice Covered: Type 3SX.

2. Indoors:

- a. Type 1 unless otherwise indicated.
- b. Damp or Dusty Locations: **[Type 12][Type 2][Type 4][Type 5]**.
- c. Surface Mounted in Kitchens and Other Locations Exposed to Oil or Coolants: Type 12.
- d. Flush Mounted in Kitchens and Other Locations Exposed to Oil or Coolants: **[Type 12][Type 12K]**.
- e. Locations Exposed to Airborne Dust, Lint, Fibers, or Flyings: **[Type 4][Type 6]**.
- f. Locations Exposed to Hosedown: **[Type 4][Type 6][Type 6P]**.
- g. Locations Exposed to Brief Submersion: **[Type 6][Type 6P]**.
- h. Locations Exposed to Prolonged Submersion: Type 6P.
- i. Locations Exposed to Corrosive Agents: **[Type 4X][Type 6P]**.
- j. Locations Exposed to Spraying Oil or Coolants: Type 13.

C. Exposed Boxes Installed Less Than 2.5 m (8 ft) Above Floor:

- 1. **[Provide cast-metal boxes][Boxes with knockouts or unprotected openings are prohibited]**.
- 2. Provide exposed cover. Flat covers with angled mounting slots or knockouts are prohibited.

3.2 INSTALLATION OF BOXES AND COVERS FOR ELECTRICAL SYSTEMS

A. Comply with manufacturer's published instructions.

B. Reference Standards for Installation: Unless more stringent installation requirements are specified in Contract Documents or manufacturers' published instructions, comply with the following:

- 1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
- 2. Electrical Safety: NFPA 70E.
- 3. Commissioning of Active and Passive Fire Protection Features: NFPA 3 and NFPA 4.
- 4. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
- 5. Communications Work: BICSI N1.
- 6. Life Safety and Means of Egress Work: NFPA 101.
- 7. Emergency and Standby Power Work: NFPA 110, NFPA 111, and NECA NEIS 416.
- 8. Work in Confined Spaces: NFPA 350.
- 9. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
- 10. Outlet, Device, Pull, and Junction Boxes: Article 314 of NFPA 70.
- 11. Consult Architect for resolution of conflicting requirements.

C. Special Installation Techniques:

- 1. Provide boxes in wiring and raceway systems wherever required for pulling of wires, making connections, and mounting of devices or fixtures.
- 2. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to **[center][top][bottom]** of box unless otherwise indicated.
- 3. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box, whether installed indoors or outdoors.
- 4. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same

- vertical channel.
- 5. Locate boxes so that cover or plate will not span different building finishes.
- 6. Support boxes in recessed ceilings independent of ceiling tiles and ceiling grid.
- 7. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for purpose.
- 8. Fasten junction and pull boxes to, or support from, building structure. Do not support boxes by conduits.
- 9. Set metal floor boxes level and flush with finished floor surface.
- 10. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.
- 11. Do not install aluminum boxes, enclosures, or fittings in contact with concrete or earth.
- 12. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to ensure a continuous ground path.
- 13. Boxes and Enclosures in Areas or Walls with Acoustical Requirements:
 - a. Seal openings and knockouts in back and sides of boxes and enclosures with acoustically rated putty.
 - b. Provide gaskets for cover plates and covers.
- 14. **<Insert more stringent installation requirements that supplement or supersede listed standards and manufacturers' published instructions>.**

D. Interfaces with Other Work:

- 1. Identification: Provide labels for boxes and associated electrical equipment.
 - a. Identify field-installed conductors, interconnecting wiring, and components.
 - b. Label each enclosure with engraved metal or laminated-plastic nameplate.
 - c. Provide warning signs and arc-flash hazard warning labels for electrical equipment.
- 2. Coordinate installation of new products for **<Insert system or product family/category>** with existing conditions.
 - a. **<Insert requirements for transition between new and existing>.**
- 3. Coordinate with **<Insert Section number and title>** for **<Insert description of interfacing related Work>.**
 - a. **<Insert requirements for transition between this Section and related Work>.**

3.3 FIELD QUALITY CONTROL OF BOXES AND COVERS

A. Administrant for Electrical Power Tests and Inspections:

- 1. **[Owner][Tenant]** will engage qualified medium-voltage electrical testing and inspecting agency to administer and perform tests and inspections.
- 2. Engage qualified medium-voltage electrical testing and inspecting agency to administer and perform tests and inspections.
- 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
- 4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].

B. Administrant for Communications Tests and Inspections:

- 1. **[Owner][Tenant]** will engage qualified communications testing and inspecting agency to

- administer and perform tests and inspections.
2. Engage qualified communications testing and inspecting agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].

C. Administrant for Security Tests and Inspections:

1. **[Owner][Tenant]** will engage qualified security testing and inspecting agency to administer and perform tests and inspections.
2. Engage qualified security testing and inspecting agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].

D. Administrant for Fire-Alarm Tests and Inspections:

1. **[Owner][Tenant]** will engage qualified fire-alarm testing and inspecting agency to administer and perform tests and inspections.
2. Engage qualified fire-alarm testing and inspecting agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].

E. Acceptance Testing Preparation:

1. **<Insert requirements>**.

F. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.

G. Tests and Inspections:

1. Perform manufacturer's recommended tests and inspections.
2. Perform tests and inspections recommended by standards listed in "Reference Standards for Installation" Paragraph.

H. Nonconforming Work:

1. Boxes and covers will be considered defective if they do not pass tests and inspections.
2. Remove and replace defective units and retest.

I. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

3.4 CLEANING

- A. Remove construction dust and debris from boxes before installing cover plates, covers, and hoods.



3.5 PROTECTION

- A. After installation, protect boxes from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 26 05 33 16



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Task	Specification	Specification Description
26 05 33 16	26 05 00 00	Sleeves and Sleeve Seals for Electrical Raceways and Cabling
26 05 33 16	26 27 26 00	Wiring Devices



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SECTION 26 05 33 23 - SURFACE RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Surface metal raceways and fittings.
2. Surface nonmetallic raceways.
3. Strut-type channel raceways and fittings.
4. Wireways and auxiliary gutters.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies temperature, humidity, acoustical, and other field conditions applicable to the Work specified in this Section.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies seismic hazard, wind hazard, and other structural design conditions applicable to the Work specified in this Section.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional coordination, scheduling, sequencing, submittal, and installation requirements applicable to the Work for electrical, communications, and electronic safety and security systems on the Project, including wiring methods.
4. Section 260526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding referenced by this Section.
5. Section 260553 "Identification for Electrical Systems" specifies warning signs referenced by this Section.
6. Section 270528 "Pathways for Communications Systems"[**and Section 271100 "Communications Equipment Room Fittings"**] specifies additional requirements for identification of communications equipment and cabling.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Samples: For each type of product requiring samples for source quality control.
- C. Sustainable Design Submittals:
1. Product data for sustainable design features for each type of product.

1.3 INFORMATIONAL SUBMITTALS

- A. Manufacturer's published instructions.

1.4 QUALIFICATIONS

- A. Electrical Power Testing (EPT) Technician III: Possessing active NICET EPT Level III certification. Able to manage switching procedures; conduct tests of complex equipment; analyze test and equipment



data; plan a job; and lead a team. Has experience performing NFPA 70B, IEEE, and NETA electrical tests.

- B. Electrical Power Testing (EPT) Technician IV: Possessing active NICET EPT Level IV certification. Able to conduct tests of complex metering and relay systems; evaluate tests, test equipment, test results, and power system performance; recommend actions to maintain or improve system performance; and lead multi-team projects.
- C. Electrical Power Testing and Inspecting Agency: Entities possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
 - 1. On-site electrical testing supervisors must possess active NICET EPT Technician [III][IV] certification.
- D. Communications Testing and Inspecting Agency: Entity possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
 - 1. On-site communications testing supervisor must have **[BICSI Technician (TECH)]<Insert certification program>** certification and documented training, and be experienced with testing communications equipment in accordance with **[BICSI]<Insert code enforced by authorities having jurisdiction>** testing standards.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2.2 SURFACE METAL RACEWAYS AND FITTINGS

- A. Source Quality Control:
 - 1. Samples:
 - a. Surface Metallic Raceway Nonmetallic Cover Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors for each type, **[12 inch (300 mm)]<Insert dimension>** long.
- B. UL RJBT - Surface Metal Raceways and Fittings with Metal Covers:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[MonoSystems, Inc]**
 - c. **[Wiremold; Legrand North America, LLC]**

- d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[MonoSystems, Inc]**
 - c. **[Wiremold; Legrand North America, LLC]**
 - d. **<Insert manufacturer's name>**
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN RJBT; including UL 5.
 4. Standard Features:
 - a. **[Galvanized steel][Aluminum]** base with snap-on covers.
 - b. **[Manufacturer's standard enamel finish in color selected by Architect][Prime coated, ready for field painting]**.
 - c. Wiring Channels: **[Single][Dual][Triple]**. Multiple channels must be capable of housing a standard 20 to 30 A device flush within the raceway.
 5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
- C. UL RJBT - Surface Metal Raceways and Fittings with Nonmetallic Covers:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Union Products International, Inc.]**
 - b. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[Union Products International, Inc.]**
 - b. **<Insert manufacturer's name>**
- 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN RJBT; including UL 5.
- 4. Standard Features:
 - a. UL 94, V-0 requirements for self-extinguishing characteristics.
 - b. **[Galvanized steel][Aluminum]** base with snap-on covers.
 - c. Provide texture and color selected by Architect from **[manufacturer's standard][custom]** colors.
 - d. Wiring Channels: **[Single][Dual][Triple]**. Multiple channels must be capable of housing a standard 20 to 30 A device flush within the raceway.
- 5. Sustainable Design Features:
 - a. Solvent cements for use with nonmetallic raceways and covers have VOC content less than **[510][490]** g/L.
 - b. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - c. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - d. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - e. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - f. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

2.3 SURFACE NONMETALLIC RACEWAYS

- A. Source Quality Control:
 - 1. Samples:
 - a. Surface Nonmetallic Raceway Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors for each type, **[12 inch (300 mm)][<Insert dimension>** long.
- B. UL RJTX - Surface Nonmetallic Raceways and Fittings with Nonmetallic Covers:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[HellermannTyton]**

- b. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - d. [Panduit Corp]
 - e. [Wiremold; Legrand North America, LLC]
 - f. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [HellermannTyton]
 - b. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - d. [Panduit Corp]
 - e. [Wiremold; Legrand North America, LLC]
 - f. <Insert manufacturer's name>
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
- a. UL CCN RJTX; including UL 5A.
 - b. UL 94, V-0 requirements for self-extinguishing characteristics.
4. Standard Features:
- a. Provide texture and color selected by Architect from [manufacturer's standard][custom] colors.
 - b. Wiring Channels: [Single][Dual]. Multiple channels must be capable of housing a standard 20 to 30 A device flush within the raceway.
5. Sustainable Design Features:
- a. Solvent cements for use with nonmetallic raceways and covers have VOC content less than [510][490] g/L.
 - b. Corporate Sustainability Report: Provide [third-party-verified]corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - c. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - d. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - e. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - f. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
- C. UL RJTX - Surface Nonmetallic Raceways and Fittings with Metallic Covers:
- 1. Manufacturers: Subject to compliance with requirements, [provide products by the



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

- a. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. <Insert manufacturer's name>
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN RJTX; including UL 5A.
 - b. UL 94, V-0 requirements for self-extinguishing characteristics.
4. Standard Features:
 - a. [Manufacturer's standard enamel finish in color selected by Architect][Prime coated, ready for field painting].
 - b. Wiring Channels: [Single][Dual]. Multiple channels must be capable of housing a standard 20 to 30 A device flush within the raceway.
5. Sustainable Design Features:
 - a. Solvent cements for use with nonmetallic raceways and covers have VOC content less than [510][490] g/L.
 - b. Corporate Sustainability Report: Provide [third-party-verified]corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - c. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - d. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - e. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - f. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

2.4 STRUT-TYPE CHANNEL RACEWAYS AND FITTINGS

A. Source Quality Control:

1. Samples:
 - a. Strut-Type Channel Raceway Nonmetallic Covers for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors for each type, [12 inch (300 mm)]<Insert dimension> long.

B. UL RIUU - Strut-Type Channel Raceways and Fittings with Metallic Covers:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[Atkore Unistrut]**
 - c. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - d. **[Power-Strut; Atkore International]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Atkore Unistrut]**
 - c. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - d. **[Power-Strut; Atkore International]**
 - e. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN RIUU; including UL 5B.
4. Standard Features:
 - a. **[Manufacturer's standard enamel finish in color selected by Architect][Prime coated, ready for field painting].**
5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

C. UL RIUU - Strut-Type Channel Raceways and Fittings with Nonmetallic Covers:

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



- a. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. <Insert manufacturer's name>
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN RIUU; including UL 5B.
 - b. UL 94, V-0 requirements for self-extinguishing characteristics.
4. Standard Features:
 - a. UL 94, V-0 requirements for self-extinguishing characteristics.
 - b. Provide texture and color selected by Architect from [manufacturer's standard][custom] colors.
5. Sustainable Design Features:
 - a. Solvent cements for use with nonmetallic raceways and covers have VOC content less than [510][490] g/L.
 - b. Corporate Sustainability Report: Provide [third-party-verified]corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - c. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - d. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - e. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - f. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

2.5 WIREWAYS AND AUXILIARY GUTTERS

A. Source Quality Control:

1. Samples:
 - a. Nonmetallic Wireway and Auxiliary Gutter Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors for each type, **[12 inch (300 mm)]<Insert dimension>** long.

B. UL ZOYX - Metal Wireways and Auxiliary Gutters:

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

following]:

- a. [ABB, Electrification Business]
 - b. [Cooper B-line; brand of Eaton, Electrical Sector]
 - c. [Hoffman; brand of nVent Electrical plc]
 - d. [MonoSystems, Inc]
 - e. [Square D; Schneider Electric USA]
 - f. [Wiegmann; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - g. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [ABB, Electrification Business]
 - b. [Cooper B-line; brand of Eaton, Electrical Sector]
 - c. [Hoffman; brand of nVent Electrical plc]
 - d. [MonoSystems, Inc]
 - e. [Square D; Schneider Electric USA]
 - f. [Wiegmann; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - g. <Insert manufacturer's name>
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
- a. UL CCN ZOYX; including UL 870.
4. Standard Features:
- a. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
 - b. Finish: Manufacturer's standard enamel finish.
 - c. Wireway Covers: [Hinged type][Screw-cover type][Flanged-and-gasketed type] unless otherwise indicated.
5. Sustainable Design Features:
- a. Corporate Sustainability Report: Provide [third-party-verified]corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
6. Other Available Features Required by the Project:
- a. Degree of Protection: [Type 1][Type 3R][Type 4][Type 12]<Insert type> unless otherwise

indicated.

C. UL ZOYX - Nonmetallic Wireways and Auxiliary Gutters:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Hoffman; brand of nVent Electrical plc]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Hoffman; brand of nVent Electrical plc]**
 - b. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN ZOYX; including UL 870.
 - b. UL 94, V-0 requirements for self-extinguishing characteristics.
4. Standard Features:
 - a. Fittings and Accessories: Couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings must match and mate with wireways as required for complete system.
 - b. PVC Solvents and Adhesives: As recommended by wireway manufacturer.
 - c. Material:
 - 1) Fiberglass polyester, extruded and fabricated to required size and shape, without holes or knockouts. Cover must be gasketed with oil-resistant gasket material and fastened with captive screws treated for corrosion resistance. Connections must be flanged and have stainless steel screws and oil-resistant gaskets.
 - 2) PVC, extruded and fabricated to required size and shape, and having snap-on cover, mechanically coupled connections, and plastic fasteners.
5. Sustainable Design Features:
 - a. Solvent cements for use with nonmetallic raceways and covers have VOC content less than **[510][490]** g/L.
 - b. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - c. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - d. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - e. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard

- development organization, is publicly available for product.
- f. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

PART 3 - EXECUTION

3.1 INSTALLATION OF SURFACE RACEWAYS FOR ELECTRICAL SYSTEMS

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in Contract Documents or manufacturers' published instructions, comply with the following:
 - 1. Electrical Construction: ICC IBC, ICC IFB, NFPA 1, NFPA 70, and NECA NEIS 1.
 - 2. Electrical Safety: NFPA 70E.
 - 3. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
 - 4. Communications Work: BICSI N1.
 - 5. Work in Confined Spaces: NFPA 350.
 - 6. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
 - 7. Auxiliary Gutters: Article 366 of NFPA 70.
 - 8. Surface Metal Raceway: Article 386 of NFPA 70.
 - 9. Surface Nonmetallic Raceway: Article 388 of NFPA 70.
 - 10. Consult Architect for resolution of conflicting requirements.
- C. Special Installation Techniques:
 - 1. Install surface raceways only where indicated on Drawings.
 - 2. Install surface raceway with a minimum **2 inch (50 mm)** radius control at bend points.
 - 3. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding **48 inch (1200 mm)** and with no less than two supports per straight raceway section. Support surface raceway in accordance with manufacturer's published instructions. Tape and glue are unacceptable support methods.
 - 4. **<Insert more stringent installation requirements that supplement or supersede listed standards and manufacturers' published instructions>.**
- D. Interfaces with Other Work:
 - 1. Identification: Provide labels for surface raceways and associated electrical equipment.
 - a. Identify field-installed conductors, interconnecting wiring, and components.
 - b. Provide warning signs.
 - 2. Coordinate installation of new products for **<Insert system or product family/category>** with existing conditions.
 - a. **<Insert requirements for transition between new and existing>.**
 - 3. Coordinate with **<Insert Section number and title>** for **<Insert description of interfacing related Work>.**
 - a. **<Insert requirements for transition between this Section and related Work>.**

3.2 FIELD QUALITY CONTROL OF SURFACE RACEWAYS

- A. Administrant for Electrical Power Tests and Inspections:
1. **[Owner][Tenant]** will engage qualified medium-voltage electrical testing and inspecting agency to administer and perform tests and inspections.
 2. Engage qualified medium-voltage electrical testing and inspecting agency to administer and perform tests and inspections.
 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
 4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].
- B. Administrant for Communications Tests and Inspections:
1. **[Owner][Tenant]** will engage qualified communications testing and inspecting agency to administer and perform tests and inspections.
 2. Engage qualified communications testing and inspecting agency to administer and perform tests and inspections.
 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
 4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].
- C. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.
- D. Tests and Inspections:
1. Perform manufacturer's recommended tests and inspections.
 2. Perform tests and inspections recommended by standards listed in "Reference Standards for Installation" Paragraph.
- E. Nonconforming Work:
1. Boxes and covers will be considered defective if they do not pass tests and inspections.
 2. Remove and replace defective units and retest.
- F. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

3.3 CLEANING

- A. Remove construction dust and debris from surface raceways before installing covers.

3.4 PROTECTION

- A. After installation, protect surface raceways from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 26 05 33 23



Task	Specification	Specification Description
26 05 33 23	26 05 39 00	Underfloor Raceways For Electrical Systems
26 05 33 23	26 05 00 00	Sleeves and Sleeve Seals for Electrical Raceways and Cabling



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SECTION 26 05 36 00 - CABLE TRAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal cable trays.
2. Nonmetallic cable trays.
3. Cable tray accessories.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

C. Products Installed, but Not Furnished, under This Section:

1. Section 078413 "Penetration Firestopping" specifies firestopping products installed under this Section.
2. Section 260526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding products installed under this Section.
3. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs installed by this Section.

1.2 ACTION SUBMITTALS

A. Product Data:

1. Metal cable trays.
2. Nonmetallic cable trays.
3. Cable tray accessories.

B. Shop Drawings:

1. Cable tray fabrication drawings, diagrams, and supporting documents.

C. Field quality-control reports.

1.3 INFORMATIONAL SUBMITTALS

A. Manufacturers' published instructions.

B. Field Reports:

1. Factory test reports.

2. Manufacturer's field reports for field quality-control support.

PART 2 - PRODUCTS

2.1 METAL CABLE TRAYS

- A. Description: This product category covers metal cable trays and metal cable tray systems intended for field assembly and for use in accordance with Article 392 of NFPA 70.
- B. Performance Criteria:
 1. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 2. Listing Criteria: UL CCN CYNW; including NEMA VE 1 and suitability for use as equipment grounding conductors in accordance with Sections 392.60(A) and 392.60(B) of NFPA 70.
- C. UL CYNW - Ladder Cable Tray :
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[Atkore Cope]**
 - c. **[BASOR Electric]**
 - d. **[Chalfant Manufacturing Company]**
 - e. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - f. **[Hoffman; brand of nVent Electrical plc]**
 - g. **[MonoSystems, Inc]**
 - h. **[MP Husky USA Cable Tray & Cable Bus]**
 - i. **[Niedax Inc.]**
 - j. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Atkore Cope]**
 - c. **[BASOR Electric]**
 - d. **[Chalfant Manufacturing Company]**
 - e. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - f. **[Hoffman; brand of nVent Electrical plc]**
 - g. **[MonoSystems, Inc]**
 - h. **[MP Husky USA Cable Tray & Cable Bus]**
 - i. **[Niedax Inc.]**
 - j. **<Insert manufacturer's name>**

3. Source Limitations: Obtain products from single manufacturer.
4. General Characteristics:
 - a. Configuration: Two longitudinal side rails with transverse rungs swaged or welded to side rails, complying with NEMA VE 1.
 - b. Radius-Fitting Rung Spacing: **9 inch (225 mm)** at center of tray's width.
 - c. Minimum Cable-Bearing Surface for Rungs: **7/8 inch (22 mm)** width with radius edges.
 - d. No portion of the rungs must protrude below the bottom plane of side rails.
 - e. Structural Performance of Each Rung: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a **200 lb. (90 kg)** concentrated load, when tested in accordance with NEMA VE 1.
 - f. Splicing Assemblies: Bolted type using serrated flange locknuts.
 - g. Splice-Plate Capacity: Splices located within support span must not diminish rated loading capacity of cable tray.
5. Materials and Finishes (Steel):
 - a. Straight Section and Fitting Side Rails and Rungs: Steel complies with the minimum mechanical properties of **[ASTM A1011/A1011M, SS, Grade 33][ASTM A1008/A1008M, Grade 33, Type 2]**.
 - b. Steel Tray Splice Plates: ASTM A1011/A1011M, HSLAS, Grade 50, Class 1.
 - c. Fasteners: Steel complies with the minimum mechanical properties of ASTM A510/A510M, Grade 1008.
 - d. Finish:
 - 1) Hot-dip galvanized after fabrication, complying with ASTM A123/A123M, Class B2, with **[galvanized, ASTM B633][chromium-zinc plated, ASTM F1136][stainless steel, Type 316]** hardware.
 - 2) Hot-dip galvanized after fabrication, complying with ASTM A653/A653M, **G90 (Z275)**, with **[galvanized, ASTM B633][chromium-zinc plated, ASTM F1136]** hardware.
 - 3) Electrogalvanized after fabrication, complying with ASTM B633, with galvanized, ASTM B633 hardware.
 - 4) **[Epoxy-resin][Powder-coat enamel]** paint, with **[chromium-zinc plated, ASTM F1136][stainless steel, Type 316, ASTM F593 and ASTM F594]** hardware.
 - a) Powder-Coat Enamel: Cable tray manufacturer's recommended primer and corrosion-inhibiting treatment, with factory-applied powder-coat paint.
 - b) Epoxy-Resin Prime Coat: Cold-curing epoxy primer, MPI# 101.
 - c) Epoxy-Resin Topcoat: Epoxy, cold-cured gloss, MPI# 77.
 - 5) Factory-standard primer, ready for field painting, with chromium-zinc-plated hardware in accordance with ASTM F1136.
 - 6) Black oxide finish for support accessories and miscellaneous hardware in accordance with ASTM D769.
 - 7) **<Insert finish>**.
6. Materials and Finishes (Aluminum):
 - a. Materials: Alloy 6063-T6 in accordance with ANSI H35.1/H 35.1M for extruded components, and **[Alloy 5052-H32][or][Alloy 6061-T6]** in accordance with ANSI H35.1/H 35.1M for fabricated parts.
 - b. Hardware: **[Chromium-zinc-plated steel, ASTM F1136][Stainless steel, Type 316, ASTM F593 and ASTM F594]**.
 - c. Hardware for Aluminum Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM F593 and ASTM F594.

7. Materials and Finishes (Stainless Steel):
 - a. Materials: Low-carbon, passivated stainless steel, **[Type 304L][or][Type 316L]**, ASTM F593 and ASTM F594.
 - b. Hardware for Stainless Steel Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM F593 and ASTM F594.
8. Options:
 - a. Width: **[6 inch (150 mm)][9 inch (225 mm)][12 inch (300 mm)][18 inch (450 mm)][24 inch (600 mm)][30 inch (750 mm)][36 inch (900 mm)]** unless otherwise indicated on Drawings.
 - b. Minimum Usable Load Depth: **[3 inch (75 mm)][4 inch (100 mm)][5 inch (125 mm)][6 inch (150 mm)]**.
 - c. Straight Section Lengths: **[10 ft (3.0 m)][12 ft (3.7 m)][20 ft (6.0 m)][24 ft (7.4 m)]**, except where shorter lengths are required to facilitate tray assembly.
 - d. Rung Spacing: **[6 inch (150 mm)][9 inch (225 mm)][12 inch (300 mm)][18 inch (450 mm)]** on center.
 - e. Fitting Minimum Radius: **[12 inch (300 mm)][24 inch (600 mm)][36 inch (900 mm)][48 inch (1200 mm)]**.
 - f. Class Designation: Comply with NEMA VE 1, **[Class 5AA][Class 5A][Class 8AA][Class 8A][Class 10AA][Class 10A][Class 12AA][Class 12A][Class 20AA][Class 20A]<Insert designation>**.
 - g. Covers: **[Solid][Louvered][Ventilated-hat][2-in-3 pitch]** type made of same materials and with same finishes as cable tray.

D. UL CYNW - Wire-Mesh Cable Tray :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Atkore Cope]**
 - b. **[BASOR Electric]**
 - c. **[Cablofil; Legrand North America, LLC]**
 - d. **[Chalfant Manufacturing Company]**
 - e. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - f. **[Enduro Composites Inc.]**
 - g. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - h. **[MonoSystems, Inc]**
 - i. **[MP Husky USA Cable Tray & Cable Bus]**
 - j. **[Niedax Inc.]**
 - k. **[Snaketray]**
 - l. **[WBT LLC]**
 - m. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Atkore Cope]**
 - b. **[BASOR Electric]**
 - c. **[Cablofil; Legrand North America, LLC]**

- d. [Chalfant Manufacturing Company]
 - e. [Cooper B-line; brand of Eaton, Electrical Sector]
 - f. [Enduro Composites Inc.]
 - g. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - h. [MonoSystems, Inc]
 - i. [MP Husky USA Cable Tray & Cable Bus]
 - j. [Niedax Inc.]
 - k. [Snaketray]
 - l. [WBT LLC]
 - m. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. General Characteristics:
 - a. Configuration: [**Galvanized**]-steel wire mesh, complying with NEMA VE 1.
 - b. Structural Performance: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a **200 lb. (90 kg)** concentrated load, when tested in accordance with NEMA VE 1.
 - c. Splicing Assemblies: Bolted type using serrated flange locknuts.
 - d. Splice-Plate Capacity: Splices located within support span must not diminish rated loading capacity of cable tray.
5. Materials and Finishes (Steel):
 - a. Straight Sections and Fittings: Steel complies with the minimum mechanical properties of [**ASTM A1011/A1011M, SS, Grade 33**][**ASTM A1008/A1008M, Grade 33, Type 2**].
 - b. Steel Tray Splice Plates: ASTM A1011/A1011M, HSLAS, Grade 50, Class 1.
 - c. Fasteners: Steel complies with the minimum mechanical properties of ASTM A510/A510M, Grade 1008.
 - d. Finish:
 - 1) Hot-dip galvanized after fabrication, complying with ASTM A123/A123M, Class B2, with [**galvanized, ASTM B633**][**chromium-zinc plated, ASTM F1136**][**stainless steel, Type 316**] hardware.
 - 2) Hot-dip galvanized after fabrication, complying with ASTM A653/A653M, **G90 (Z275)**, with [**galvanized, ASTM B633**][**chromium-zinc plated, ASTM F1136**] hardware.
 - 3) Electrogalvanized after fabrication, complying with ASTM B633, with galvanized, ASTM B633 hardware.
 - 4) [**Epoxy-resin**][**Powder-coat enamel**] paint, with [**chromium-zinc plated, ASTM F1136**][**stainless steel, Type 316, ASTM F593 and ASTM F594**] hardware.
 - a) Powder-Coat Enamel: Cable tray manufacturer's recommended primer and corrosion-inhibiting treatment, with factory-applied powder-coat paint.
 - b) Epoxy-Resin Prime Coat: Cold-curing epoxy primer, MPI# 101.
 - c) Epoxy-Resin Topcoat: Epoxy, cold-cured gloss, MPI# 77.
 - 5) Factory-standard primer, ready for field painting, with chromium-zinc-plated hardware in accordance with ASTM F1136.
 - 6) Black oxide finish for support accessories and miscellaneous hardware in accordance with ASTM D769.
 - 7) **<Insert finish>**.
6. Options:

- a. Width: [2 inch (50 mm)][4 inch (100 mm)][6 inch (150 mm)][8 inch (200 mm)][12 inch (300 mm)][16 inch (400 mm)][18 inch (450 mm)][20 inch (500 mm)][24 inch (600 mm)] unless otherwise indicated on Drawings.
- b. Minimum Usable Load Depth: [1 inch (25 mm)][2 inch (50 mm)][4 inch (100 mm)][6 inch (150 mm)].
- c. Straight Section Lengths: [10 ft (3.0 m)][12 ft (3.7 m)], except where shorter lengths are required to facilitate tray assembly.
- d. Class Designation: Comply with NEMA VE 1, [Class 5AA][Class 5A][Class 8AA][Class 8A][Class 10AA][Class 10A][Class 12AA][Class 12A][Class 20AA][Class 20A]<Insert designation>.

E. UL CYNW - Single-Rail Cable Tray :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Atkore Cope]
 - b. [Cable Management Solutions, Inc.]
 - c. [Cooper B-line; brand of Eaton, Electrical Sector]
 - d. [MonoSystems, Inc]
 - e. [MP Husky USA Cable Tray & Cable Bus]
 - f. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Atkore Cope]
 - b. [Cable Management Solutions, Inc.]
 - c. [Cooper B-line; brand of Eaton, Electrical Sector]
 - d. [MonoSystems, Inc]
 - e. [MP Husky USA Cable Tray & Cable Bus]
 - f. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. General Characteristics:
 - a. Configuration: An extruded-aluminum assembly, consisting of a single longitudinal center rail with transverse rungs arranged symmetrically about the center rail complying with NEMA VE 1.
 - b. Construction: Aluminum rungs mechanically connected to aluminum center rail in at least two places, with ends finished to protect installers and cables.
 - c. Radius-Fitting Rung Spacing: 9 inch (225 mm) at center of tray's width.
 - d. Support Point: Splice fittings must be hanger support point.
 - e. Support Spacing: Support each section at midpoint. Support wall-mounted sections a maximum of one-sixth of the section length from each end.
 - f. Unbalanced Loads: Maintain cable tray rungs within six degrees of horizontal under all loading conditions.
 - g. Splicing Assemblies: Bolted type using serrated flange locknuts.
 - h. Splicing Assembly Capacity: Splices located within support span must not diminish rated loading capacity of cable tray.
 - i. Splices and Connectors: Protect cables from edges of center rail and do not intrude into cable fill area.

5. Materials: Aluminum alloy 6063-T6 in accordance with ANSI H35.1/H 35.1M for extruded components, and **[Alloy 5052-H32][or][Alloy 6061-T6]** in accordance with ANSI H35.1/H 35.1M for fabricated parts.
6. Hardware: **[Chromium-zinc-plated steel, ASTM F1136][Stainless steel, Type 316, ASTM F593 and ASTM F594]**.
 - a. Hardware for Aluminum Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM F593 and ASTM F594.
7. Options:
 - a. Width: **[6 inch (150 mm)][9 inch (225 mm)][12 inch (300 mm)][18 inch (450 mm)][24 inch (600 mm)]** unless otherwise indicated on Drawings.
 - b. Minimum Usable Load Depth: **[3 inch (75 mm)][4 inch (100 mm)][5 inch (125 mm)][6 inch (150 mm)]**.
 - c. Straight Section Lengths: **[10 ft (3.0 m)][12 ft (3.7 m)]**, except where shorter lengths are required to facilitate tray assembly.
 - d. Rung Spacing: **[6 inch (150 mm)][9 inch (225 mm)][12 inch (300 mm)]** on center.
 - e. Class Designation: Comply with NEMA VE 1, **[Class 5AA][Class 5A][Class 8AA][Class 8A][Class 10AA][Class 10A][Class 12AA][Class 12A][Class 20AA][Class 20A]**<Insert designation>.
 - f. Covers: **[Solid][Louvered][Ventilated-hat][2-in-3 pitch]** type made of same materials and with same finishes as cable tray.

F. UL CYNW - Solid-Bottom Cable Tray :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[Atkore Cope]**
 - c. **[BASOR Electric]**
 - d. **[Chalfant Manufacturing Company]**
 - e. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - f. **[MonoSystems, Inc]**
 - g. **[MP Husky USA Cable Tray & Cable Bus]**
 - h. **[Niedax Inc.]**
 - i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Atkore Cope]**
 - c. **[BASOR Electric]**
 - d. **[Chalfant Manufacturing Company]**
 - e. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - f. **[MonoSystems, Inc]**
 - g. **[MP Husky USA Cable Tray & Cable Bus]**
 - h. **[Niedax Inc.]**
 - i. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.

4. General Characteristics:

- a. Configuration: Two longitudinal side rails with a nonventilated continuous bottom.
- b. No portion of the continuous bottom must protrude below the bottom plane of side rails.
- c. Structural Performance: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a **200 lb. (90 kg)** concentrated load, when tested in accordance with NEMA VE 1.
- d. Splicing Assemblies: Bolted type using serrated flange locknuts.
- e. Splice-Plate Capacity: Splices located within support span must not diminish rated loading capacity of cable tray.

5. Materials and Finishes (Steel):

- a. Straight Sections and Fittings: Steel complies with the minimum mechanical properties of **[ASTM A1011/A1011M, SS, Grade 33][ASTM A1008/A1008M, Grade 33, Type 2]**.
- b. Steel Tray Splice Plates: ASTM A1011/A1011M, HSLAS, Grade 50, Class 1.
- c. Fasteners: Steel complies with the minimum mechanical properties of ASTM A510/A510M, Grade 1008.
- d. Finish:
 - 1) Mill galvanized before fabrication complying with ASTM A653/A653M, **G90 (Z275)**, with **[galvanized, ASTM B633][chromium-zinc plated, ASTM F1136]** hardware.
 - 2) Electrogalvanized before fabrication, complying with ASTM B633, with galvanized, ASTM B633 hardware.
 - 3) Hot-dip galvanized after fabrication complying with ASTM A123/A123M, Class B2, with **[chromium-zinc plated, ASTM F1136][stainless steel, Type 316]** hardware.
 - 4) **[Epoxy-resin][Powder-coat enamel]** paint, with **[chromium-zinc plated, ASTM F1136][stainless steel, Type 316, ASTM F593 and ASTM F594]** hardware.
 - a) Powder-Coat Enamel: Cable tray manufacturer's recommended primer and corrosion-inhibiting treatment, with factory-applied powder-coat paint.
 - b) Epoxy-Resin Prime Coat: Cold-curing epoxy primer, MPI# 101.
 - c) Epoxy-Resin Topcoat: Cold-cured epoxy gloss, MPI# 77.
 - 5) Factory-standard primer, ready for field painting, with chromium-zinc-plated hardware in accordance with ASTM F1136.
 - 6) Black oxide finish for support accessories and miscellaneous hardware in accordance with ASTM D769.
 - 7) **<Insert finish>**.

6. Materials and Finishes (Aluminum):

- a. Materials: Alloy 6063-T6 in accordance with ANSI H35.1/H 35.1M for extruded components, and **[Alloy 5052-H32][or][Alloy 6061-T6]** in accordance with ANSI H35.1/H 35.1M for fabricated parts.
- b. Hardware: **[Chromium-zinc-plated steel, ASTM F1136][Stainless steel, Type 316, ASTM F593 and ASTM F594]**.
- c. Hardware for Aluminum Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM F593 and ASTM F594.

7. Materials and Finishes (Stainless Steel):

- a. Materials: Low-carbon, passivated stainless steel, **[Type 304L][or][Type 316L]**, ASTM F593 and ASTM F594.
- b. Hardware for Stainless Steel Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM

F593 and ASTM F594.

8. Options:
 - a. Width: [6 inch (150 mm)][9 inch (225 mm)][12 inch (300 mm)][18 inch (450 mm)][24 inch (600 mm)][30 inch (750 mm)][36 inch (900 mm)] unless otherwise indicated on Drawings.
 - b. Minimum Usable Load Depth: [3 inch (75 mm)][4 inch (100 mm)][5 inch (125 mm)][6 inch (150 mm)].
 - c. Straight Section Lengths: [10 ft (3.0 m)][12 ft (3.7 m)][20 ft (6.0 m)][24 ft (7.4 m)], except where shorter lengths are required to facilitate tray assembly.
 - d. Fitting Minimum Radius: [12 inch (300 mm)][24 inch (600 mm)][36 inch (900 mm)][48 inch (1200 mm)].
 - e. Class Designation: Comply with NEMA VE 1, [Class 5AA][Class 5A][Class 8AA][Class 8A][Class 10AA][Class 10A][Class 12AA][Class 12A][Class 20AA][Class 20A]<Insert designation>.
 - f. Covers: [Solid][Louvered][Ventilated-hat][2-in-3 pitch] type made of same materials and with same finishes as cable tray.

G. UL CYNW - Trough Cable Tray :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [ABB, Electrification Business]
 - b. [Cablofil; Legrand North America, LLC]
 - c. [Chalfant Manufacturing Company]
 - d. [Cooper B-line; brand of Eaton, Electrical Sector]
 - e. [MonoSystems, Inc]
 - f. [MP Husky USA Cable Tray & Cable Bus]
 - g. [Niedax Inc.]
 - h. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [ABB, Electrification Business]
 - b. [Cablofil; Legrand North America, LLC]
 - c. [Chalfant Manufacturing Company]
 - d. [Cooper B-line; brand of Eaton, Electrical Sector]
 - e. [MonoSystems, Inc]
 - f. [MP Husky USA Cable Tray & Cable Bus]
 - g. [Niedax Inc.]
 - h. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. General Characteristics:
 - a. Splicing Assemblies: Bolted type using serrated flange locknuts.
 - b. Splicing Assembly Capacity: Splices located within support span must not diminish rated loading capacity of cable tray.
5. Materials and Finishes (Steel):

- a. Straight Section and Fitting Side Rails and Rungs: Steel complies with the minimum mechanical properties of **[ASTM A1011/A1011M, SS, Grade 33][ASTM A1008/A1008M, Grade 33, Type 2]**.
 - b. Steel Tray Splice Plates: ASTM A1011/A1011M, HSLAS, Grade 50, Class 1.
 - c. Fasteners: Steel complies with the minimum mechanical properties of ASTM A510/A510M, Grade 1008.
 - d. Finish:
 - 1) Hot-dip galvanized after fabrication complying with ASTM A123/A123M, Class B2, with **[galvanized, ASTM B633][chromium-zinc plated, ASTM F1136][stainless steel, Type 316]** hardware.
 - 2) Hot-dip mill galvanized before fabrication complying with ASTM A653/A653M, **G90 (Z275)**, with **[galvanized, ASTM B633][chromium-zinc plated, ASTM F1136]** hardware.
 - 3) Electrogalvanized after fabrication, complying with ASTM B633, with galvanized, ASTM B633 hardware.
 - 4) **[Epoxy-resin][Powder-coat enamel]** paint, with **[chromium-zinc plated, ASTM F1136][stainless steel, Type 316, ASTM F593 and ASTM F594]** hardware.
 - a) Powder-Coat Enamel: Cable tray manufacturer's recommended primer and corrosion-inhibiting treatment, with factory-applied powder-coat paint.
 - b) Epoxy-Resin Prime Coat: Cold-curing epoxy primer, MPI# 101.
 - c) Epoxy-Resin Topcoat: Epoxy, cold-cured gloss, MPI# 77.
 - 5) Factory-standard primer, ready for field painting, with chromium-zinc-plated hardware in accordance with ASTM F1136.
 - 6) Black oxide finish for support accessories and miscellaneous hardware in accordance with ASTM D769.
 - 7) **<Insert finish>**.
6. Materials and Finishes (Aluminum):
- a. Materials: Alloy 6063-T6 in accordance with ANSI H35.1/H 35.1M for extruded components, and **[Alloy 5052-H32][or][Alloy 6061-T6]** in accordance with ANSI H35.1/H 35.1M for fabricated parts.
 - b. Hardware: **[Chromium-zinc-plated steel, ASTM F1136][Stainless steel, Type 316, ASTM F593 and ASTM F594]**.
 - c. Hardware for Aluminum Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM F593 and ASTM F594.
7. Materials and Finishes (Stainless Steel):
- a. Materials: Low-carbon, passivated stainless steel, **[Type 304L][or][Type 316L]**, ASTM F593 and ASTM F594.
 - b. Hardware for Stainless Steel Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM F593 and ASTM F594.
8. Options:
- a. Configuration:
 - 1) A **[flat][corrugated]** bearing surface with a **[solid][ventilated]** bottom contained within two longitudinal side rails, with both edges welded to the side rails complying with NEMA VE 1.
 - 2) Single, formed sheet with a **[solid][ventilated]** bottom, complying with NEMA VE 1.

- b. Width: [6 inch (150 mm)][9 inch (225 mm)][12 inch (300 mm)][18 inch (450 mm)][24 inch (600 mm)][30 inch (750 mm)][36 inch (900 mm)] unless otherwise indicated on Drawings.
- c. Minimum Usable Load Depth: [3 inch (75 mm)][4 inch (100 mm)][5 inch (125 mm)][6 inch (150 mm)].
- d. Straight Section Lengths: [10 ft (3.0 m)][12 ft (3.6 m)][20 ft (6.0 m)][24 ft (7.4 m)], except where shorter lengths are required to facilitate tray assembly.
- e. Fitting Minimum Radius: [12 inch (300 mm)][24 inch (600 mm)][36 inch (900 mm)][48 inch (1200 mm)].
- f. Class Designation: Comply with NEMA VE 1, [Class 5AA][Class 5A][Class 8AA][Class 8A][Class 10AA][Class 10A][Class 12AA][Class 12A][Class 20AA][Class 20A]<Insert designation>.
- g. Covers: [Solid][Louvered][Ventilated-hat][2-in-3 pitch] type made of same materials and with same finishes as cable tray.

H. UL CYNW - Channel Cable Tray :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [ABB, Electrification Business]
 - b. [Atkore Cope]
 - c. [Cooper B-line; brand of Eaton, Electrical Sector]
 - d. [MP Husky USA Cable Tray & Cable Bus]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [ABB, Electrification Business]
 - b. [Atkore Cope]
 - c. [Cooper B-line; brand of Eaton, Electrical Sector]
 - d. [MP Husky USA Cable Tray & Cable Bus]
 - e. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. General Characteristics:
 - a. Structural Performance: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a **200 lb (90 kg)** concentrated load, when tested in accordance with NEMA VE 1.
 - b. Splicing Assemblies: Bolted type using serrated flange locknuts.
 - c. Splicing Assembly Capacity: Splices located within support span must not diminish rated loading capacity of cable tray.
5. Materials and Finishes (Steel):
 - a. Straight Section and Fitting Side Rails and Rungs: Steel complies with the minimum mechanical properties of [ASTM A1011/A1011M, SS, Grade 33][ASTM A1008/A1008M, Grade 33, Type 2].
 - b. Steel Tray Splice Plates: ASTM A1011/A1011M, HSLAS, Grade 50, Class 1.
 - c. Fasteners: Steel complies with the minimum mechanical properties of ASTM A510/A510M, Grade 1008.

- d. Finish:
- 1) Hot-dip galvanized after fabrication complying with ASTM A123/A123M, Class B2, with **[galvanized, ASTM B633][chromium-zinc plated, ASTM F1136][Stainless steel, Type 316]** hardware.
 - 2) Hot-dip mill galvanized before fabrication complying with ASTM A653/A653M, **G90 (Z275)**, with **[galvanized, ASTM B633][chromium-zinc plated, ASTM F1136]** hardware.
 - 3) Electrogalvanized after fabrication, complying with ASTM B633, with galvanized, ASTM B633 hardware.
 - 4) **[Epoxy-resin][Powder-coat enamel]** paint, with **[chromium-zinc plated, ASTM F1136][stainless steel, Type 316, ASTM F593 and ASTM F594]** hardware.
 - a) Powder-Coat Enamel: Cable tray manufacturer's recommended primer and corrosion-inhibiting treatment, with factory-applied powder-coat paint.
 - b) Epoxy-Resin Prime Coat: Cold-curing epoxy primer, MPI# 101.
 - c) Epoxy-Resin Topcoat: Epoxy, cold-cured gloss, MPI# 77.
 - 5) Factory-standard primer, ready for field painting, with chromium-zinc-plated hardware in accordance with ASTM F1136.
 - 6) Black oxide finish for support accessories and miscellaneous hardware in accordance with ASTM D769.
 - 7) **<Insert finish>**.
6. Materials and Finishes (Aluminum):
- a. Materials: Alloy 6063-T6 in accordance with ANSI H35.1/H 35.1M for extruded components, and **[Alloy 5052-H32][or][Alloy 6061-T6]** in accordance with ANSI H35.1/H 35.1M for fabricated parts.
 - b. Hardware: **[Chromium-zinc-plated steel, ASTM F1136][Stainless steel, Type 316, ASTM F593 and ASTM F594]**.
 - c. Hardware for Aluminum Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM F593 and ASTM F594.
7. Materials and Finishes (Stainless Steel):
- a. Materials: Low-carbon, passivated stainless steel, **[Type 304L][or][Type 316L]**, ASTM F593 and ASTM F594.
 - b. Hardware for Stainless Steel Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM F593 and ASTM F594.
8. Options:
- a. Configuration: Single, formed sheet with a **[solid][ventilated]** bearing surface, complying with NEMA VE 1.
 - b. Width: **[3 inch (75 mm)][4 inch (100 mm)][6 inch (150 mm)]** unless otherwise indicated on Drawings.
 - c. Minimum Usable Load Depth: **[1-1/4 inch (30 mm)][2 inch (50 mm)]**.
 - d. Straight Section Lengths: **[10 ft (3.0 m)][12 ft (3.7 m)]**, except where shorter lengths are required to facilitate tray assembly.
 - e. Fitting Minimum Radius: **[12 inch (300 mm)][24 inch (600 mm)][36 inch (900 mm)][48 inch (1200 mm)]**.
 - f. Class Designation: Comply with NEMA VE 1, **[Class 5AA][Class 5A][Class 8AA][Class 8A][Class 10AA][Class 10A][Class 12AA][Class 12A][Class 20AA][Class 20A]<Insert designation>**.

- g. Covers: **[Solid][Louvered][Ventilated-hat][2-in-3 pitch]** type made of same materials and with same finishes as cable tray.

2.2 NONMETALLIC CABLE TRAYS

- A. Description: This product category covers nonmetallic, including fiberglass (fiberglass-reinforced plastic), cable trays and cable tray systems intended for field assembly and for use in accordance with Article 392 of NFPA 70.
- B. Performance Criteria:
1. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 2. Listing Criteria: UL CCN CYOV; including UL 568.
- C. UL CYOV - Fiberglass Cable Tray :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[Allied Tube & Conduit; Atkore International]**
 - c. **[Atkore Cope]**
 - d. **[Cablofil; Legrand North America, LLC]**
 - e. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - f. **[Enduro Composites Inc.]**
 - g. **[MonoSystems, Inc]**
 - h. **[MP Husky USA Cable Tray & Cable Bus]**
 - i. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Allied Tube & Conduit; Atkore International]**
 - c. **[Atkore Cope]**
 - d. **[Cablofil; Legrand North America, LLC]**
 - e. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - f. **[Enduro Composites Inc.]**
 - g. **[MonoSystems, Inc]**
 - h. **[MP Husky USA Cable Tray & Cable Bus]**
 - i. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain products from single manufacturer.
 4. General Characteristics:
 - a. Configuration: Two longitudinal members with rounded edges and smooth surfaces, supporting a bearing surface, complying with NEMA FG 1.

- b. Temperature Rating: Reduce the load rating of trays exposed to temperatures above **75 deg F (24 deg C)** in accordance with Table 4-3, "Working Loads," in NEMA FG 1.
- c. Splicing Assemblies: Minimum four nuts and bolts per plate. Splice plates must be furnished with straight sections and fittings.
- d. Splicing Assembly Capacity: Splices located within support span must not diminish rated loading capacity of cable tray.
- e. Fasteners: Fiberglass-encapsulated, ASTM F593 and ASTM F594 stainless steel, Type 316. Design fasteners so that no metal is visible when fully assembled and tightened. Fastener encapsulation must not be damaged when torqued to manufacturer's recommended value.

5. Options:

- a. Materials: Straight section structural elements; side rails, rungs, and splice plates must be pultruded from glass-fiber-reinforced **[polyester][vinyl ester]** resin, complying with NEMA FG 1 and UL 568.
- b. Width: **[6 inch (150 mm)][9 inch (225 mm)][12 inch (300 mm)][18 inch (450 mm)][24 inch (600 mm)][30 inch (750 mm)][36 inch (900 mm)]** unless otherwise indicated on Drawings.
- c. Minimum Usable Load Depth: **[1 inch (25 mm)][2 inch (50 mm)][3 inch (75 mm)][5 inch (125 mm)][7 inch (175 mm)]** in accordance with NEMA FG 1.
- d. Straight Section Lengths: **[10 ft (3.0 m)][20 ft (6.0 m)]**.
- e. Class Designation: Comply with NEMA VE 1, **[Class 5AA][Class 5A][Class 8AA][Class 8A][Class 10AA][Class 10A][Class 12AA][Class 12A][Class 20AA][Class 20A]<Insert designation>**.
- f. Fitting Minimum Radius: **[12 inch (300 mm)][24 inch (600 mm)]**.
- g. Covers: **[Solid][Louvered][Ventilated-hat][2-in-3 pitch]** type made of same materials and with same finishes as cable tray.

D. UL CYOV - Fiberglass Channel Cable Tray :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[Atkore Cope]**
 - c. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - d. **[Enduro Composites Inc.]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Atkore Cope]**
 - c. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - d. **[Enduro Composites Inc.]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. General Characteristics:

- a. Temperature Rating: Reduce the load rating of trays exposed to temperatures above **75 deg F (24 deg C)** in accordance with Table 4-3, "Working Loads," in NEMA FG 1.
 - b. Splicing Assemblies: Minimum four nuts and bolts per plate. Splice plates must be furnished with straight sections and fittings.
 - c. Splicing Assembly Capacity: Splices located within support span must not diminish rated loading capacity of cable tray.
 - d. Fasteners: Fiberglass-encapsulated, ASTM F593 and ASTM F594 stainless steel, Type 316. Design fasteners so that no metal is visible when fully assembled and tightened. Fastener encapsulation must not be damaged when torqued to manufacturer's recommended value.
5. Options:
- a. Configuration: Two longitudinal members with rounded edges and smooth surfaces, supporting a **[solid][ventilated]** bearing surface, complying with NEMA FG 1.
 - b. Materials: Straight section structural elements; side rails, rungs, and splice plates must be pultruded from glass-fiber-reinforced **[polyester][vinyl ester]** resin, complying with NEMA FG 1 and UL 568.
 - c. Width: **[3 inch (75 mm)][4 inch (100 mm)][6 inch (150 mm)]** unless otherwise indicated on Drawings.
 - d. Minimum Usable Load Depth: **[1-1/4 inch (30 mm)][2 inch (50 mm)]**.
 - e. Straight Section Lengths: **[10 ft (3.0 m)][12 ft (3.7 m)]**, except where shorter lengths are required to facilitate tray assembly.
 - f. Class Designation: Comply with NEMA VE 1, **[Class 5AA][Class 5A][Class 8AA][Class 8A][Class 10AA][Class 10A][Class 12AA][Class 12A][Class 20AA][Class 20A]<Insert designation>**.
 - g. Fitting Minimum Radius: **[12 inch (300 mm)][24 inch (600 mm)]**.
 - h. Covers: **[Solid][Louvered][Ventilated-hat][2-in-3 pitch]** type made of same materials and with same finishes as cable tray.

2.3 CABLE TRAY ACCESSORIES

- A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.
- B. Barrier Strips: Same materials and finishes as for cable tray.
- C. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

2.4 SOURCE QUALITY CONTROL

- A. Product Data: Prepare and submit catalog cuts, brochures, **[diagrams,][schedules,]** and performance data illustrating size, physical appearance, and other characteristics of product.
 - 1. Include data indicating dimensions and finishes for each type of cable tray indicated.
- B. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.
- C. Factory Tests:
 - 1. Owner will witness required factory tests. Notify Architect at least 14 days before date of tests and indicate their approximate duration.

2. Testing Administrator: **[Owner will engage][Engage]** qualified electrical testing agency to evaluate cable trays.
3. Factory Tests and Inspections: Perform the following tests and inspections on cable trays, by, or under supervision of, qualified electrical testing laboratory recognized by authorities having jurisdiction before delivering to site. Affix label with name and date of **[manufacturer's][qualified electrical testing laboratory's]** certification of system compliance.
 - a. Test and inspect cable trays in accordance with **[NEMA FG 1][NEMA VE 1]**.
4. Nonconforming Work:
 - a. Equipment that does not pass tests and inspections will be considered defective.
5. Factory Test Reports: Prepare and submit factory test and inspection reports.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Shop Drawings: Prepare and submit the following for each cable tray system:
 1. Cable Tray Fabrication Drawings, Diagrams, and Supporting Documents:
 - a. Show fabrication and installation details of cable trays, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.
 - b. Include load calculations to show that dead and live loads do not exceed manufacturer's rating for tray and its support elements.
 - c. Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:
 - 1) Vertical and horizontal offsets and transitions.
 - 2) Clearances for access above and to sides of cable trays.
 - 3) Vertical elevation of cable trays above the floor or bottom of ceiling structure.

3.2 INSTALLATION OF CABLE TRAYS

- A. Install cable tray and support systems in accordance with **[NEMA FG 1][NEMA VE 2]**.
- B. Install cable tray as a complete system, including fasteners, hold-down clips, support systems, barrier strips, adjustable horizontal and vertical splice plates, elbows, reducers, tees, crosses, cable dropouts, adapters, covers, and bonding.
- C. Install cable tray, so that the tray is accessible for cable installation and all splices are accessible for inspection and adjustment.
- D. Remove burrs and sharp edges from cable trays.
- E. Join aluminum cable tray with splice plates; use four square-neck carriage bolts and locknuts.

- F. Fasten cable tray supports to building structure[**and install seismic restraints**].
- G. Design fasteners and supports to carry cable tray, cables, and a concentrated load of **200 lb (90 kg)**. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems." [**Comply with seismic-restraint details in accordance with Section 260548.16 "Seismic Controls for Electrical Systems."**]
- H. Place supports, so that spans do not exceed maximum spans on schedules, and provide clearances shown on Drawings. Install intermediate supports when cable weight exceeds the load-carrying capacity of tray rungs.
- I. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.
- J. Support assembly to prevent twisting from eccentric loading.
- K. Install center-hung supports for single-rail trays designed for 60 versus 40 percent eccentric loading condition, with a safety factor of 3.
- L. Do not install more than one cable tray splice between supports.
- M. Support wire-basket cable trays with [center support hangers][trapeze hangers][wall brackets].
- N. Support [center support hangers][trapeze hangers] for wire-basket trays with [1/4 inch (6 mm)][3/8 inch (10 mm)] diameter rods.
- O. Make connections to equipment with flanged fittings fastened to cable trays and to equipment. Support cable trays independent of fittings. Do not carry weight of cable trays on equipment enclosure.
- P. Install expansion connectors where cable trays cross building expansion joints and in cable tray runs that exceed recommended dimensions. Space connectors and set gaps in accordance with applicable standard.
- Q. Make changes in direction and elevation using manufacturer's recommended fittings.
- R. Make cable tray connections using manufacturer's recommended fittings.
- S. Seal penetrations through fire and smoke barriers.
- T. Install capped metal sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.
- U. Install cable trays with enough workspace to permit access for installing cables.
- V. Install barriers to separate cables of different systems, such as power, communications, and data processing, or of different insulation levels, such as 600, 5000, and 15 000 V.
- W. Install permanent covers[**and cover clamps**], if used, after installing cable.
- X. Clamp covers on cable trays installed outdoors with heavy-duty clamps.
- Y. Install warning signs in visible locations on or near cable trays after cable tray installation.

3.3 CABLE TRAY GROUNDING

- A. Ground cable trays in accordance with NFPA 70 unless additional grounding is specified.
- B. Cable trays with electrical power conductors must be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.
- C. Cable trays with single-conductor power conductors must be bonded together with a grounding conductor run in the tray along with the power conductors and bonded to the tray at **72 inch (1800 mm)** intervals. The grounding conductor must be sized in accordance with Article 250 and Article 392 of NFPA 70.
- D. When using epoxy- or powder-coat painted cable trays as a grounding conductor, completely remove coating at all splice contact points or ground connector attachment. After completing splice-to-grounding-bolt attachment, repair the coated surfaces with coating materials recommended by cable tray manufacturer.
- E. Bond cable trays to power source for cables contained within with bonding conductors sized in accordance with Article 250 of NFPA 70.

3.4 INSTALLATION OF CABLES

- A. Install cables only when each cable tray run has been completed and inspected.
- B. Fasten cables on horizontal runs with cable clamps or cable ties. Tighten clamps only enough to secure the cable, without indenting the cable jacket. Install cable ties with a tool that includes an automatic pressure-limiting device.
- C. Fasten cables on vertical runs to cable trays every **18 inch (450 mm)**.
- D. Fasten and support cables that pass from one cable tray to another or drop from cable trays to equipment enclosures. Fasten cables to the cable tray at the point of exit and support cables independent of the enclosure. The cable length between cable trays or between cable tray and enclosure must be no more than **72 inch (1800 mm)**.
- E. Tie mineral-insulated cables down every **36 inch (900 mm)** where required to provide a two-hour fire rating and every **72 inch (1800 mm)** elsewhere.
- F. In existing construction, remove inactive or dead cables from cable trays.

3.5 FABRICATION OF CONNECTION POINTS

- A. Remove paint from all connection points before making connections. Repair paint after the connections are completed.
- B. Connect raceways to cable trays in accordance with requirements in NEMA VE 2 and NEMA FG 1.

3.6 INSTALLATION OF CABLE TRAY MARKINGS AND SIGNS

- A. Trays Containing Cables Operating Over 600 V: Provide hazard markings in accordance with Section 392.18 of NFPA 70 and with NEMA Z535.4.

1. Legend: "DANGER - HIGH VOLTAGE - KEEP AWAY."

- B. Ladder Cable Trays: Provide warning signs to prevent use as personnel ladder.

1. Lettering: [1-1/2 inch (40 mm)]<Insert dimension> high.
2. Legend: "WARNING! NOT TO BE USED AS WALKWAY, LADDER, OR SUPPORT FOR LADDERS OR PERSONNEL."

3.7 FIELD QUALITY CONTROL

- A. Acceptance Testing Preparation:

1. <Insert requirements>.

- B. Field tests and inspections must be witnessed by [Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>.

- C. Tests and Inspections:

1. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements.
2. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable trays, vibrations, and thermal expansion and contraction conditions, which may cause or have caused damage.
3. Verify that the number, size, and voltage of cables in cable trays do not exceed that permitted by NFPA 70. Verify that communications or data-processing circuits are separated from power circuits by barriers or are installed in separate cable trays.
4. Verify that there are no intruding items, such as pipes, hangers, or other equipment, in the cable tray.
5. Remove dust deposits, industrial process materials, trash of any description, and any blockage of tray ventilation.
6. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorque in suspect areas.
7. Check for improperly sized or installed bonding jumpers.
8. Check for missing, incorrect, or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
9. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable trays. Test entire cable tray system for continuity. Maximum allowable resistance is 1 Ω .

- D. Nonconforming Work:

1. Cable tray will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

- E. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

- F. Manufacturer Services: Engage factory-authorized service representative to [support][supervise] field tests and inspections.

1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at Project site.

3.8 PROTECTION

A. Protect installed cable trays and cables.

1. Install temporary protection for cables in open trays to safeguard exposed cables against falling objects or debris during construction. Temporary protection for cables and cable tray can be constructed of wood or metal materials and must remain in place until the risk of damage is over.
2. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.
3. Repair damage to paint finishes with matching touchup coating recommended by cable tray manufacturer.

END OF SECTION 26 05 36 00



Task	Specification	Specification Description
26 05 36 00	26 05 00 00	Sleeves and Sleeve Seals for Electrical Raceways and Cabling



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SECTION 26 05 39 00 - UNDERFLOOR RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Flat-top, steel underfloor raceways.
2. Flush, flat-top underfloor raceways.
3. Cellular metal underfloor raceways.
4. Trench-type underfloor raceways.
5. Electrical connection components for precast cellular concrete floor decks.
6. Electrical connection components for electrified cellular steel floor decks.
7. Supports, raceway fittings, and hardware.
8. Junction boxes.
9. Service fittings/activations.

B. Related Requirements:

1. Section 034100 "Precast Structural Concrete" for precast concrete units used as cellular concrete floor raceways.
2. Section 053100 "Steel Decking" for rough-in of underfloor duct distribution system.
3. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
4. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.2 DEFINITIONS

- A. Activation: Nomenclature used by some manufacturers for a service fitting.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include finishes, construction details, material descriptions, dimensions, and profiles for underfloor raceway components, fittings, and accessories.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For underfloor raceways.

1. Include floor plans, elevations, sections, and details.
2. Detail fabrication and assembly of underfloor raceways.
 - a. Identify components and accessories, such as expansion-joint assemblies, straight raceway lengths, preset and afterset inserts, and service fittings.
 - b. Detail preparation and installation methods and instructions.

- c. Provide dimensions locating raceway header and distribution elements. Include spacing between preset inserts and between preset inserts and ends of duct runs, walls, columns, junction boxes, and header duct connections.
- d. Provide raceway fill charts for each duct size provided for each conductor size the duct is identified to accept. Provide separate charts for power and communication conductors and cables.
- e. Show connections between raceway elements and relationships between components and adjacent structural and architectural elements, including slab reinforcement, floor finish work, permanent partitions, expansion joints[, **architectural module lines**][, and **pretensioning or post-tensioning components**].
- f. Indicate height of preset inserts, junction boxes, and raceways coordinated with depth of concrete slab and floor fill.
- g. Indicate thickening of slabs where required for adequate encasement of raceway components.
- h. Document coordination of exposed components with floor-covering materials to ensure that fittings and trim are suitable for indicated floor-covering material.
- i. Revise locations from those indicated in the Contract Documents, as required to suit field conditions and to ensure a functioning layout. Identify proposed deviations from the Contract Documents.
- j. Show details of connections and terminations of underfloor raceways at panelboards and communication terminal equipment in equipment rooms, wire closets, and similar spaces.
- k. Identify those cells of cellular floor deck that are to be connected and fitted for the following underfloor distribution:
 - 1) Power.
 - 2) Voice.
 - 3) Data.
 - 4) Signal.
 - 5) Communications.
 - 6) **<Insert system>**.

C. Samples: For each underfloor raceway product, in specified finish, including the following:

- 1. Service fittings and flush and recessed outlet and junction-box covers.
- 2. A section of each service raceway configuration, with specified preset insert and service fitting installed.
- 3. A junction box of each size and type for use with underfloor raceway.
- 4. A section of each header raceway configuration, complete with provisions for connection with service raceway.
- 5. A section of trench-type raceway, complete with cover and required trim.
- 6. A junction box of each size and type for use with trench-type raceway, complete with cover and trim.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For underfloor raceways, to include in emergency, operation, and maintenance manuals.
 - 1. In addition to items specified in Section 260010 "Supplemental Requirements for Electrical,"

include the following:

- a. Manufacturer's written instructions for locating preset inserts and for installing afterset inserts.
- B. Project Record Documents: Submit final as-built Drawings, indicating dimensioned locations for all ducts, junction boxes, and preset inserts. Typical spacing designation must be accepted only for preset insert spacing along a continuous length of duct.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Afterset Inserts:
 - a. Furnish quantity equal to [10]<Insert number> percent of service fittings installed, but no fewer than <Insert number> units.
 - b. Furnish quantity equal to [5]<Insert number> percent of each type of preset insert installed, but no fewer than <Insert number> units.
 2. Service Fittings: Furnish [three]<Insert number> of each type of service fitting indicated for each 100 ft. (30 m) of distribution raceway or active-floor-cell length.
 3. Outlet Blanking Covers: Furnish quantity equal to [10]<Insert number> percent of each type of floor opening installed for outlets, but no fewer than <Insert number> units.
- B. Furnish [one]<Insert number> electronic instrument(s) and other tools, as recommended by underfloor raceway manufacturer for detecting, locating, and uncovering preset inserts in metal raceway under floor covering and up to 3/8 inch (10 mm) of concrete fill.
- C. Furnish [one]<Insert number> set(s) of tools needed for installing afterset inserts in underfloor service raceway, including the following:
 1. Electric Drill: Variable speed, 1/2 inch (13 mm) capacity.
 2. Hole Saw: Diamond bit, for dry concrete, [2 inch (50 mm)]<Insert dimension> size.
 3. Insert installation tool.
 4. <Insert name of tool>.

1.7 QUALITY ASSURANCE

- A. Comply with UL 884.
- B. Comply with NFPA 70.
- C. Mockup: Install a mockup for evaluation of surface preparation and duct installation techniques and workmanship.
 1. Mockup area must be designated by Architect.
 2. Do not proceed with remaining work until workmanship, appearance, and performance are approved.
 3. Repair or reinstall mockup area as required to produce acceptable work.
 4. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.

5. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

PART 2 - PRODUCTS**2.1 SYSTEM DESCRIPTION**

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Jacks, Receptacles, and Fittings:
 1. Comply with Section 262726 "Wiring Devices" for power outlets, faceplates, and connectors.
 2. Comply with Section 271513 "Communications Copper Horizontal Cabling" for twisted pair jacks, outlets, assemblies, and faceplates.
 3. Comply with Section 271523 "Communications Optical Fiber Horizontal Cabling" for optical fiber jacks, outlets, assemblies, and faceplates.
 4. Comply with Section 271533 "Communications Coaxial Horizontal Cabling" for coaxial jacks, outlets, assemblies, and faceplates.

2.2 FLAT-TOP, STEEL UNDERFLOOR RACEWAYS

- A. Description: Steel, rectangular, flat-top, single-channel raceways with premanufactured inserts.
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 1. **[MonoSystems, Inc]**
 2. **[Square D; Schneider Electric USA]**
 3. **[Walker Systems, Inc.]**
 4. **<Insert manufacturer's name>**
- C. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 1. **[MonoSystems, Inc]**
 2. **[Square D; Schneider Electric USA]**
 3. **[Walker Systems, Inc.]**
 4. **<Insert manufacturer's name>**
- D. Source Limitations: Obtain underfloor raceway components for each system through single source from single manufacturer.
- E. Material: One-piece, continuous weld, minimum **0.0598 inch (1.5 mm)** thick steel, with **[corrosion-resistant][galvanized]** coating inside and out after welding.
- F. Cross-Section Shape: Rectangular, with rounded corners.
- G. Number of Longitudinal Channels: **[Two][Three][Four]**, separated by steel wall(s).

- H. Number of Levels: **[One][Two]**.
- I. Minimum Bending Radius for Communication Cables: Combination of raceways, fittings, inserts, junction boxes, service fittings, and mounting and connection arrangements for wiring devices and jacks must provide a **[2 inch (50 mm)]<Insert dimension>** minimum bending radius for communication cables.
- J. Service Raceways: Fitted with preset inserts.
1. Nominal Multichannel Underfloor Raceway Dimensions:
 - a. Depth: **1-3/8 inch (35 mm)**.
 - b. Overall Width: **[6 inch (150 mm)][10 inch (250 mm)][15 inch (375 mm)]<Insert dimension>**.
 - c. Power Service Channel Width: **[3-1/2 inch (88 mm)][4-3/8 inch (110 mm)]<Insert dimension>**.
 - d. Communication Service Channel Width: **[3-1/2 inch (88 mm)][4 inch (100 mm)][6-1/2 inch (163 mm)]<Insert dimension>**.
 2. Nominal Single-Channel Underfloor Raceway Dimensions:
 - a. Depth: **1-1/2 inch (38 mm)**.
 - b. Power Service Raceway Width: **3-1/4 inch (81 mm)**.
 - c. Communication Service Raceway Width: **[3-1/4 inch (81 mm)][6 inch (150 mm)]**.
 - d. Number of Single-Channel Raceways per Run: **[One][Two][Three][Four][Five]** unless otherwise indicated.
 3. Preset Inserts: **[Rectangular][Round]**.
 - a. Spacing: **[12 inch (300 mm)][24 inch (600 mm)]** on center.
 - b. Size:
 - 1) Rectangular dimensions as required to accommodate mounting and connection of flush- and surface-mounted, **[single-][and multiple-]**outlet service fittings or to connect to wiring extensions for feeding wall outlets for **[power][communications][power and communications]<Insert system>**.
 - 2) **[2 inch (50 mm)]<Insert dimension>** in diameter.
 - c. Equip each insert with a disposable cover, and select insert height so cover is **1/8 inch (3 mm)** below surface of concrete.
 - d. Arrange insert for optional attachment of flush-, surface-, or wiring-extension service fitting to replace disposable cover. Arrange brackets, mountings, barriers, and floor access covers to support, isolate, and provide access to **[flush][or][surface]** outlet-mounting connector, jack, and receptacle devices.
- K. Header Raceways: **[Single-][Multi]**channel, without preset inserts (blank raceway).
1. Nominal Raceway Dimensions:
 - a. Depth: **[Same as service raceways][2-1/2 inch (63 mm)][2-3/4 inch (69 mm)][3 inch (75 mm)][3-1/2 inch (88 mm)]**.
 - b. Power Header Raceway Width: **[3-1/2 inch (88 mm)][4-3/8 inch (110 mm)]<Insert dimension>**.
 - c. Communication Header Raceway Width: **[3-1/2 inch (88 mm)][4 inch (100 mm)][6-1/2 inch (163 mm)]**.



2. Arrangement: **[In same plane as][Below]** service raceways.
3. Connections: Arranged to connect with service raceways at **[single][two]**-level junction boxes.

2.3 FLUSH, FLAT-TOP UNDERFLOOR RACEWAYS

- A. Description: **[Single][or][multichannel]** underfloor raceways installed on floor slab with top of raceway flush with concrete topping added hereafter, and then covered with finish material.
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 1. **[Walker Systems, Inc.]**
 2. **<Insert manufacturer's name>**
- C. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 1. **[Walker Systems, Inc.]**
 2. **<Insert manufacturer's name>**
- D. Source Limitations: Obtain underfloor raceway components for each system through single source from single manufacturer.
- E. General Characteristics:
 1. Material: Steel.
 2. Cross-Section Shape: Rectangular, **[single channel][and][multichannel, separated by steel wall(s)]**.
 3. Listed and labeled for installation with top flush with concrete floor.
 4. Number of Levels: One.
- F. Service Raceways: Fitted with preset inserts.
 1. Number of Longitudinal Channels per Multichannel Raceway: **[Two][Three]**.
 2. Number of Single-Channel Raceways per Run: **[One][Two][Three]** unless otherwise indicated.
 3. Nominal Channel Dimensions: **3 inch (75 mm)** wide by **1-1/4 inch (31 mm)** deep.
 4. Preset Inserts: Threaded opening with removable steel plug that is flush with top of raceway when screwed in place.
 - a. Spacing: **[12 inch (300 mm)][24 inch (600 mm)]** on center, full length of each service raceway.
 - b. Arrangement: Stagger insert locations on parallel raceways or channels to accommodate placement of adjacent service fittings.
 - c. Size: **1-5/8 inch (41 mm)** diameter.
- G. Trench Duct Crossunder: Fitting attached to underside of trench duct.
 1. Nominal Channel Dimensions: Same as service raceways.
 2. Arrangement: Offset by depth of trench duct.
 3. Connections: Arranged to connect trench duct to flush duct through factory-cut, grommeted openings.

- H. Header Raceways: Raceways same as service raceways, except without preset inserts (blank raceway).

1. Nominal Channel Dimensions: Same as service raceways.
2. Arrangement: In same plane as service raceways.
3. Connections: Arranged to connect with service raceways at junction boxes.

2.4 CELLULAR METAL UNDERFLOOR RACEWAYS

- A. Description: Multichannel, cellular, underfloor service raceways installed on floor slab with top of raceway flush concrete topping added hereafter, and then covered with finish material.
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

1. **[ASC Steel Deck; ASC Profiles, LLC]**
2. **[Dennis Filges Company, Inc]**
3. **[Epic Metals Corporation]**
4. **[HH Robertson]**
5. **[United Steel Deck, Inc.]**
6. **[Walker Systems, Inc.]**
7. **<Insert manufacturer's name>**

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

1. **[ASC Steel Deck; ASC Profiles, LLC]**
2. **[Dennis Filges Company, Inc]**
3. **[Epic Metals Corporation]**
4. **[HH Robertson]**
5. **[United Steel Deck, Inc.]**
6. **[Walker Systems, Inc.]**
7. **<Insert manufacturer's name>**

- D. Source Limitations: Obtain underfloor raceway components for each system through single source from single manufacturer.

- E. Material:

1. Galvanized-steel sheet, ASTM A653/A653M, Structural Steel (SS), Grade **33 (230)** minimum, **[G60 (Z180)][G90 (Z275)]** zinc coating.
2. Galvanized- and shop-primed steel sheet, ASTM A653/A653M, Structural Steel (SS), Grade **33 (230)**, **G60 (Z180)** zinc coating; with underside surface cleaned, pretreated, and primed with manufacturer's standard **[gray][white]** baked-on, rust-inhibitive primer.

- F. Number of Longitudinal Cells: Three, separated by steel walls.

- G. Nominal Dimensions of Cells:

1. Overall Depth: **1-1/4 inch (31 mm)** unless otherwise indicated.
2. Cross-Sectional Area of Cells: Power cells: **5-1/2 sq. inch (34.4 sq. cm)**; communication system cells: **16 sq. inch (100 sq. cm)**.

- H. Minimum Bending Radius for Communication Cables: Combination of raceways, fittings, inserts,



junction boxes, service fittings, and mounting and connection arrangements for wiring devices and jacks must provide a [2 inch (50 mm)]<Insert dimension> minimum bending radius for communication cables.

I. Service Raceways: Fitted with preset inserts.

1. Preset Inserts: Rectangular-shaped metal housing assemblies arranged to provide electrical outlet access to each cell of each raceway designated for service raceway use. Inserts must be provided throughout the entire length of each such raceway.
 - a. Spacing: [12 inch (300 mm)][24 inch (600 mm)][30 inch (750 mm)] on center.
 - b. Include housing and connecting provisions for a flush or recessed, single-, double-, or triple-outlet service fitting.
 - c. Include mounting and connecting provisions for a surface, single- or multiple-outlet service fitting.
 - d. Include connecting provisions for a wiring-extension service fitting to feed wall outlets.
 - e. Equip each insert with a disposable cover plate arranged for installation with top 1/8 inch (3 mm) below surface of concrete. Arrange insert to receive a flush-, recessed-, or wiring-extension service fitting to replace disposable top.

J. Header Assembly: A junction box and raceway arrangement positioned to feed wires and cables to service raceways.

1. Three-compartment junction box connecting blank, [multicell cellular][flat-top, multichannel] header raceway (no inserts) with cellular service raceways at right angles to header raceway.
2. Cellular header raceway must be made of the same material and have the same nominal dimensions as service raceways.
3. Provide capability for service raceways to be run in both perpendicular directions at the intersection with header raceway.

2.5 TRENCH-TYPE UNDERFLOOR RACEWAYS

A. Description: Trench-type raceways used as header or feeder raceways to serve service raceways.

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

1. [Dennis Filges Company, Inc]
2. [HH Robertson]
3. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
4. [Square D; Schneider Electric USA]
5. [Walker Systems, Inc.]
6. <Insert manufacturer's name>

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

1. [Dennis Filges Company, Inc]
2. [HH Robertson]
3. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
4. [Square D; Schneider Electric USA]

5. **[Walker Systems, Inc.]**
6. **<Insert manufacturer's name>**

- D. Source Limitations: Obtain underfloor raceway components for each system through single source from single manufacturer.
- E. Trench: Steel, shop or factory welded and fabricated to indicated sizes. Include the following features:
 1. Slab Depth Adjustment: Minimum of minus **1/8 inch (3 mm)** to plus **5/8 inch (17 mm)** before and during concrete placement.
 2. Cover Supports: Height adjustable, with leveling screws to rigidly support cover assembly.
 3. Screed Strip: Extruded aluminum along both edges at proper elevation without requiring shim material.
 4. Trim Strip: Select to accommodate floor finish material.
 5. Partitions: Arranged to separate channels and isolate wiring of different systems.
 6. Grommeted openings in active floor cells or service raceways.
 7. Manufacturer's standard corrosion-resistant finish, applied after fabrication.
- F. Cover Plates: Removable, steel plates, **1/4 inch (6 mm)** thick, each weighing **60 lb. (27 kg)** or less with full gasket attached to side units. Fabricate intermediate supports to limit unsupported spans to **[15 inch (375 mm)]<Insert dimension>** or less. Fabricate covers with appropriate depth recess to receive indicated floor finish.

2.6 ELECTRICAL CONNECTION COMPONENTS FOR CELLULAR STEEL FLOOR DECK

- A. Source Limitations for Electrified Cellular Steel Floor-Deck Components: Obtain electrical components, such as preset inserts, afterset inserts, service fittings, header ducts, and trench header ducts, from cellular steel floor-deck manufacturer.
- B. Preset Inserts: Rectangular metal-housing assemblies.
 1. Spacing: **[12 inch (300 mm)][24 inch (600 mm)][30 inch (750 mm)]** on center.
 2. Size: As required to provide electrical outlet access to each cell of each group of three cells that is designated for electrical service raceway use.
 3. Equip each insert with a disposable cover arranged for installation with top **1/8 inch (3 mm)** below surface of concrete. Arrange insert to receive a flush-, recessed-, or wiring-extension service fitting to replace disposable cover.
 4. Include housing and connecting provisions for a **[flush or recessed][surface]** service fitting, **[single][double][triple]** outlet.
 5. Include connecting provisions for a wiring-extension service fitting to feed wall outlets.

2.7 ELECTRICAL CONNECTION COMPONENTS FOR PRECAST CELLULAR CONCRETE FLOOR DECK

- A. Source Limitations for Electrified Cellular Concrete Floor-Deck Components: Obtain electrical components, such as preset inserts, afterset inserts, service fittings, header ducts, and trench header ducts, from cellular concrete floor-deck manufacturer or from single source from single manufacturer.
- B. Afterset Inserts: Round metal-nipple assembly with internal and external threading, arranged to screw into plug driven into **1-7/8 inch (47 mm)** hole drilled through floor fill, where present, and deck-cell wall into floor raceway cell.
 1. Inserts must be compatible with floor-mounting service fittings.
 2. Inserts must provide wiring path from cell to **[power][communication][power and**

- communication]<Insert system>[wall][and][ceiling] outlets.**
 3. Inserts must provide wiring path from cell to header raceway.

2.8 SUPPORTS, RACEWAY FITTINGS, AND HARDWARE

- A. Source Limitations: Obtain underfloor raceway supports, fittings, and hardware components for each system through single source from single manufacturer.
- B. Supports, fittings, and hardware must be compatible with raceway and outlet system and must be listed for use with raceway systems and components delivered.
- C. Supports: Adjustable for height and arranged to maintain alignment and spacing of raceways during concrete placement. Include hold-down straps.
- D. Raceway Fittings: Couplings, expansion-joint sleeves, cross-under offsets, vertical and horizontal elbows, grounding screws, adapters, end caps, and other fittings suitable for use with basic components to form a complete installation.

2.9 JUNCTION BOXES

- A. Description: Raceway manufacturer's standard enclosure for indicated type, quantity, arrangement, and configuration of raceways at each raceway junction, intersection, and access location. Include the following accessories and features:
 - 1. Mounting brackets.
 - 2. Escutcheons and holders to accommodate surrounding floor covering.
 - 3. Means for leveling and height adjustment more than **3/8 inch (10 mm)** before and after concrete is placed.
 - 4. Boxes must withstand a minimum **[300 lb (136 kg)]<Insert value>** concentrated load. Internal supports must be provided as needed to meet this requirement.
 - 5. All boxes must provide **2 inch (50 mm)** minimum bend radius for data and communication cables.
 - 6. Raceway Openings: For underfloor raceways and conduits arranged to accommodate raceway layout.
 - 7. Covers must have appropriate depth recess to receive specific floor finish material.
 - 8. Partitions to separate wiring of different systems.

2.10 SERVICE FITTINGS/ACTIVATIONS

- A. Source Limitations: Obtain underfloor raceway service fittings and hardware for each system through single source from single manufacturer.
- B. Exposed Parts Finish: **[Brass][Brushed aluminum]<Insert finish>**.
- C. Flush, Single-System Service Fitting for Round Inserts: Include mounting and cover to support and provide access to single connector, jack, or receptacle device; mounted flush with floor within body of insert.
 - 1. Connector, Jack, and Receptacle Devices: Single modular type.
 - 2. Power Receptacle Outlet: Suitable for 20 A, 120 V device.

- D. Flush, [Single-][or][Multiple-]System Service Fitting for Rectangular Inserts: Include mounting, hinged cover, and trim to support and provide access to connector, jack, or receptacle devices mounted flush with floor within insert.
1. Connector, Jack, and Receptacle Devices: Modular type.
 2. Power Receptacle Rating: 20 A, 120 V unless otherwise indicated.
 3. Recess-Mounted Service Fitting: Modular fittings compatible with preset inserts. Include device plates for indicated systems and provisions for receptacles, jacks, and connectors. Include hinged flush covers with recessed depth to match thickness of floor finish material. Provide for internally mounted receptacle- and communication-jack and connector assemblies.
 - a. Duplex receptacle.
 - b. Duplex data jacks.
 - c. Double duplex receptacles.
 - d. Duplex receptacle and duplex data jacks.
 - e. Fiber-optic cable connector.
- E. Surface-Mounted Service Fitting: Modular pedestal type, with locking attachment matched to insert floor opening.
1. Power-outlet, double-faced, surface-mounted unit for duplex receptacle on both sides.
 2. Power-outlet, single-faced, surface-mounted unit for duplex receptacle on one side.
 3. Communication-outlet, double-faced, surface-mounted unit.
 - a. Include bushed openings on both sides; **1 inch (25 mm)** minimum diameter; insulated with nonconducting material.
 - b. Include provisions for modular dual fiber-optic connector assembly on both sides.
 - c. Include provisions for modular dual jack-connector assembly, rated for [Category 5][Category 5e][Category 6] on both sides.
 4. Communication-outlet, single-faced, surface-mounted unit with bushed opening on one side; **1 inch (25 mm)** minimum diameter; insulated with nonconducting material.
 5. Combination surface-mounted unit for duplex receptacle on one side and with communication cable connection provision on opposite side.
 - a. Communication Side:
 - 1) Include bushed opening; **1 inch (25 mm)** minimum diameter; insulated with nonconducting material.
 - 2) Include provisions for modular dual fiber-optic connector assembly.
 - 3) Include provisions for modular dual jack-connector assembly, rated for [Category 5][Category 5e][Category 6].
 6. Flush-Mounted Service Fittings: Modular fittings compatible with preset inserts and must include covers, provisions for receptacles jacks and connector assemblies and wiring extensions to wall-mounted outlets, and associated device plates for indicated systems. Include flush covers, recessed to suit floor finish material.
 7. Indicate types and locations of devices on Drawings.
 - a. Duplex convenience receptacle.
 - b. Duplex data outlets.
 - c. Double duplex convenience receptacles.
 - d. Duplex convenience receptacle and duplex data outlets.
 - e. Double duplex data outlets.
 - f. Duplex fiber-optic communication connector.
 - g. Wiring-Extension Service Fittings: Arrangement of brackets and mountings to support and

provide access to wiring or cabling of a cell, and to connect the cable or raceway that extends the system to an individual wall outlet. Provide for connection of [ERMC][FMC][ENT][Type MC cable] for power extensions, and [ERMC][FMC][ENT][optical fiber/communication cable raceway] for communication system extensions.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install raceways aligned and leveled and, unless otherwise indicated, parallel or perpendicular to floor supports.
- B. Maintain arrangement of conductor services throughout the raceway system.
- C. Install a concrete mud slab for support of cellular metal, flush duct, or trench duct raceway. Construct mud slab with wire mesh in the top **1 inch (25 mm)** of concrete.
- D. Install a vapor barrier between the cellular metal raceway and a substrate in contact with earth.
- E. Arrange supports to attain proper elevation, alignment, and spacing of raceways. Fasten supports securely at ends and at intervals not to exceed **60 inch (1500 mm)**, to prevent movement during concrete pour.
- F. Level raceway components with finished slab and make adjustments in raceway component elevation to accommodate indicated floor finishes.
- G. Junction Boxes: Install tops level and flush with finished floor. Install blank closure plates or plugs to close unused junction-box openings. Grout boxes in place to prevent movement during construction. Place top covers in inverted position during construction to prevent damage to surface of cover. Reinstall covers in proper position prior to final acceptance of the Work.
- H. Install preset inserts per manufacturer's instructions.
- I. Adjust supports to maintain a **1/8 to 3/8 inch (3.0 to 10 mm)** finished concrete cover over preset inserts.
- J. Remove burrs, sharp edges, dents, and mechanical defects.
- K. Cap or plug boxes, insert- and service-fitting openings, and open ends of raceways.
- L. Install expansion fittings with suitable bonding jumper where raceways cross building expansion joints.
- M. Bond underfloor raceway components to create a continuous bonding path.

- N. Seal raceways, cells, junction boxes, and inserts to prevent water, concrete, or foreign matter from entering raceways before and during pouring slab or placing fill. Tape joints or seal with compound, as recommended in writing by underfloor raceway manufacturer.
- O. Install a marker at the center of the last insert of each cell and channel of each straight run of metal underfloor service raceway to locate the insert and identify the system.
 - 1. Install markers at last inserts on both sides of permanent walls and at first inserts adjacent to each junction box.
 - 2. Install markers flush at screed line before pouring slab or placing fill. Extend marker with grommets screw when floor covering is placed. Do not extend through carpet.
 - 3. Use slotted-head screw to identify electrical power; use Phillips-head screw to identify conventional communications.
 - 4. Use another distinctive screw head to identify third system, such as special-purpose wiring.
- P. Protect underfloor raceway system from damage. Do not use the installed duct system as working platforms or walkways. Do not allow equipment or heavy traffic over duct during construction period, without first installing ramps over the duct. Ramps must be designed so that imposed loads are not transferred to the duct. Components of the system that are damaged during construction must be replaced.
- Q. Install concrete surrounding underfloor raceways according to Section 033000 "Cast-in-Place Concrete."
- R. Afterset Inserts: Cut, hole saw, and drill slab and raceways to allow for installation at locations indicated on plans.
- S. Wiring must comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and NFPA 70 requirements for wet locations.
 - 1. Install wiring from outlet insert toward junction boxes, then to termination at panel.
 - 2. Splices: All splices and taps must be made in junction boxes. No splices or taps must be made in raceways or outlet inserts.

3.3 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. Perform visual inspection of interior of each **[junction box]****[section of trench raceway]** to verify absence of dirt, dust, construction debris, and moisture. Replace damaged and malfunctioning components.
 - 2. Prior to and after concrete pour, perform point-to-point tests of ground continuity and resistance of ground path between the most remote accessible fitting on each branch of each underfloor raceway system and the main electrical distribution grounding system.
 - a. Determine cause and perform correction of any point-to-point resistance value that exceeds 0.05 ohms.
 - b. Comply with NETA Acceptance Testing Specification about safety, suitability of test equipment, test instrument calibration, and test report and records.
- B. Prepare test and inspection reports.

3.4 CLEANING

- A. Clean and swab out underfloor raceways, inserts, and junction boxes after finish has been applied to floor slab, and remove foreign material, dirt, and moisture. Leave interiors clean and dry.

END OF SECTION 26 05 39 00



Task	Specification	Specification Description
26 05 39 00	26 05 00 00	Sleeves and Sleeve Seals for Electrical Raceways and Cabling



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SECTION 26 05 43 00 - UNDERGROUND DUCTS AND UTILITY STRUCTURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Type EPEC raceways and fittings.
2. Type ERMC-SS raceways, elbows, couplings, and nipples.
3. Type ERMC-S raceways, elbows, couplings, and nipples.
4. Type IMC raceways.
5. Type PVC raceways and fittings.
6. Type RTRC-BG raceways and fittings.
7. Fittings for conduit, tubing, and cable.
8. Electrically conductive corrosion-resistant compounds for threaded conduit.
9. Solvent cements.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" specifies additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" specifies seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
3. **[Section 013100 "Project Management and Coordination"]<Insert Section number and title>** specifies preinstallation conference procedures.
4. Section 260519 "Low-Voltage for Electrical Power Conductors and Cables" specifies nonmetallic underground conduit with conductors (Type NUCC).
5. Section 260553 "Identification for Electrical Systems" specifies underground-line warning tape and concrete cable routing markers (warning planks).

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at **[Project site]<Insert location>**.

B. Preinstallation Coordination Meeting(s): For underground ducts and raceways. Conduct meeting(s) **[as videoconference][or][at Project site]<Insert location>** before **<Insert construction activity>**.

1. Attendees: Installers, fabricators, representatives of manufacturers, and administrators for field tests and inspections. Notify Architect[, **Construction Manager**], and **Owner's Commissioning Authority** of scheduled meeting dates.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. For concrete and steel used in precast concrete **[manholes][and][handholes]**, also include product certificates as required by ASTM C858.

B. Sustainable Design Product Data:

1. Laboratory Test Reports: For solvents and adhesives, indicating compliance with requirements for low-emitting materials.

C. Shop Drawings:**1. Electric Utility Duct Banks and Structures:**

- a. Include plans, elevations, sections, and details, including attachments to other Work.
- b. Indicate locations of private property boundaries and utility easements.
- c. Include information required for approval by electric utility and for obtaining public space utility work permits.

2. Precast or Factory-Fabricated Concrete Structures:

- a. Include plans, elevations, sections, and details, including attachments to other Work.
- b. Include duct entry provisions, including locations and duct sizes, and methods and materials for waterproofing duct entry locations.
- c. Include reinforcement details.
- d. Include frame and cover design and manhole chimneys.
- e. Include [ladder][step] details.
- f. Include grounding details.
- g. Include dimensioned locations of cable rack inserts, pulling-in and lifting irons, sumps, and other accessories.
- h. Include joint details.

3. Factory-Fabricated Handholes and Boxes Other Than Precast Concrete:

- a. Include dimensioned plans, sections, and elevations, and fabrication and installation details.
- b. Include duct entry provisions, including locations and duct sizes, and methods and materials for waterproofing duct entry locations.
- c. Include cover design.
- d. Include grounding details.
- e. Include dimensioned locations of cable rack inserts, pulling-in and lifting irons, and other accessories.

D. Field quality-control reports.**1.4 INFORMATIONAL SUBMITTALS****A. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.****B. Field Reports:**

1. Factory Test Reports: For handholes and boxes.
2. Manufacturer's field reports for field quality-control support.

PART 2 - PRODUCTS

2.1 TYPE EPEC RACEWAYS AND FITTINGS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 651A and UL CCN EAZX.

B. Schedule 40 Electrical HDPE Underground Conduit (EPEC-40):

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Blue Diamond Industries, LLC]**
 - b. **[JM Eagle]**
 - c. **[Petroflex North America]**
 - d. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - e. **[Southwire Company, LLC]**
 - f. **<Insert manufacturer's name>**
2. Dimensional Specifications: Schedule 40.
3. Options:
 - a. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)][Metric designator 21 (trade size 3/4)]**.

C. Schedule 80 Electrical HDPE Underground Conduit (EPEC-80):

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Blue Diamond Industries, LLC]**
 - b. **[JM Eagle]**
 - c. **[Petroflex North America]**
 - d. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - e. **[Southwire Company, LLC]**
 - f. **<Insert manufacturer's name>**
2. Dimensional Specifications: Schedule 80.
3. Options:
 - a. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)][Metric designator 21 (trade size 3/4)]**.

D. Type A Electrical HDPE Underground Conduit (EPEC-A):

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

following]:

- a. <Insert manufacturer's name>
- 2. Dimensional Specifications: Type A.
- 3. Options:
 - a. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)][Metric designator 21 (trade size 3/4)]**.

E. Type B Electrical HDPE Underground Conduit (EPEC-B):

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. <Insert manufacturer's name>
- 2. Dimensional Specifications: Type B.
- 3. Options:
 - a. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)][Metric designator 21 (trade size 3/4)]**.

2.2 TYPE ERM-SS RACEWAYS, ELBOWS, COUPLINGS, AND NIPPLES

A. Performance Criteria:

- 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
- 2. General Characteristics: UL 6A and UL CCN DYWV.

B. Stainless Steel Electrical Rigid Metal Conduit (ERM-SS), Elbows, Couplings, and Nipples:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[Allied Tube & Conduit; Atkore International]**
 - c. **[Calconduit; Atkore International]**
 - d. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - e. **[Patriot Aluminum Products, LLC]**
 - f. <Insert manufacturer's name>
- 2. Material: Stainless steel.
- 3. Options:
 - a. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)][Metric designator 21 (trade size 3/4)]**.
 - b. Colors: As indicated on Drawings.

2.3 TYPE ERM-S RACEWAYS, ELBOWS, COUPLINGS, AND NIPPLES

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 6 and UL CCN DYIX.

B. Galvanized-Steel Electrical Rigid Metal Conduit (ERM-S-G), Elbows, Couplings, and Nipples:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Allied Tube & Conduit; Atkore International]**
 - b. **[Calconduit; Atkore International]**
 - c. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - d. **[Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - e. **[Patriot Aluminum Products, LLC]**
 - f. **[Republic Conduit; Nucor Corporation, Nucor Tubular Products]**
 - g. **[Topaz Lighting & Electric]**
 - h. **[Western Tube; Zekelman Industries]**
 - i. **[Wheatland Tube; Zekelman Industries]**
 - j. **<Insert manufacturer's name>**
2. Exterior Coating: Zinc.
3. Options:
 - a. Interior Coating: **[Zinc with organic top coating][Zinc][Organic coating]**.
 - b. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)][Metric designator 21 (trade size 3/4)]**.
 - c. Colors: As indicated on Drawings.

C. PVC-Coated-Steel Electrical Rigid Metal Conduit (ERM-S-PVC), Elbows, Couplings, and Nipples:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[Bluesteel Services LLC]**
 - c. **[Calbond; Atkore International]**
 - d. **[KorKap; Robroy Industries]**
 - e. **[Perma-Cote; Robroy Industries]**
 - f. **[Plasti-Bond; Robroy Industries]**
 - g. **<Insert manufacturer's name>**
2. Additional Characteristics:
3. Fittings for PVC-Coated Conduit:
 - a. Minimum coating thickness of **0.040 inch**, with overlapping sleeves protecting threaded joints.
 - b. Conduit bodies must be Form 8 with effective seal and positive placement feature to ease and assure proper installation. Certified results confirming seal performance at 15 psig



- (positive) and 25 inch Hg (vacuum) for 72 hours must be available. Conduit bodies must be supplied with plastic-encapsulated stainless steel cover screws.
- c. Form **2 inch** long or one pipe diameter long, whichever is less, PVC sleeve at openings of female fittings, except unions. Inside sleeve diameter must be matched to outside diameter of metal conduit.
 - d. PVC coating on outside of conduit couplings must be protected from tool damage during installation.
 - e. Female threads on fittings and couplings must be protected by urethane coating.
 - f. Fittings must be from same manufacturer as conduit.
 - g. Beam clamps and U bolts must be formed and sized to fit outside diameter of coated conduit. Plastic-encapsulated nuts must cover exposed portions of threads.
4. Options:
- a. Exterior Coating: PVC complying with NEMA RN 1[**and marked ETL Verified PVC-001**].
 - b. Interior Coating: [**Zinc with organic top coating**][Zinc][**Organic coating**].
 - c. Minimum Trade Size: [**Metric designator 16 (trade size 1/2)**][**Metric designator 21 (trade size 3/4)**].
 - d. Colors: As indicated on Drawings.
 - e. Conduit Fittings for Hazardous (Classified) Locations: UL 1203.
 - f. Expansion and Deflection Fittings: UL 651 with flexible external bonding jumper.

2.4 TYPE IMC RACEWAYS

A. Performance Criteria:

- 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
- 2. General Characteristics: UL 1242 and UL CCN DYBY.

B. Steel Electrical Intermediate Metal Conduit (IMC):

- 1. Manufacturers: Subject to compliance with requirements, [**provide products by the following**][**provide products by one of the following**][**available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following**]:
 - a. [**ABB, Electrification Business**]
 - b. [**Allied Tube & Conduit; Atkore International**]
 - c. [**Calconduit; Atkore International**]
 - d. [**Republic Conduit; Nucor Corporation, Nucor Tubular Products**]
 - e. [**Topaz Lighting & Electric**]
 - f. [**Western Tube; Zekelman Industries**]
 - g. [**Wheatland Tube; Zekelman Industries**]
 - h. <Insert manufacturer's name>
- 2. Options:
 - a. Exterior Coating: [**Zinc**][**Alternative corrosion-resistant coating**].
 - b. Interior Coating: [**Zinc with organic top coating**][Zinc][**Organic coating**].
 - c. Minimum Trade Size: [**Metric designator 16 (trade size 1/2)**][**Metric designator 21 (trade size 3/4)**].
 - d. Colors: As indicated on Drawings.

2.5 TYPE PVC RACEWAYS AND FITTINGS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 651 and UL CCN DZYR.

B. Schedule 40 Rigid PVC Conduit (PVC-40) and Fittings:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[Calconduit; Atkore International]**
 - c. **[JM Eagle]**
 - d. **[NAPCO; Westlake Chemical Corp.]**
 - e. **[Opti-Com Manufacturing Network, Inc (OMNI)]**
 - f. **[Topaz Lighting & Electric]**
 - g. **<Insert manufacturer's name>**
2. Dimensional Specifications: Schedule 40.
3. Options:
 - a. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)][Metric designator 21 (trade size 3/4)]**.
 - b. Markings: **[For use with maximum 90 deg C wire.][For directional boring applications.]**

C. Schedule 80 Rigid PVC Conduit (PVC-80) and Fittings:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[Calconduit; Atkore International]**
 - c. **[JM Eagle]**
 - d. **[Opti-Com Manufacturing Network, Inc (OMNI)]**
 - e. **[Topaz Lighting & Electric]**
 - f. **<Insert manufacturer's name>**
2. Dimensional Specifications: Schedule 80.
3. Options:
 - a. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)][Metric designator 21 (trade size 3/4)]**.
 - b. Markings: **[For use with maximum 90 deg C wire.][For directional boring applications.]**

D. Type A Rigid PVC Concrete-Encased Conduit (PVC-A) and Fittings:

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



following]:

- a. **[Southern Pipe, Inc.]**
- b. **<Insert manufacturer's name>**
- 2. Dimensional Specifications: Type A.
- 3. Options:
 - a. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)][Metric designator 21 (trade size 3/4)]**.

E. Type EB Rigid PVC Concrete-Encased Underground Conduit (PVC-EB) and Fittings:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[JM Eagle]**
 - b. **[Southern Pipe, Inc.]**
 - c. **<Insert manufacturer's name>**
- 2. Dimensional Specifications: Type EB.
- 3. Options:
 - a. Minimum Trade Size: **[Metric designator 53 (trade size 2)][Metric designator 78 (trade size 3)][Metric designator 103 (trade size 4)]**.

2.6 TYPE RTRC-BG RACEWAYS AND FITTINGS

A. Performance Criteria:

- 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
- 2. General Characteristics: UL 2420 and UL CCN DZKT, for Type BG.

B. Low-Halogen, Belowground Reinforced Thermosetting Resin Conduit (RTRC-BG) and Fittings:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **<Insert manufacturer's name>**
- 2. Options:
 - a. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)][Metric designator 21 (trade size 3/4)]**.

2.7 FITTINGS FOR CONDUIT, TUBING, AND CABLE

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.

B. Metallic Fittings for Type ERM, Type IMC, Type PVC, Type EPEC, and Type RTRC Raceways:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[Appleton; Emerson Electric Co., Automation Solutions]**
 - c. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - d. **[Konkore Fittings; Atkore International]**
 - e. **[O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group]**
 - f. **[Penn Aluminum Conduit & EMT; Penn Aluminum International LLC; Berkshire Hathaway]**
 - g. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - h. **[Southwire Company, LLC]**
 - i. **[Topaz Lighting & Electric]**
 - j. **<Insert manufacturer's name>**
2. General Characteristics: UL 514B and UL CCN DWTT.
3. Options:
 - a. Material: **[Steel][Die cast]**.
 - b. Coupling Method: **[Compression coupling][Raintight compression coupling with distinctive color gland nut][Setscrew coupling. Setscrew couplings with only single screw per conduit are unacceptable]**.
 - c. Conduit Fittings for Hazardous (Classified) Locations: UL 1203.
 - d. Expansion and Deflection Fittings: UL 651 with flexible external bonding jumper.

2.8 ELECTRICALLY CONDUCTIVE CORROSION-RESISTANT COMPOUNDS FOR THREADED CONDUIT

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL Subject 2419 and UL CCN FOIZ.

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

1. **[ABB, Electrification Business]**
2. **<Insert manufacturer's name>**

2.9 SOLVENT CEMENTS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: As recommended by conduit manufacturer in accordance with UL 514B and UL CCN DWTT.
3. Sustainability Characteristics:
 - a. VOC Content: **[510][490]<Insert value>** g/L or less for **[PVC][CPVC]** conduit and fittings.
 - b. Low-Emitting Material Requirements: As recommended by solvent and adhesive manufacturer and that complies with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

B. Solvent Cements for Type PVC Raceways and Fittings:

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

2.10 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics:
 - a. ASTM C858 for design and manufacturing processes.
 - b. SCTE 77.

2.11 MANHOLES FOR EXTERIOR UNDERGROUND WIRING

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics:
 - a. ASTM C858 for design and manufacturing processes.
 - b. SCTE 77.

B. Cast-in-Place Concrete Manholes:

1. Description: Underground utility structures, constructed in place, complete with accessories, hardware, and features. Include concrete knockout panels for duct entrance and sleeve for ground rod.

2. Additional Criteria: Comply with Section 033000 "Cast-in-Place Concrete."

2.12 SOURCE QUALITY CONTROL

A. Factory Tests for Handholes and Boxes:

1. Testing Administrator: **[Owner will engage][Engage]** qualified structural testing agency to evaluate handholes and boxes.
 - a. Tests of materials must be performed by independent testing agency.
 - b. Strength tests of complete boxes and covers must be by independent testing agency or manufacturer. Qualified registered professional engineer must certify tests by manufacturer.
2. Factory Tests and Inspections: Perform the following tests and inspections on handholes and boxes, by, or under supervision of, qualified electrical testing laboratory recognized by authorities having jurisdiction, before delivering to site. Affix label with name and date of **[manufacturer's][qualified testing laboratory's]** certification of system compliance.
 - a. Precast Concrete Utility Structures: Test and inspect in accordance with ASTM C1037.
 - b. Polymer Concrete and Nonconcrete Handhole and Pull-Box Prototypes: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests must be for specified tier ratings of products supplied. Testing machine pressure gages must have current calibration certification, complying with ISO 9000 and ISO 10012, and traceable to NIST standards.
3. Nonconforming Work:
 - a. Equipment that does not pass tests and inspections will be considered defective.
4. Factory Test Reports: Prepare and submit factory test and inspection reports.

PART 3 - EXECUTION

3.1 INSTALLATION OF DUCTS AND DUCT BANKS

A. Reference Standards:

1. Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with NEMA TCB 2 for installation of underground ducts and duct banks.
2. Consult Architect for resolution of conflicting requirements.

B. Special Techniques:

1. Where indicated on Drawings, install duct, spacers, and accessories into duct-bank configuration shown. Duct installation requirements in this Section also apply to duct bank.
2. Steel raceway, bends, and fittings in **[single duct run or duct bank][on Project]** must be of same type.
3. Slope: Pitch duct minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope duct from high point between two manholes to drain in both directions.

4. Expansion and Deflection Fittings: Install expansion and deflection fitting in each duct in area of disturbed earth adjacent to manhole or handhole.
5. Install expansion fitting near center of straight line duct with calculated expansion of more than **3/4 inch**.
6. Curves and Bends:
 - a. Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with minimum radius of **[48 inch][12.5 ft][25 ft]**, both horizontally and vertically, at other locations unless otherwise indicated.
 - b. Field bending must be in accordance with NFPA 70 minimum radii requirements, except bends over 45 degrees must be made with minimum radius of **[48 inch][12.5 ft][25 ft]**. Use only equipment specifically designed for material and size involved. Use PVC heating bender for bending PVC conduit.
 - c. Duct must have maximum of 180 degrees of bends between pull points.
7. Joints: Use solvent-cemented joints in nonmetallic duct and fittings and make watertight in accordance with manufacturer's published instructions. Stagger couplings so those of adjacent duct do not lie in same plane. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with minimum **3 inch** of concrete for minimum of **12 inch** on each side of coupling.
 - a. Install insulated grounding bushings on steel raceway terminations that are less than **12 inch** below grade or floor level and do not terminate in hubs.
8. Installation Adjacent to High-Temperature Steam Lines: Where duct is installed parallel to underground steam lines, perform calculations showing duct will not be subject to environmental temperatures above **104 deg F**. Where environmental temperatures are calculated to rise above **104 deg F**, and anywhere duct crosses above underground steam line, install insulation blankets listed for direct burial to isolate duct bank from steam line to maintain maximum environmental temperature of **104 deg F**.
9. End Bell Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately **10 inch** o.c. for **5 inch** duct, and vary proportionately for other duct sizes.
 - a. Begin change from regular spacing to end-bell spacing **10 ft** from end bell, without reducing duct slope and without forming trap in line.
 - b. Grout end bells into structure walls from both sides to provide watertight entrances.
10. Duct Terminators for Entrances to Cast-in-Place Manholes and Concrete Handholes: Use manufactured, cast-in-place duct terminators, with entrances into structure spaced approximately **6 inch** o.c. for **4 inch** duct, and vary proportionately for other duct sizes.
 - a. Begin change from regular spacing to terminator spacing **10 ft** from terminator, without reducing duct line slope and without forming trap in line.
11. Building Wall Penetrations: Make transition from underground duct to steel raceway at least **10 ft** outside building wall, without reducing duct line slope away from building and without forming trap in line. Use fittings manufactured for transition to steel raceway type installed. Install steel raceway penetrations of building walls as specified in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."
12. Install manufactured steel raceway elbows for stub-ups at poles unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
 - a. Couple steel elbows to ducts with adapters designed for this purpose, and encase coupling with minimum **3 inch** of concrete for minimum of **12 inch** on each side of coupling.

13. Sealing: Provide temporary closure at terminations of duct with pulled cables. Seal spare duct at terminations. Use sealing compound and plugs to withstand at least **15 psig** hydrostatic pressure.
14. Pulling Cord: Install **200 lbf** test nylon cord in empty ducts.
15. Concrete-Encased Ducts and Duct Bank:
 - a. Excavate trench bottom to provide firm and uniform support for duct. Prepare trench bottoms as specified in Section 312000 "Earth Moving" for pipes **6 inch** or less in nominal diameter.
 - b. Width: Excavate trench [**3 inch**][**12 inch**] wider than duct on each side.
 - c. Depth: Install so top of duct envelope is at least **24 inch** below finished grade in areas not subject to deliberate traffic, and at least **30 inch** below finished grade in deliberate traffic paths for vehicles unless otherwise indicated. Install so top of duct envelope is below local frost line.
 - d. Support duct on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
 - e. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than [**four**][**five**] spacers per **20 ft** of duct. Place spacers within **24 inch** of duct ends. Stagger spacers approximately **6 inch** between tiers. Secure spacers to earth and to duct to prevent floating during concreting. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
 - f. Minimum Space between Ducts: **3 inch** between edge of duct and exterior envelope wall, **2 inch** between ducts for like services, and **4 inch** between power and communications ducts.
 - g. Elbows:
 - 1) Use manufactured duct elbows for stub-ups and at changes of direction in duct unless otherwise indicated. Extend encasement throughout length of elbow.
 - 2) Use manufactured steel elbows for stub-ups, at building entrances, and at changes of direction in duct run.
 - h. Stub-ups to Outdoor Equipment: Extend concrete-encased steel raceway horizontally minimum of **60 inch** from edge of equipment base.
 - 1) Stub-ups must [**terminate in coupling installed flush with**][**be minimum 4 inch above**] finished floor and minimum **3 inch** from conduit side to edge of slab.
 - i. Stub-ups to Indoor Equipment: Extend concrete-encased steel raceway horizontally minimum of **60 inch** from edge of wall. Install insulated grounding bushings on terminations at equipment.
 - 1) Stub-ups must [**terminate in coupling installed flush with**][**be minimum 4 inch above**] finished floor and no less than **3 inch** from conduit side to edge of slab.
 - j. Reinforcement: Reinforce concrete-encased duct where crossing disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
 - k. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
 - l. Concrete Cover: Install minimum of **3 inch** of concrete cover between edge of duct to exterior envelope wall, **2 inch** between duct of like services, and **4 inch** between power and communications ducts.
 - m. Place minimum **6 inch** of engineered fill above concrete encasement of duct.
 - n. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.

- 1) Start at one end and finish at other, allowing for expansion and contraction of duct as its temperature changes during and after pour. Use expansion fittings installed in accordance with manufacturer's published instructions, or use other specific measures to prevent expansion-contraction damage.
 - 2) If more than one pour is necessary, terminate each pour in vertical plane and install **3/4 inch** reinforcing-rod dowels extending minimum of **18 inch** into concrete on both sides of joint near corners of envelope.
- o. Pouring Concrete: Comply with requirements in "Concrete Placement" Article in Section 033000 "Cast-in-Place Concrete." Place concrete carefully during pours to prevent voids under and between duct and at exterior surface of envelope. Do not allow heavy mass of concrete to fall directly onto ducts. Allow concrete to flow around duct and rise up in middle, uniformly filling open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-installation application.
16. Direct-Buried Duct and Duct Bank:
- a. Excavate trench bottom to provide firm and uniform support for duct. Comply with requirements in Section 312000 "Earth Moving" for preparation of trench bottoms for pipes less than **6 inch** in nominal diameter.
 - b. Width: Excavate trench [**3 inch**][**12 inch**] wider than duct on each side.
 - c. Depth: Install top of duct at least **36 inch** below finished grade unless otherwise indicated.
 - d. Set elevation of top of duct bank below frost line.
 - e. Place minimum **3 inch** of sand as bed for duct. Place sand to minimum of **6 inch** above top level of duct.
 - f. Support ducts on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
 - g. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than [**four**][**five**] spacers per **20 ft** of duct. Place spacers within **24 inch** of duct ends. Stagger spacers approximately **6 inch** between tiers. Secure spacers to earth and to ducts to prevent floating during concreting. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
 - h. Install duct with minimum of **3 inch** between ducts for like services and **6 inch** between power and communications duct.
 - i. Install manufactured duct elbows for stub-ups, at building entrances, and at changes of direction in duct direction unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
 - j. Install manufactured steel elbows for stub-ups, at building entrances, and at changes of direction in duct.
- 1) Couple RNC duct to steel raceway with adapters designed for this purpose, and encase coupling with minimum **3 inch** of concrete.
 - 2) Stub-ups to Outdoor Equipment: Extend concrete-encased steel raceway horizontally minimum of **60 inch** from edge of base. Install insulated grounding bushings on terminations at equipment.
 - a) Stub-ups must [**terminate in coupling installed flush with**][**be minimum 4 inch above**] finished base and minimum **3 inch** from conduit side to edge of base.
 - 3) Stub-ups to Indoor Equipment: Extend concrete-encased steel raceway horizontally on exterior of wall minimum of **60 inch** from edge of wall. Install insulated grounding bushings on terminations at equipment.
 - 4) Stub-ups through interior floors must [**terminate in coupling installed flush**

with][be minimum 4 inch above] finished floor and no less than **3 inch** from conduit side to edge of equipment pad or floor slab.

- k. After installing first tier of duct, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand place backfill to **4 inch** over duct and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction. Comply with requirements in Section 312000 "Earth Moving" for installation of backfill materials.
17. Warning Planks: Bury warning planks approximately **12 inch** above direct-buried duct, placing them **36 inch** o.c. Align planks along width and along centerline of duct or duct bank. Provide additional plank for each **12 inch** increment of duct-bank width over nominal **18 inch**. Space additional planks **12 inch** apart, horizontally across width of ducts.
18. Underground-Line Warning Tape: Bury **[nonconducting][conducting]** underground line specified in Section 260553 "Identification for Electrical Systems" no less than **12 inch** above concrete-encased duct and duct banks **and approximately 12 inch below grade]**. Align tape parallel to and within **3 inch** of centerline of duct bank. Provide additional warning tape for each **12 inch** increment of duct-bank width over nominal **18 inch**. Space additional tapes **12 inch** apart, horizontally across width of ducts.
19. Ground ducts and duct banks in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

C. Interfaces with Other Work:

1. Coordinate installation of new products for **<Insert system or product group>** with existing conditions.
 - a. **<Insert requirements for transition between new and existing>.**
2. Coordinate with **<Insert Section number and title>** for **<Insert description of interfacing related Work>.**
 - a. **<Insert requirements for transition between this Section and related Work>.**

3.2 INSTALLATION OF CONCRETE MANHOLES, HANDHOLES, AND BOXES

A. Reference Standards:

1. Precast Concrete Handholes: Comply with ASTM C891 unless otherwise indicated.
2. Consult Architect for resolution of conflicting requirements.

B. Special Techniques:

1. Cast-in-Place Manholes:
 - a. Finish interior surfaces with smooth-troweled finish.
 - b. Knockouts for Future Duct Connections: Form and pour concrete knockout panels **1-1/2 to 2 inch** thick, arranged as indicated.
 - c. Comply with requirements in Section 033000 "Cast-in-Place Concrete" for cast-in-place concrete, formwork, and reinforcement.
2. Precast Concrete Handholes and Manholes:



- a. Install units level and plumb and with orientation and depth coordinated with connecting duct to minimize bends and deflections required for proper entrances.
 - b. Unless otherwise indicated, support units on level bed of crushed stone or gravel graded from **1 inch** sieve to **No. 4** sieve and compacted to same density as adjacent undisturbed earth.
 - c. Field-cut openings for conduits in accordance with enclosure manufacturer's published instructions. Cut wall of enclosure with tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.
 3. Elevations:
 - a. Manhole Roof: Install with rooftop at least **15 inch** below finished grade.
 - b. Manhole Frame: In paved areas and trafficways, set frames flush with finished grade. Set other manhole frames **1 inch** above finished grade.
 - c. Install handholes with bottom below frost line, **<Insert depth of frost line below grade at Project site>** below grade.
 - d. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes **1 inch** above finished grade.
 - e. Where indicated, cast handhole cover frame integrally with handhole structure.
 4. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.
 5. Manhole Access: Circular opening in manhole roof; sized to match cover size.
 - a. Manholes with Fixed Ladders: Offset access opening from manhole centerlines to align with ladder.
 - b. Install chimney, constructed of **[precast concrete][cast-iron]** collars and rings, and cast-iron frame to connect cover with manhole roof opening. Provide moisture-tight joints and waterproof grouting for frame and chimney.
 6. Waterproofing: Apply waterproofing to exterior surfaces of manholes **[and handholes]** after concrete has cured at least three days. Waterproofing materials and installation are specified in **[Section 071353 "Elastomeric Sheet Waterproofing"]****[Section 071354 "Thermoplastic Sheet Waterproofing"]****<Insert waterproofing Section>**. After duct has been connected and grouted, and before backfilling, waterproof joints and connections, and touch up abrasions and scars. Waterproof exterior of manhole chimneys after mortar has cured at least three days.
 7. Dampproofing: Apply dampproofing to exterior surfaces of manholes **[and handholes]** after concrete has cured at least three days. Dampproofing materials and installation are specified in Section 071113 "Bituminous Dampproofing." After ducts are connected and grouted, and before backfilling, dampproof joints and connections, and touch up abrasions and scars. Dampproof exterior of manhole chimneys after mortar has cured at least three days.
 8. Hardware: Install removable hardware, including pulling eyes, cable stanchions, **[and]** cable arms, **[and insulators]**, as required for installation and support of cables and conductors and as indicated.
 9. Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.
 10. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than **3-7/8 inch** for manholes and **2 inch** for handholes, for anchor bolts installed in field. Use minimum of two anchors for each cable stanchion.
 11. Ground manholes, handholes, and boxes in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Interfaces with Other Work:
1. Coordinate installation of new products for **<Insert system or product group>** with existing

conditions.

a. <Insert requirements for transition between new and existing>.

2. Coordinate with <Insert Section number and title> for <Insert description of interfacing related Work>.

a. <Insert requirements for transition between this Section and related Work>.

3.3 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. Reference Standards:

1. <Insert reference standard> for <Insert reason>.
2. Consult Architect for resolution of conflicting requirements.

B. Special Techniques:

1. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting duct, to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of duct, and seal joint between box and extension as recommended by manufacturer.
2. Unless otherwise indicated, support units on level bed of crushed stone or gravel, graded from **1/2 inch** sieve to **No. 4** sieve and compacted to same density as adjacent undisturbed earth.
3. Elevation: In paved areas and trafficways, set cover flush with finished grade. Set covers of other handholes **1 inch** above finished grade.
4. Install handholes and boxes with bottom below frost line, **<Insert depth of frost line below grade at Project site>** below grade.
5. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.
6. Field cut openings for duct in accordance with enclosure manufacturer's published instructions. Cut wall of enclosure with tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.
7. For enclosures installed in **[asphalt paving][and]<Insert material>** and subject to occasional, nondeliberate, heavy-vehicle loading, form and pour concrete ring encircling, and in contact with enclosure entry, and with top surface screeded to top of box cover frame. Bottom of ring must rest on **[compacted earth]<Insert material>**.
 - a. Concrete: **3000 psi**, 28-day strength, complying with Section 033000 "Cast-in-Place Concrete," with troweled finish.
 - b. Dimensions: **[10 inch wide by 12 inch deep]<Insert dimensions>**.
8. Ground handholes and boxes in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

C. Interfaces with Other Work:

1. Coordinate installation of new products for <Insert system or product group> with existing conditions.
 - a. <Insert requirements for transition between new and existing>.
2. Coordinate with <Insert Section number and title> for <Insert description of interfacing

related Work>.

- a. **<Insert requirements for transition between this Section and related Work>.**

3.4 FIELD QUALITY CONTROL

A. Acceptance Testing Preparation:

1. **<Insert requirements>.**

B. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>.**

C. Tests and Inspections:

1. Demonstrate capability and compliance with requirements on completion of installation of underground duct, duct bank, and utility structures.
2. Pull solid aluminum or wood test mandrel through duct to prove joint integrity and adequate bend radii, and test for out-of-round duct. Provide minimum **12 inch** long mandrel equal to duct size minus **1/4 inch**. If obstructions are indicated, remove obstructions and retest.
3. Test manhole **[and handhole]** grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 260526 "Grounding and Bonding for Electrical Systems."

D. Nonconforming Work:

1. Underground ducts, raceways, and structures will be considered defective if they do not pass tests and inspections.
2. Correct deficiencies and retest as specified above to demonstrate compliance.

E. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

F. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.

1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at Project site.

END OF SECTION 26 05 43 00



Task	Specification	Specification Description
26 05 43 00	26 05 00 00	Sleeves and Sleeve Seals for Electrical Raceways and Cabling



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SECTION 26 05 46 00 - POLES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Lighting standards.
2. Lighting standard accessories.
3. Utility poles.
4. Utility pole accessories.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies temperature, humidity, acoustical, and other field conditions applicable to the Work specified in this Section.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies seismic hazard, wind hazard, other structural design conditions applicable to the Work specified in this Section.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work.
4. Section 260526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding components referenced by this Section.
5. Section 260529 "Hangers and Supports for Electrical Systems" specifies hangers and supports referenced by this Section.
6. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs referenced by this Section.
7. Section 260573 "Power System Studies" specifies arc-flash hazard analysis and warning labels referenced by this Section.
8. **[Section 262726 "Wiring Devices"] [Section 262726.31 "General-Grade Single Straight-Blade Receptacles"] [and] [Section 262726.33 "General-Grade Duplex Straight-Blade Receptacles"]** specify receptacles referenced by this Section.
9. Section 270528 "Pathways for Communications Systems" specifies additional requirements for raceway materials, routing, locations, and identification of communications equipment and cabling.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include data on construction details, profiles, EPA, cable entrances, materials, dimensions, weight, rated design load, and ultimate strength of individual components.
2. Include finishes for lighting poles and luminaire-supporting devices.
3. Anchor bolts.
4. Manufactured pole foundations.
5. Product Certificates: Include product certificate, signed by manufacturers of poles, certifying that products are designed for indicated load requirements in accordance with AASHTO LTS-6-M and that load imposed by luminaire and attachments has been included in design. The certification must be based on design calculations signed and sealed by a professional engineer.
6. Include manufacturer's sample extended warranty language.

B. Samples: Submit finish samples for each exposed lighting pole, standard, and luminaire-supporting

device and for each color and texture specified.

- C. Shop Drawings: Prepare and submit the following:
 - 1. Plans, elevations, sections, and **[mounting][and][attachment]** details.
 - 2. Details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Details of fabrication and assembly of **[poles][and][pole accessories]**.
 - 4. Foundation construction details, including material descriptions, dimensions, anchor bolts, support devices, and calculations, signed and sealed by a professional engineer licensed in the state of installation.
 - 5. Anchor bolt templates keyed to specific poles and certified by manufacturer.
 - 6. Method and procedure of pole installation. Include manufacturer's published installations.
- D. Field quality-control reports.

1.3 INFORMATIONAL SUBMITTALS

- A. Material Test Reports:
 - 1. For each foundation component, by qualified testing laboratory.
 - 2. For each pole, by qualified testing laboratory.
- B. Soil test reports.
- C. Manufacturer's published instructions.
- D. Field Reports:
 - 1. Manufacturer's field reports for field quality-control support.

1.4 CLOSEOUT SUBMITTALS

- A. Warranty documentation.

1.5 WARRANTY

- A. Special Installer Extended Warranty: Installer warrants that fabricated and installed **[pole(s)][and luminaire-lowering device(s)]** perform in accordance with specified requirements and agrees to repair or replace products that fail to perform as specified within extended-warranty period. Warranty must convey to Owner upon acceptance of the Work.
 - 1. Extended-Warranty Period: **[Two][Three][Four]<Insert number>** years from date of Substantial Completion; full coverage for labor, materials, and equipment.
- B. Special Manufacturer Extended Warranty: Manufacturer warrants that **[pole(s)][and luminaire-lowering device(s)]** perform in accordance with specified requirements and agrees to provide repair or replacement of products that fail to perform as specified within extended-warranty period, including materials that corrode, fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs from special warranty period. Warranty must convey to Owner upon acceptance of the Work.

1. Extended-Warranty Period: **[Five]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for labor, materials, and equipment.
2. Warranty Period for Corrosion Resistance: **[Five]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for labor, materials, and equipment.
3. Warranty Period for Color Retention: **[Five]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for labor, materials, and equipment.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Description: **<Insert brief description of desired system, assembly, or equipment>**.
- B. Performance Criteria:
 1. Regulatory Requirements:
 - a. Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 2. Utility Approval: Comply with **<Insert name of utility>** requirements.
 3. General Characteristics:
 - a. Structural Characteristics: Comply with AASHTO LTS-6-M.
 - b. Dead Load: Weight of luminaire and its horizontal and vertical supports, lowering devices, and supporting structure, applied in accordance with AASHTO LTS-6-M.
 - c. Live Load: Single load of **500 lb** distributed in accordance with AASHTO LTS-6-M.
 - d. Ice Load: Load of **3 lb/ft²**, applied in accordance with AASHTO LTS-6-M for applicable areas on the Ice Load Map.
 - e. Wind Load for Poles Exceeding 50 ft (15 m) Height:
 - 1) Basic Wind Speed: **[100 mile/h][90 mile/h]<Insert value from AASHTO LTS-6-M for this Project>**.
 - 2) Wind Importance Factor: **[1.0]<Insert value from AASHTO LTS-6-M>**.
 - 3) Minimum Design Life: **[50 years]<Insert value from AASHTO LTS-6-M>**.
 - 4) Velocity Conversion Factor: **[1.0]<Insert value from AASHTO LTS-6-M>**.
 - f. Wind Load for Poles Not Exceeding 50 ft (15 m) Height:
 - 1) Basic Wind Speed: **[100 mile/h][90 mile/h]<Insert value from AASHTO LTS-6-M for this Project>**.
 - 2) Wind Importance Factor: **[1.0]<Insert value from AASHTO LTS-6-M>**.
 - 3) Minimum Design Life: **[25 years]<Insert value from AASHTO LTS-6-M>**.
 - 4) Velocity Conversion Factor: **[1.0]<Insert value from AASHTO LTS-6-M>**.
 - g. Strength Analysis: For each pole, multiply the actual EPA of luminaires and brackets by a factor of **[1.1]<Insert number>** to obtain the EPA used in pole selection strength analysis.
 - h. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless steel fasteners and mounting bolts unless otherwise indicated.
 - i. General Finish Requirements:
 - 1) Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

- 2) Appearance of Finished Work: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.2 LIGHTING STANDARDS

A. Steel Lighting Standard:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[American LitePole]**
 - b. **[Appleton; Emerson Electric Co., Automation Solutions]**
 - c. **[Bridgewell Resources]**
 - d. **[Cooper Lighting Solutions; Signify North America Corp.]**
 - e. **[E-conolight]**
 - f. **[H.E. Williams]**
 - g. **[Hapco]**
 - h. **[Hubbell Electrical Solutions; Hubbell Incorporated]**
 - i. **[Kim Lighting; brand of GE Current, a Daintree company; American Industrial Partners (AIP)]**
 - j. **[Lithonia Lighting; Acuity Brands Lighting, Inc.]**
 - k. **[LSI Industries]**
 - l. **[Millerbernd Manufacturing Company]**
 - m. **[NAFCO; brand of Wisconsin Lighting Lab, Inc.]**
 - n. **[RAB Lighting]**
 - o. **[Ruud Lighting; brand of Cree Lighting; subsidiary of Ideal Industries, Inc.]**
 - p. **[Union Metal Industries Corp.]**
 - q. **<Insert manufacturer's name>**
2. Source Limitations: **[Obtain lighting standards from single manufacturer or producer][For lighting standards, obtain each color, grade, finish, type, and variety of lighting standard from single source with resources to provide products of consistent quality in appearance and physical properties].**
3. Standard Features:
 - a. Comply with requirements in Article 410 of NFPA 70 for luminaire supports.
 - b. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless steel fasteners and mounting bolts unless otherwise indicated.
 - c. General Finish Requirements:
 - 1) Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
 - 2) Appearance of the Finished Work: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.
 - d. Carbon Steel Poles: Comply with ASTM A500/A500M, Grade B carbon steel with a minimum yield of **46,000 psig**; one-piece construction up to **40 ft** in height with access handhole in lighting standard wall.

- 1) Shape: **[Round, tapered][Round, straight][Square, tapered][Square, straight]**.
 - 2) Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.
- e. Stainless Steel Poles: Comply with **[ASTM A240/A240M][ASTM A666]**, stainless steel with a minimum yield of **55,000 psi**; one-piece construction up to **40 ft** in height with access handhole in lighting standard wall.
- 1) Shape: **[Round, tapered][Round, straight][Square, tapered][Square, straight]**.
 - 2) Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.
- f. Steel Mast Arms: **[Single-arm][Truss][Davit]** type, continuously welded to lighting standard attachment plate. Material and finish same as plate.
- g. Brackets for Luminaires: Detachable, cantilever, without underbrace.
- 1) Adaptor fitting welded to lighting standard, allowing the bracket to be bolted to the lighting standard-mounted adapter, then bolted together with **[stainless steel][galvanized-steel]** bolts.
 - 2) Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire. Match lighting standard material and finish.
- h. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to lighting standard top.
- i. Grounding and Bonding Lugs: Welded **1/2 inch** threaded lug, listed for attaching grounding and bonding conductors of type and size indicated, and accessible through handhole.
- j. Steps: Fixed steel, with nonslip treads.
- 1) For climbing positions, install at **15 inch** vertical spacing, alternating on opposite sides of lighting standard, oriented 180 degrees from each other; first step must be at an elevation **10 ft** above finished grade.
 - 2) For working positions, install steps on opposite side of lighting standard, oriented 180 degrees from each other at the same elevation.
- k. Handhole: Oval shaped, with minimum clear opening of **2-1/2-by-5 inch**, with cover secured by stainless steel captive screws.
- l. Intermediate Handhole and Cable Support: Weatherproof, **3-by-5 inch** handhole located at midpoint of lighting standard, with cover for access to internal welded attachment lug for electric cable support grip.
- m. Cable Support Grip: Wire-mesh type with rotating attachment eye, sized for diameter of cable and rated for a minimum load equal to weight of supported load multiplied by a 5.0 safety factor.
- n. Platform for Lamp Ballast Servicing: Factory fabricated of steel, with finish matching that of lighting standard.
- o. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.
- p. Galvanized Finish: After fabrication, hot-dip galvanize in accordance with ASTM A123/A123M.
- q. Factory-Painted Finish: Comply with NAAMM/NOMMA AMP 500 recommendations for applying and designating finishes.
- 1) Surface Preparation: Clean surfaces in accordance with SSPC-SP 1 to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, in accordance with SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
 - 2) Interior Surfaces of Pole: One coat of bituminous paint, or otherwise treat for equal corrosion protection.



- 3) Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.
 - a) Color: **[As indicated by manufacturer's designations][Match Architect's sample][As selected by Architect from manufacturer's full range].**
- r. Powder-Coat Finish: Comply with NAAMM/NOMMA AMP 500 recommendations for applying and designating finishes.
 - 1) Surface Preparation: Clean surfaces in accordance with SSPC-SP 1 to remove dirt, oil, grease, and other contaminants that could impair powder-coat bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, in accordance with SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
 - 2) Powder Coat: Comply with AAMA 2604.
 - a) Electrostatic-applied powder coating; single application and cured to a minimum **2.5 to 3.5 mil** dry film thickness. Coat interior and exterior of lighting standard for equal corrosion protection.
 - b) Color: **[As indicated by manufacturer's designations][Match Architect's sample][As selected by Architect from manufacturer's full range].**
4. Other Available Features Required by the Project:
 - a. Fasteners: **[Stainless steel][Galvanized steel]<Insert finish or grade>**, size and type as determined by manufacturer. Corrosion-resistant items compatible with support components.
 - 1) Materials: Compatible with lighting standards as well as the substrates to which lighting standards are fastened and may not cause galvanic action at contact points.
 - 2) Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.

B. Aluminum Lighting Standard:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[American LitePole]**
 - b. **[Appleton; Emerson Electric Co., Automation Solutions]**
 - c. **[Bridgewell Resources]**
 - d. **[Cooper Lighting Solutions; Signify North America Corp.]**
 - e. **[E-conolight]**
 - f. **[H.E. Williams]**
 - g. **[Hapco]**
 - h. **[Hubbell Electrical Solutions; Hubbell Incorporated]**
 - i. **[Kim Lighting; brand of GE Current, a Daintree company; American Industrial Partners (AIP)]**
 - j. **[Lithonia Lighting; Acuity Brands Lighting, Inc.]**
 - k. **[LSI Industries]**
 - l. **[Lyte Poles; brand of DWM Holdings, Inc.]**
 - m. **[NAFCO; brand of Wisconsin Lighting Lab, Inc.]**
 - n. **[Ruud Lighting; brand of Cree Lighting; subsidiary of Ideal Industries, Inc.]**
 - o. **[Sentry Electric, LLC]**

- p. [Union Metal Industries Corp.]
 - q. [Valmont Industries, Inc.]
 - r. <Insert manufacturer's name>
2. Source Limitations: [Obtain lighting standards from single manufacturer or producer][For lighting standards, obtain each color, grade, finish, type, and variety of lighting standard from single source with resources to provide products of consistent quality in appearance and physical properties].
 3. Standard Features:
 - a. Comply with requirements in Article 410 of NFPA 70 for luminaire supports.
 - b. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless steel fasteners and mounting bolts unless otherwise indicated.
 - c. General Finish Requirements:
 - 1) Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
 - 2) Appearance of the Finished Work: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.
 - d. [Seamed][Seamless], extruded structural tube complying with ASTM B221, [Alloy 6063-T6][Alloy 6061-T6], with access handhole in in lighting standard wall.
 - 1) Shape: [Round, tapered][Round, straight][Square, tapered][Square, straight].
 - 2) Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.
 - e. Mast Arms: [Aluminum][Steel][Single-arm][Truss][Davit] type, continuously welded to lighting standard attachment plate. Material and finish same as plate.
 - f. Brackets for Luminaires: Detachable, cantilever, without underbrace.
 - 1) Adaptor fitting welded to lighting standard, allowing the bracket to be bolted to the lighting standard-mounted adapter, then bolted together with [stainless steel][galvanized-steel] bolts.
 - 2) Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire. Match lighting standard material and finish.
 - g. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to lighting standard top.
 - h. Grounding and Bonding Lugs: Bolted 1/2 inch threaded lug, listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.
 - i. Handhole: Oval shaped, with minimum clear opening of 2-1/2 by 5 inch, with cover secured by stainless steel captive screws.
 - j. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.
 - k. Aluminum Finish: Comply with NAAMM/NOMMA AMP 500 recommendations for applying and designating finishes.
 - 1) Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
 - 2) Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20 requirements; and seal aluminum surfaces with clear, hard-coat wax.
 - 3) Class I, Clear-Anodic Finish: AA-M32C22A41 (Mechanical Finish: Medium satin;



Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I clear coating of 0.018 mm or thicker), complying with AAMA 611.

- 4) Class I, Color-Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: Medium; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I integrally colored or electrolytically deposited color coating 0.018 mm or thicker), complying with AAMA 611.

- I. Factory-Painted Finish: Comply with NAAMM/NOMMA AMP 500 recommendations for applying and designating finishes.

- 1) Surface Preparation: Clean surfaces to comply with SSPC-SP 1 to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, in accordance with SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
- 2) Interior Surfaces of Pole: One coat of bituminous paint, or otherwise treat for equal corrosion protection.
- 3) Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.

- a) Color: **[As indicated by manufacturer's designations][Match Architect's sample][As selected by Architect from manufacturer's full range].**

- m. Powder-Coat Finish: Comply with NAAMM/NOMMA AMP 500 recommendations for applying and designating finishes.

- 1) Surface Preparation: Clean surfaces to comply with SSPC-SP 1 to remove dirt, oil, grease, and other contaminants that could impair powder coat bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, in accordance with SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
- 2) Powder coat must comply with AAMA 2604.

- a) Electrostatic applied powder coating; single application with a minimum **2.5 to 3.5 mil** dry film thickness; cured in accordance with manufacturer's published instructions. Coat interior and exterior of lighting standard for equal corrosion protection.
- b) Color: **[As indicated by manufacturer's designations][Match Architect's sample][As selected by Architect from manufacturer's full range].**

4. Other Available Features Required by the Project:

- a. Fasteners: **[Stainless steel][Galvanized steel]<Insert finish or grade>**, size and type as determined by manufacturer. Corrosion-resistant items compatible with support components.
 - 1) Materials: Compatible with lighting standards as well as to substrates to which lighting standards are fastened and may not cause galvanic action at contact points.
 - 2) Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.

- C. Fiberglass Lighting Standard:

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

- a. **[Alliance; a division of GEOTEK]**
 - b. **[Bridgewell Resources]**
 - c. **[CMT; a Valmont Company]**
 - d. **[Lithonia Lighting; Acuity Brands Lighting, Inc.]**
 - e. **[PLP Composite Technologies, Inc]**
 - f. **[Shakespeare; a Valmont Company]**
 - g. **[Valmont Industries, Inc.]**
 - h. **[Whately; a Valmont Company]**
 - i. **[Wood Preservers, Inc.]**
 - j. **<Insert manufacturer's name>**
2. Source Limitations: **[Obtain lighting standards from single manufacturer or producer][For lighting standards, obtain each color, grade, finish, type, and variety of lighting standard from single source with resources to provide products of consistent quality in appearance and physical properties].**
3. Standard Features:
- a. Comply with requirements in Article 410 of NFPA 70 for luminaire supports.
 - b. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless steel fasteners and mounting bolts unless otherwise indicated.
 - c. General Finish Requirements:
 - 1) Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
 - 2) Appearance of the Finished Work: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.
 - d. Designed specifically for supporting luminaires, with factory-formed cable entrance and handhole.
 - e. Not less than 65 percent by weight of fiberglass roving, with resin and pigment making up the remainder.
 - f. Roving must be continuously applied with uniform tension, with multiple layers placed to meet axial and compressive strength requirements.
 - g. Shape: **[Round, tapered][Round, straight][Square, tapered][Square, straight].**
 - h. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.
 - i. Surface Finish: Smooth and uniform along surface of lighting standard.
 - j. Paint Finish: Pigmented polyurethane, with a minimum dry film thickness of **1.5 mil**. Polyurethane may be omitted if the surface layer of the lighting standard is inherently UV inhibited.
 - k. Mast Arms: **[Aluminum][Steel][Fiberglass][Single-arm][Truss][Davit]** type, continuously welded to lighting standard attachment plate. Material and finish same as plate. Adaptor plate must be steel hot-dip galvanized in accordance with ASTM A153/A153M or Alloy 6061-T6 aluminum encased within fiberglass roving, allowing the mast arm adaptor to be bolted to the lighting standard.
 - l. Brackets for Luminaires: Detachable, cantilever, without underbrace.
 - 1) Adaptor Fitting: Steel, hot-dip galvanized in accordance with ASTM A153/A153M, or Alloy 6061-T6 aluminum, permanently bonded within fiberglass roving, allowing the bracket to be bolted to the lighting standard-mounted adapter. Bolt together with **[stainless steel][galvanized-steel]** bolts; use anti-seize compound when bolting dissimilar metals.
 - 2) Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire. Match lighting standard material and finish.



- m. Pole-Top Tenons: Steel, hot-dip galvanized in accordance with ASTM A153/A153M, or Alloy 6061-T6 aluminum, permanently bonded to the fiberglass shaft. Fabricated to support luminaire or luminaires and brackets indicated.
 - n. Handhole: Oval shaped, with minimum clear opening of **2-1/2 by 5 inch**, with cover secured by stainless steel captive screws.
 - o. Grounding: Bare, stranded copper, 6 AWG, **[suspended inside of lighting standard][inside 3/4 inch conduit fastened to the interior of the lighting standard]**, connected to luminaire(s), ground lug near handhole, and ground rod.
 - p. Grounding and Bonding Lugs: Bolted **1/2 inch** threaded lug, listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.
4. Other Available Features Required by the Project:
- a. Resin Color: **[Black][Dark][Bronze]<Insert color>**; uniform coloration throughout entire wall thickness.
 - b. Anchor Base: Integral galvanized-steel or aluminum casting, enclosing and permanently bonded to the exterior of the fiberglass shaft.
 - c. Fasteners: **[Stainless steel][Galvanized steel]<Insert finish or grade>**, size and type as determined by manufacturer. Corrosion-resistant items compatible with support components.
 - 1) Materials: Compatible with lighting standards as well as the substrates to which lighting standards are fastened and may not cause galvanic action at contact points.
 - 2) Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.

D. Laminated Wood Lighting Standard:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Bell Lumber and Pole Company]**
 - b. **[Hughes Brothers, Inc.]**
 - c. **[Laminated Wood Systems, Inc.]**
 - d. **[Lithonia Lighting; Acuity Brands Lighting, Inc.]**
 - e. **[McFarland Cascade]**
 - f. **[Timber Technologies, LLC]**
 - g. **[TimberWood Products; J.H. Baxter & Co.]**
 - h. **[Valmont Industries, Inc.]**
 - i. **<Insert manufacturer's name>**
- 2. Source Limitations: **[Obtain lighting standards from single manufacturer or producer][For lighting standards, obtain each color, grade, finish, type, and variety of lighting standard from single source with resources to provide products of consistent quality in appearance and physical properties]**.
- 3. Standard Features:
 - a. Comply with requirements in Article 410 of NFPA 70 for luminaire supports.
 - b. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless steel fasteners and mounting bolts unless otherwise indicated.
 - c. General Finish Requirements:

- 1) Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
 - 2) Appearance of the Finished Work: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.
- d. Species and Grades for Structural Laminated Timber: Complying with APA A190.1. Use **[Southern pine][Douglas fir][Alaska cedar][any species listed in APA 117]**, engineered and fabricated to withstand indicated structural loads without exceeding allowable design working stresses in accordance with **[APA 117][AWPA/ANSI O5.2]**.
 - e. Features include **[wood bracket][wood crossarm][lighting standard-top adaptor]<Insert items>** for mounting luminaire(s), metal lighting standard cap, and concealed raceway path connected to access handhole.
 - f. Mounting Provisions: **[Embedded]<Insert description of other mounting unless detailed on the Drawings>**.
 - g. Appearance Grade: Architectural appearance grade complying with AITC 110.
 - h. Preservative Treatment:
 - 1) Exposure: Comply with **[AWPA U1, Use Category UC4A][AWPA U1, Use Category UC4B][AWPA U1, Use Category UC4C]**.
 - 2) Treatment after Dressing and End Cutting: Comply with AWPA M4 for surface cuts to a depth of more than **1/16 inch**.
 - i. Adhesive: Wet-use type complying with ASTM D2559.
 - j. End Sealer: Manufacturer's standard, transparent, colorless wood sealer that is effective in retarding the transmission of moisture at cross-grain cuts and is compatible with indicated finish.
 - k. Penetrating Sealer: Manufacturer's standard, transparent, penetrating wood sealer that is compatible with indicated finish.
 - l. Finish: **[Natural, unstained wood][Semitransparent stain applied after erection][Factory-applied semitransparent stain]**, color as selected by Architect.
4. Other Available Features Required by the Project:
 - a. Fasteners: **[Stainless steel][Galvanized steel]<Insert finish or grade>**, size and type as determined by manufacturer. Corrosion-resistant items compatible with support components.
 - 1) Materials: Compatible with lighting standards as well as to substrates to which lighting standards are fastened and may not cause galvanic action at contact points.
 - 2) Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.

E. Wood Lighting Standard:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American Pole & Timber]**
 - b. **[Baldwin Pole & Piling Co., Inc.]**
 - c. **[Bell Lumber and Pole Company]**
 - d. **[Cavawood Architectural Products]**
 - e. **[Cobb Lumber Company]**

- f. [Cox Utility Products Division]
 - g. [Guelph Utility Pole Co., Ltd.; a Stella-Jones company]
 - h. [Koppers Performance Chemicals]
 - i. [Langdale Forest Products Company]
 - j. [Lithonia Lighting; Acuity Brands Lighting, Inc.]
 - k. [McFarland Cascade]
 - l. [Stella-Jones]
 - m. [T.R. Miller Mill Co., Inc.]
 - n. [Texas Electric Cooperatives, Inc.]
 - o. [Thomasson Company]
 - p. [TimberWood Products; J.H. Baxter & Co.]
 - q. [United Wood Treating Company]
 - r. [Wood Preservers, Inc.]
 - s. <Insert manufacturer's name>
2. Source Limitations: **[Obtain lighting standards from single manufacturer or producer][For lighting standards, obtain each color, grade, finish, type, and variety of lighting standard from single source with resources to provide products of consistent quality in appearance and physical properties].**
3. Standard Features:
- a. Comply with requirements in Article 410 of NFPA 70 for luminaire supports.
 - b. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless steel fasteners and mounting bolts unless otherwise indicated.
 - c. General Finish Requirements:
 - 1) Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
 - 2) Appearance of the Finished Work: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.
 - d. **[Douglas fir][Southern yellow pine], [machine trimmed by turning,]** for wood species used; and bored, roofed, and grained before treatment.
 - 1) Pole Brand: Brand the manufacturer's trademark and date of treatment, height and class of lighting standard, wood species, preservation code, and retention. Brand must be placed so that the bottom of the brand is minimum **10 ft** from lighting standard butt.
 - 2) Mounting Provisions: Embedded.
 - e. Preservative Treatment: Treat in accordance with **[AWPA U1, Use Category UC4A][AWPA U1, Use Category UC4B][AWPA U1, Use Category UC4C].**
 - f. Luminaire Brackets: Comply with NEMA/ANSI C136.13.
4. Other Available Features Required by the Project:
- a. Fasteners: **[Stainless steel][Galvanized steel]<Insert finish or grade>**, size and type as determined by manufacturer. Corrosion-resistant items compatible with support components.
 - 1) Materials: Compatible with lighting standards as well as the substrates to which lighting standards are fastened and may not cause galvanic action at contact points.
 - 2) Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after

fabrication unless otherwise indicated.

F. Prestressed Concrete Lighting Standard:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Baldwin Pole & Piling Co., Inc.]**
 - b. **[Holophane; an Acuity Brands company]**
 - c. **[Lithonia Lighting; Acuity Brands Lighting, Inc.]**
 - d. **[Lonestar Prestress Mfg., Inc.]**
 - e. **[NOV Ameron]**
 - f. **[Pre-Cast Specialties, Inc.]**
 - g. **[Seminole Pole, Inc.]**
 - h. **[StressCrete Group]**
 - i. **<Insert manufacturer's name>**
2. Source Limitations: **[Obtain lighting standards from single manufacturer or producer][For lighting standards, obtain each color, grade, finish, type, and variety of lighting standard from single source with resources to provide products of consistent quality in appearance and physical properties]**.
3. Standard Features:
 - a. Comply with requirements in Article 410 of NFPA 70 for luminaire supports.
 - b. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless steel fasteners and mounting bolts unless otherwise indicated.
 - c. General Finish Requirements:
 - 1) Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
 - 2) Appearance of the Finished Work: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.
 - d. Comply with ASTM C1089**[and manufactured by centrifugal spin-casting process][and manufactured by static-casting method]**.
 - 1) Shape: **[Round, tapered][Round, straight][Square, tapered][Square, straight]**.
 - 2) Mounting Provisions: **[Steel butt flange for bolted mounting to foundation or breakaway support][Embedded]**.
 - 3) Finishing: Capped at top and plugged at bottom. Seat each reinforcing strand with epoxy adhesive.
 - 4) Grounding: Continuous copper ground wire cast into lighting standard. Terminate at top of lighting standard**[and attach to 24 inch lighting rod]**.
 - 5) Raceway: Smooth, internal, and not less than **3 inch** in diameter.
 - e. Concrete: Minimum 28-day compressive strength of **[7000 psi]<Insert value>**.
 - f. Cured with wet steam and aged for a minimum of 15 days prior to installation.
 - g. Reinforcement: **[Reinforcing bars complying with ASTM A615/A615M][Cold-drawn spiral wire complying with ASTM A1064/A1064M][Prestressing strand, 270 K, complying with ASTM A416/A416M]**.
 - h. Surface Treatment: Hard, nonporous, and resistant to water, frost, and road and soil chemicals; and must have a maximum water-absorption rate of 3 percent.



- i. Finish Texture: **[Standard form][Polished exposed aggregate][Etched exposed aggregate]**.
- 1) Exposed aggregate must be of **<Insert aggregate type selected from manufacturers' lists>** type.
- j. Nameplate: Aluminum cast into lighting standard wall at approximately **5 ft** above ground line, listing name of manufacturer, the Project identifier, overall height, and approximate weight.
- k. Pole Brackets: Comply with NEMA/ANSI C136.31.
- 4. Other Available Features Required by the Project:
 - a. Fasteners: **[Stainless steel][Galvanized steel]<Insert finish or grade>**, size and type as determined by manufacturer. Compatible with lighting standards as well as the substrates to which lighting standards are fastened and may not cause galvanic action at contact points.

2.3 LIGHTING STANDARD ACCESSORIES

- A. Duplex Receptacle: Ground-fault circuit interrupter type, 120 V(ac), 20 A in a weatherproof assembly.
 - 1. **[Surface mounted][Recessed][12 inch]<Insert dimensions>** above finished grade.
 - a. UL 50E, **[Type 3R][Type 4X]**, nonmetallic polycarbonate plastic or reinforced fiberglass, enclosure with cover; color to match pole.
 - b. Lockable hasp and latch complying with OSHA lockout and tag-out requirements.
- B. Minimum 1800 W transformer, protected by replaceable fuses, mounted behind access cover.
- C. Base Covers: Manufacturers' standard metal units, finished same as pole, and arranged to cover pole's mounting bolts and nuts.
- D. Transformer-Type Base: Same material and color as pole. Coordinate dimensions to suit pole's base flange and to accept **[ballast(s)][indicated accessories]**. Include removable flanged access cover secured with bolts or screws.
- E. Decorative accessories, supplied by decorative pole manufacturer, include the following:
 - 1. Banner Arms: **<Insert material>**.
 - 2. Flag Holders: **<Insert material>**.
 - 3. Ladder Rests: **<Insert material>**.
- F. Lowering System for Luminaires:
 - 1. System Description: Capable of lowering luminaire **[assembly]** to a service position within **36 inch** of finished grade in winds up to **30 mile/h**. Provide manual plug connection to electrical power accessible in lowered position. Assembled system of pole, luminaire, and lowering device must be capable of loads specified in "Performance Requirements" Article.
 - 2. Compatibility of Material: Materials for attachment and connection of luminaire-mounting assembly, lowering device, lowering cable, and portable winch must be compatible to avoid corrosion and electrolysis.
 - 3. Structural and Mechanical Design Safety Factor: 5.0, minimum, for static and dynamic loads of

- load-bearing components, including cable.
4. Luminaire-Mounting and Disconnect Arrangement: Multiple **[ring][carriage]**-mounted luminaires, arranged for lowering and rising as a group.
 - a. Electrical cable for normal operating power to luminaires must manually disconnect inside pole base, using weatherproof multi-pin connector, and must be arranged to move within the pole during lowering and rising of luminaire assembly.
 - b. Electrical cable for normal operating power to luminaires must automatically disconnect at weatherproof multi-pin connector within the pole-top lowering head at the beginning of the lowering cycle and reconnect when luminaire or luminaire assembly is raised to the operating position.
5. Lowering Device: Weatherproof, cast-aluminum housing, and multiple mechanical latches. Moving parts of latching assembly must be located in the portion of the unit that is lowered to servicing position. Positive latching in the operating position must be indicated to the operator at the base of the pole by a clear visual signal or by other means acceptable to Owner or authorities having jurisdiction.
6. Lowering Cable: **[Zinc-electroplated-steel][or][stainless steel]** aircraft cable.
7. Portable Winch: **[Manual][120 V electric]** type. **[One]<Insert number>** required.
 - a. Winch Power Connection: Cord and plug.
 - b. Winch Raise-Lower Control: Remote-control station with **[15 ft]<Insert dimension>** of cable.

G. Mounting Hardware:

1. Anchor Bolts: Manufactured **[to ASTM F1554, Grade 55,]**with a minimum yield strength of **55,000 psi**.
 - a. Galvanizing: **[Hot-dip galvanized in accordance with ASTM A153/A153M, Class C][Mechanically deposited galvanization in accordance with ASTM B695, Class 50]**.
 - b. **[Bent][Headed]** rods **<Insert dimension>** in diameter by **<Insert dimension>** in length.
 - c. Threading: **[Uniform National Coarse][Uniform National 8]**, Class 2A.
2. Nuts: ASTM A563/A563M, Grade A, Heavy-Hex.
 - a. Galvanizing: **[Hot-dip galvanized in accordance with ASTM A153/A153M, Class C][Mechanically deposited galvanization in accordance with ASTM B695, Class 50]**.
 - b. **[Two][Four]<Insert number>** nuts provided per anchor bolt, **shipped with nuts preassembled to the anchor bolts**.
3. Washers: ASTM F436/F436M, Type 1.
 - a. Galvanizing: **[Hot-dip galvanized in accordance with ASTM A153/A153M, Class C][Mechanically deposited galvanization in accordance with ASTM B695, Class 50]**.
 - b. **[One][Two]<Insert number>** washer(s) provided per anchor bolt.

2.4 UTILITY POLES

A. Wood Utility Pole:

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

- a. **[Ace Pole Company]**
 - b. **[Baxter, J. H. & Co]**
 - c. **[Bell Lumber and Pole Company]**
 - d. **[Brown Wood Preserving Co., Inc.]**
 - e. **[Dayton Superior Corporation]**
 - f. **[Koppers Performance Chemicals]**
 - g. **[McFarland Cascade]**
 - h. **<Insert manufacturer's name>**
 2. Source Limitations: **[Obtain poles from single manufacturer or producer][For poles, obtain each color, grade, finish, type, and variety of pole from single source with resources to provide products of consistent quality in appearance and physical properties].**
 3. Standard Features:
 - a. Comply with ATIS O5.1 and RUS Bulletin 1728F-700, for wood poles pressure treated with **[creosote][pentachlorophenol][ammoniacal copper arsenate][ammoniacal copper zinc arsenate][and][chromated copper arsenate].**
 - b. Wood Species: **[Douglas fir][Lodgepole pine][Western larch][Southern yellow pine]<Insert wood species selected from ATIS O5.1>.**
 - c. Pole Marking:
 - 1) Manufacturer's Mark: Comply with ATIS O5.1; locate **10 ft** from the pole butt for poles **50 ft** long or less.
 - 2) Pole Number: Machine-embossed aluminum, alphanumeric characters not less than **2-1/2 inch** high, with aluminum nails.
 - d. Factory Operations: Machine trim poles by turning smooth, full length. Roof, gain, and bore poles before pressure treatment.
- B. Concrete Utility Pole:**
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Accord Industries]**
 - b. **[Bayshore Concrete Products Corporation]**
 - c. **[CPI Concrete Products]**
 - d. **[StressCrete Group]**
 - e. **[Valmont Industries, Inc.]**
 - f. **<Insert manufacturer's name>**
 2. Source Limitations: **[Obtain poles from single manufacturer or producer][For poles, obtain each color, grade, finish, type, and variety of pole from single source with resources to provide products of consistent quality in appearance and physical properties].**
 3. Standard Features:
 - a. Spun-cast prestressed concrete, complying with requirements of ASTM C1089.
 - 1) Comply with requirements of RUS Bulletin 1724E-216.
 - b. Design: Base design on calculation of strength required by IEEE C2 or indicated on the Drawings, whichever is greater. Design must be suitable for installation at a location where annual temperature range is between **[minus 4 deg F and plus 100 deg F]<Insert design**

- c. **temperature range at site location**>. Include pole design for embedded attachments matching fittings, brackets, and other items installed in the field.
- d. Shaft: Hollow, for poles at overhead-to-underground connections. Provide metric designator 91 (trade size 3-1/2) minimum cable raceway capacity, with **[conduit elbow][cable entry port]** at base.
- e. Water Absorption: Not more than 3 percent.
- f. Surface: Smooth, hard, nonporous, and resistant to **[soil acids][road salts][frost and freezing damage]**.
- g. Pole Marking:
 - 1) Manufacturer's Mark: Comply with ATIS O5.1; locate **10 ft** from the pole butt for poles **50 ft** long or less.
 - 2) Pole Number: Machine-embossed aluminum, alphanumeric characters not less than **2-1/2 inch** high.

2.5 UTILITY POLE ACCESSORIES

A. Crossarms:

1. Description: **[Solid-wood distribution type, complying with RUS Bulletin 1728H-701 for specified construction grade][Galvanized, steel angles]**, and complying with IEEE C2 for required climbing space and wire clearances.
2. Braces: Galvanized, flat, ferrous-metal units; **1/4 inch** thick by **1-1/4 inch** wide, minimum, with length to suit crossarm dimensions.

B. Guys and Anchors:

1. Guy Strand Assemblies: Cable and attachment assemblies must have uniform minimum breaking strength of the cable.
 - a. Cable: Seven strands. **[Zinc-coated steel, complying with ASTM A475][Aluminum-clad steel, complying with ASTM B416][Copper-clad steel, complying with ASTM B228]**. Breaking strength must be not less than **[10,000 lb]<Insert value>**.
 - b. Cable Termination:
 - 1) Thimble eye.
 - 2) Hooks and guy strain plates, complying with IEEE C135.1.
 - 3) Preformed galvanized-steel guy grips, matching material, galvanizing, and strength of the guy strand assembly.
2. Anchor and Anchor-Rod Assemblies: Hot-dip galvanized steel.
 - a. Power-installed, screw-type anchors.
 - 1) **15 inch** screw; with rod **8 ft** long by **1-1/2 inch** in diameter. Rated at **10,000 lb** when installed.
 - 2) Guy anchors must have strength and holding area as required for anchor load and soil conditions at location of that anchor.
 - b. **<Insert anchor size or type>**.
3. Strain Insulators: Epoxy-bonded fiberglass of length to meet clearance requirements specified in "Installation of Guys and Anchors" Subparagraph in "Installation of Utility Poles" Article.
4. Guy Markers: Round, of vinyl or PVC material, **[white][yellow]** color, **8 ft** long. Shatter resistant at temperatures below **0 deg F**.



PART 3 - EXECUTION

3.1 INSTALLATION OF FOUNDATIONS FOR POLES AND LIGHTING STANDARDS

- A. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Structural steel complying with ASTM A36/A36M and hot-dip galvanized in accordance with ASTM A123/A123M; and with top-plate and mounting bolts to match pole-base flange and strength required to support pole, luminaire, and accessories. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete."
- B. Precast Foundations: Factory fabricated, with structural steel complying with ASTM A36/A36M and hot-dip galvanized in accordance with ASTM A123/A123M; and with top-plate and mounting bolts to match pole-base flange and strength required to support pole, luminaire, and accessories. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete."
- C. Power-Installed Screw Foundations: Factory fabricated by pole manufacturer, with structural steel complying with ASTM A36/A36M and hot-dip galvanized in accordance with ASTM A123/A123M; and with top-plate and mounting bolts to match pole-base flange and strength required to support pole, luminaire, and accessories.
 - 1. Baseplate: Stamped with manufacturer's name, date of production, and cable entry.
- D. Direct-Buried Foundations: Install to depth indicated on the Drawings, but not less than **[one-sixth of pole height][as indicated]**. Add backfill **[in 6 to 9 inch layers, tamping each layer before adding the next][as indicated on the Drawings]**<Insert requirement>. To ensure a plumb installation, continuously check pole orientation with plumb bob while tamping.
- E. Direct-Buried Poles with Concrete Backfill: Set poles in augered holes to depth below finished grade indicated on the Drawings, but not less than **[one-sixth of pole height][as indicated]**. To ensure a plumb installation, continuously check pole orientation with plumb bob while tamping.
 - 1. Make holes **6 inch** in diameter larger than pole diameter.
 - 2. Fill augered hole around pole with air-entrained concrete having a minimum compressive strength of **3000 psi** at 28 days and finish in a dome above finished grade.
 - 3. Use a short piece of **1/2 inch** diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.
 - 4. Cure concrete a minimum of 72 hours before performing work on pole.
- F. Anchor Bolts: Install plumb using manufacturer-supplied **[steel][plywood]** template, uniformly spaced.

3.2 INSTALLATION OF LIGHTING STANDARDS

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturers' published instructions, comply with the following:
 - 1. Electrical Construction: NFPA 1, NFPA 70, and NECA NEIS 1.
 - 2. Electrical Safety: NFPA 70E.
 - 3. Hot Work: NFPA 51B.
 - 4. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
 - 5. Consult Architect for resolution of conflicting requirements.

C. Special Installation Techniques:

1. Alignment: **[Align foundations and lighting standards for optimum directional alignment of luminaires and their mounting provisions on lighting standards][Align lighting standards as indicated]**.
2. Clearances: Maintain the following minimum horizontal distances of lighting standards from surface and underground features unless otherwise indicated on the Drawings:
 - a. Fire Hydrants and Water Piping: **[60 inch]<Insert dimension>**.
 - b. Water, Gas, Electric, Communications, and Sewer Lines: **[10 ft]<Insert dimension>**.
 - c. Trees: **15 ft** from tree trunk.
 - d. **<Insert features and clearance dimensions>**.
3. Concrete Lighting Standard Foundations: Set anchor bolts in accordance with anchor-bolt templates furnished by manufacturer. Concrete materials, installation, and finishing requirements are specified in Section 033000 "Cast-in-Place Concrete."
4. Foundation-Mounted Lighting Standards: Mount lighting standards with leveling nuts and tighten top nuts to torque level in accordance with manufacturer's published instructions.
 - a. Use anchor bolts and nuts selected to resist seismic forces specified for the application and approved by manufacturer.
 - b. Grout void between lighting standard base and foundation. Use nonshrink or expanding concrete grout firmly packed to fill space.
 - c. Install base covers unless otherwise indicated.
 - d. Use a short piece of **1/2 inch** diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of lighting standard.
5. Lighting Standards and Foundations Set in Concrete-Paved Areas: Install lighting standards with a minimum **6 inch** wide, unpaved gap between the lighting standard or foundation and the edge of the adjacent concrete slab. Fill unpaved ring with pea gravel. Insert material to a level **1 inch** below top of concrete slab.
6. Raise and set lighting standard using web fabric slings (not chain or cable) at locations indicated by manufacturer.
7. Corrosion Prevention:
 - a. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum using insulating fittings or treatment.
 - b. Steel Conduits: Comply with requirements in Section 260533.13 "Conduits for Electrical Systems." In concrete foundations, wrap conduit with **0.010 inch** thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

D. Interfaces with Other Work:

1. Grounding and Bonding: Bond metallic components of lighting standards and support structures as follows:
 - a. Provide insulated equipment grounding conductors with supply feeders for bonding luminaires and other pole-mounted electrical or electronic equipment to ground terminals of their supplying power sources in accordance with Article 250 of NFPA 70.
 - b. Bond metallic components of luminaires, pole accessories, and foundation to insulated equipment grounding conductor.
2. Identification: Provide labels for lighting standards, components, wiring, cabling, terminals, and associated electrical equipment.
 - a. Identify field-installed conductors, interconnecting wiring, and components.

- b. Label each enclosure with engraved metal or laminated-plastic nameplate.
- c. Provide warning signs and arc-flash hazard warning labels for electrical equipment.

3.3 INSTALLATION OF UTILITY POLES

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturers' published instructions, comply with the following:
 - 1. Electrical Construction: **[IEEE C2][NFPA 70 and NECA NEIS 1]**.
 - 2. Electrical Safety: NFPA 70E.
 - 3. Hot Work: NFPA 51B.
 - 4. Grounding and Bonding: **[IEEE C2][NECA NEIS 331 and Article 250 of NFPA 70]**.
 - 5. Communications Work: BICSI N1.
 - 6. Consult Architect for resolution of conflicting requirements.
- C. Special Installation Techniques:
 - 1. Engage the services of a licensed surveyor to verify dimensions by field measurement, to identify locations of poles, anchors, and other features, and to verify all clearances. The survey document must also identify locations of connections to new and existing supply lines and to primary and secondary services. Notify Architect of discrepancies and field conditions that are not indicated and that will affect installation.
 - 2. Pole Orientation: Align curve of curved wood poles with straight-line runs of three or more poles. Align gained surfaces perpendicular to runs.
 - 3. Elevation of Line above Grade: Install poles with top at same elevation, unless grade changes dictate elevation change in poles, and in accordance with the following:
 - a. On level ground, set poles so tops of consecutive poles vary not more than **60 inch** in elevation.
 - b. Shorten wood poles by cutting off the top and make cuts to shed water. Apply preservative to cuts.
 - 4. Set poles in accordance with the following:
 - a. Make pole holes vertical, uniform in diameter, and large enough to permit effective use of tamping bars all around. Bore or excavate holes with an average diameter at grade less than twice the diameter of the pole at the same grade.
 - b. Use minimum depths indicated, except at locations where hole is partly or entirely in rock and if hole is not vertical or has a diameter at grade more than two times the pole diameter at the same level; in these conditions, increase the depth of the hole by the following increments before setting the pole:
 - 1) Poles up to 35 ft (10.6 m) Long: **24 inch**.
 - 2) Poles 36 to 60 ft (11 to 18.3 m) Long: **30 inch**.
 - 3) Poles 61 to 75 ft (18.6 to 22.9 m) Long: **36 inch**.
 - c. For poles on slopes, indicated hole depth is from finished grade at lowest side of hole.
 - d. Set poles in alignment and plumb except at dead ends, angles, and points of extra strain; rake poles against conductor strain **1 inch** minimum, **2 inch** maximum, (after conductors are installed at required tension) for each **10 ft** of pole length. Rake poles so they will not lean or bend in direction of strain when loaded.
 - e. Backfill holes in **6 inch** maximum lifts, and thoroughly tamp each layer before starting the

- next.
- f. Place surplus earth around pole in a conical shape, and tamp thoroughly to provide drainage away from pole.
 - g. Set poles so alternate crossarm gains face in alternate directions, except at terminals and dead ends; place gains on last two poles on side facing terminal or dead end.
 - h. Poles Set in Concrete Paved Areas: Install poles with minimum of **6 inch** wide, unpaved gap between the pole and the edge of adjacent concrete slab. Fill unpaved ring with **[pea gravel]**<Insert appropriate material> to a level **1 inch** below top of concrete slab.
5. Field treat factory-treated poles and crossarms as follows:
 - a. Poles Treated More Than One Year before Installation: Treat portion from **24 inch** above ground line to butt.
 - b. Field-Bored Holes and Field-Cut Gains and Pole Tops: Treat cut portions.
 - c. Unused Holes: Treat and plug with treated-wood-dowel drive pins.
 - d. Engage the services of qualified wood pole and crossarm treatment technician to apply treatment. Comply with requirements in AWWPA standards that govern original factory treatment for field-applied treatment and application of chemicals.
 6. Installation of Crossarms: Set line crossarms at right angle to line for straight runs and for angles 45 degrees and more. Bisect angles less than 45 degrees.
 - a. Buck Arms: Install at corners and junction poles unless otherwise indicated.
 - b. Double Crossarms: Install at dead ends, corners, angles, and line crossings.
 - c. Equipment Arms: Locate below lines and set parallel or at right angles to them, whichever provides best climbing space.
 - d. Gains: Install factory-cut or metal-pole gains only. Do not cut gains in field without specific written approval.
 7. Installation of Guys and Anchors:
 - a. Install guys to resist unbalanced loads, including those developed at angles, corners, and dead ends. Install two or more guys if a single guy will not provide adequate strength. Install separate guys if unbalanced loads are separated by **36 inch** or more. Comply with IEEE C2.
 - 1) Unless a thimble eye is used, at the pole end, install a minimum of two guy hooks and two guy strain plates.
 - 2) At the anchor end, attach guy strand assembly with preformed grips.
 - b. Protect guy strands from damage. Replace damaged guy strands. Install guy insulators where required to comply with IEEE C2 clearance requirements.
 - c. Install guys with a lead-to-height ratio of 1 to 1 unless otherwise indicated. The minimum lead-to-height ratio must be 1/2 to 1. When less than 1 to 1, increase guy strength by the ratio of the sine of the lead angle indicated to the sine of the lead angle provided.
 - d. Install screw-type guy anchors aligned in soil with guy. Set with anchor rod pointing at guy attachment on pole and rod projecting **6 to 9 inch** from ground.
 - e. Install strain insulators to provide a minimum of **12 inch** of clearance between the nearest energized surface and the strain insulator fitting farthest from the pole. When loaded to the tension indicated, fiberglass strain insulators must be loaded to not more than two-thirds of manufacturer's published rating.
 8. Guy Markers: Install at anchor end of guys to visually mark the guy wire at all accessible locations. Clamp to guy strand or anchor at top and bottom of marker.

D. Interfaces with Other Work:

1. Grounding and Bonding:
 - a. Comply with [IEEE C2][NFPA 70] grounding and bonding requirements.
 - b. Ground Rods: [Copper-clad][Zinc-coated][Stainless] steel[, sectional type]; [3/4 inch by 10 ft][5/8 inch by 8 ft].
 - 1) Install [two]<Insert number> parallel ground rods if resistance to ground by a single, ground-rod electrode exceeds 25 Ω .
 - 2) Drive ground rods until tops are **12 inch** below finished grade in undisturbed earth.
 - c. Grounding (Earthing) Conductors:
 - 1) 4 AWG minimum, soft-drawn copper.
 - 2) Conductor Protectors for Wood Poles: Half-round PVC or wood molding; if wood, use pressure-treated fir, cypress, or cedar. Protect grounding conductors running on surface of wood poles with molding extended from grade level up to and through communications service and transformer spaces.
 - 3) Ground-Rod Connections: Install bolted connectors for underground connections and connections to rods.
 - 4) Lightning Arrester Grounding Conductors: Separate from other grounding conductors.
 - d. Bonding Conductors: Provide equipment grounding conductors with supply feeders for bonding pole-mounted electrical and electronic equipment to ground terminals of their supplying power sources in accordance with Article 250 of NFPA 70.
2. Identification: Provide labels for poles, components, wiring, cabling, terminals, and associated electrical equipment.
 - a. Identify field-installed conductors, interconnecting wiring, and components.
 - b. Label each enclosure with engraved metal or laminated-plastic nameplate.
 - c. Provide warning signs and arc-flash hazard warning labels for electrical equipment.
 - d. Locate pole numbers to provide maximum visibility from the road or patrol route.

3.4 FIELD QUALITY CONTROL

- A. Administrant for Electrical Power Tests and Inspections:
 1. [Owner][Tenant] will engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
 2. Engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
 4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].
- B. Acceptance Testing Preparation:
 1. <Insert requirements>.
- C. Field tests and inspections must be witnessed by [Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>.

D. Tests and Inspections:

1. Inspect poles for nicks, mars, dents, scratches, and other damage.
2. System function tests.
3. Guy Anchors: Test one of each type and capacity installed[, **plus additional units specifically indicated for testing**]. Apply rated pull-out force in the same pull direction applied by the guy at the test location.
 - a. Acceptable Test Results: Denoted by movement of less than **3/8 inch** by the holding component of the anchor in the earth or other medium in which it is installed.
 - b. Replace or reinstall, at Architect's option, all anchors of same type and capacity as anchor type that fails this test.
4. Pole Ground Resistance: Measure resistance of each separate grounding electrode, including pole grounds. Also measure resistance of separate grounding electrode systems before bonding together.
 - a. Perform tests and obtain acceptable results before energizing any portion of overhead electrical distribution system.
 - b. Results and Follow-up: If ground resistance for a single ground electrode or pole ground, tested individually, exceeds 25 Ω , add a ground electrode not less than **10 ft** away and interconnect with 2 AWG, minimum, bare conductor buried at least **12 inch** below furnished grade.
5. **<Insert special inspections>**.

E. Nonconforming Work:

1. Unit will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

F. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

G. Manufacturer Services: Engage factory-authorized service representative to [**support**][**supervise**] field tests and inspections.

1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.

END OF SECTION 26 05 46 00



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Task	Specification	Specification Description
26 05 46 00	26 05 00 00	Sleeves and Sleeve Seals for Electrical Raceways and Cabling



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SECTION 26 05 53 00 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Labels.
2. Extruded insulating tubing.
3. Bands.
4. Tapes and stencils.
5. Tags.
6. Signs.
7. Cable ties.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. Section 284600 "Fire Detection and Alarm"[**and Section 284614 "Single- and Multiple-Station Alarms"**] specifies fire detection and alarm devices referenced in this Section.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Samples: For each type of label and sign to illustrate composition, size, colors, lettering style, mounting provisions, and graphic features of identification products.
- C. Identification Schedule: For each piece of electrical equipment and electrical system components to be index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.

PART 2 - PRODUCTS

2.1 LABELS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
2. Listing Criteria: UL CCN PGDQ2 for components; including UL 969.

B. UL PGDQ2 - Vinyl Wraparound Labels: Preprinted, flexible labels laminated with clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Brady Corporation]**
 - b. **[Champion America]**
 - c. **[emedco]**
 - d. **[Grafoplast Wire Markers]**
 - e. **[HellermannTyton]**
 - f. **[LEM Products Inc.]**
 - g. **[Marking Services Inc.]**
 - h. **[Panduit Corp]**
 - i. **[Seton Identification Products; a Brady Corporation company]**
 - j. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Brady Corporation]**
 - b. **[Champion America]**
 - c. **[emedco]**
 - d. **[Grafoplast Wire Markers]**
 - e. **[HellermannTyton]**
 - f. **[LEM Products Inc.]**
 - g. **[Marking Services Inc.]**
 - h. **[Panduit Corp]**
 - i. **[Seton Identification Products; a Brady Corporation company]**
 - j. **<Insert manufacturer's name>**

C. UL PGDQ2 - Self-Adhesive Wraparound Labels: **[Preprinted][Write-on]**, **3 mil (0.08 mm)** thick, **[polyester][vinyl]** flexible label with acrylic pressure-sensitive adhesive.

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[A'n D Cable Products]**
 - b. **[Brady Corporation]**
 - c. **[Brother International Corporation]**
 - d. **[emedco]**
 - e. **[Grafoplast Wire Markers]**
 - f. **[Ideal Industries, Inc.]**
 - g. **[LEM Products Inc.]**
 - h. **[Marking Services Inc.]**
 - i. **[Panduit Corp]**
 - j. **[Seton Identification Products; a Brady Corporation company]**
 - k. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert**

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

- a. **[A'n D Cable Products]**
 - b. **[Brady Corporation]**
 - c. **[Brother International Corporation]**
 - d. **[emedco]**
 - e. **[Grafoplast Wire Markers]**
 - f. **[Ideal Industries, Inc.]**
 - g. **[LEM Products Inc.]**
 - h. **[Marking Services Inc.]**
 - i. **[Panduit Corp]**
 - j. **[Seton Identification Products; a Brady Corporation company]**
 - k. **<Insert manufacturer's name>**
3. Self-Lamination: Clear; UV-, weather-, and chemical-resistant; self-laminating, with protective shield over legend. Size labels such that clear shield overlaps entire printed legend.
 4. Marker for Labels:
 - a. Permanent, waterproof, black ink marker recommended by tag manufacturer.
 - b. Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.
- D. UL PGDQ2 - Self-Adhesive Labels: **[Polyester][Vinyl]**, thermal, transfer-printed, **3 mil (0.08 mm)** thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[A'n D Cable Products]**
 - b. **[Brady Corporation]**
 - c. **[Brother International Corporation]**
 - d. **[emedco]**
 - e. **[Grafoplast Wire Markers]**
 - f. **[HellermannTyton]**
 - g. **[Ideal Industries, Inc.]**
 - h. **[LEM Products Inc.]**
 - i. **[Marking Services Inc.]**
 - j. **[Panduit Corp]**
 - k. **[Seton Identification Products; a Brady Corporation company]**
 - l. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[A'n D Cable Products]**
 - b. **[Brady Corporation]**
 - c. **[Brother International Corporation]**
 - d. **[emedco]**
 - e. **[Grafoplast Wire Markers]**
 - f. **[HellermannTyton]**
 - g. **[Ideal Industries, Inc.]**
 - h. **[LEM Products Inc.]**

- i. **[Marking Services Inc.]**
- j. **[Panduit Corp]**
- k. **[Seton Identification Products; a Brady Corporation company]**
- l. **<Insert manufacturer's name>**

3. Minimum Nominal Size:

- a. **1-1/2 by 6 inch (37 by 150 mm)** for raceway and conductors.
- b. **3-1/2 by 5 inch (76 by 127 mm)** for equipment.
- c. As required by authorities having jurisdiction.

2.2 EXTRUDED INSULATING TUBING

A. Performance Criteria:

- 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- 2. Listing Criteria: UL CCN YDPU2 for components; including UL 224.

B. UL YDPU2 - Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tubes with machine-printed identification labels, sized to suit diameter and shrunk to fit firmly. Full shrink recovery occurs at maximum of **200 deg F (93 deg C)**.

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

2.3 BANDS

A. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters and that stay in place by gripping action.

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

- b. [HellermannTyton]
 - c. [Marking Services Inc.]
 - d. [Panduit Corp]
 - e. [Seton Identification Products; a Brady Corporation company]
 - f. <Insert manufacturer's name>
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Brady Corporation]
 - b. [HellermannTyton]
 - c. [Marking Services Inc.]
 - d. [Panduit Corp]
 - e. [Seton Identification Products; a Brady Corporation company]
 - f. <Insert manufacturer's name>
- B. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inch (50 mm) long, with diameters sized to suit diameters and that stay in place by gripping action.
- 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Brady Corporation]
 - b. [HellermannTyton]
 - c. [Marking Services Inc.]
 - d. [Panduit Corp]
 - e. <Insert manufacturer's name>
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Brady Corporation]
 - b. [HellermannTyton]
 - c. [Marking Services Inc.]
 - d. [Panduit Corp]
 - e. <Insert manufacturer's name>

2.4 TAPES AND STENCILS

- A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
- 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Brady Corporation]
 - b. [Carlton Industries, LP]
 - c. [Champion America]
 - d. [HellermannTyton]

- e. **[Ideal Industries, Inc.]**
 - f. **[Marking Services Inc.]**
 - g. **[Panduit Corp]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[Brady Corporation]**
 - b. **[Carlton Industries, LP]**
 - c. **[Champion America]**
 - d. **[HellermannTyton]**
 - e. **[Ideal Industries, Inc.]**
 - f. **[Marking Services Inc.]**
 - g. **[Panduit Corp]**
 - h. **<Insert manufacturer's name>**
- B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than **3 mil (0.08 mm)** thick by **1 to 2 inch (25 to 50 mm)** wide; compounded for outdoor use.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
- a. **[Brady Corporation]**
 - b. **[Carlton Industries, LP]**
 - c. **[emedco]**
 - d. **[Marking Services Inc.]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[Brady Corporation]**
 - b. **[Carlton Industries, LP]**
 - c. **[emedco]**
 - d. **[Marking Services Inc.]**
 - e. **<Insert manufacturer's name>**
- C. Tape and Stencil: **4 inch (100 mm)** wide black stripes on **10 inch (250 mm)** centers placed diagonally over orange background and are **12 inch (300 mm)** wide. Stop stripes at legends.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
- a. **[HellermannTyton]**
 - b. **[LEM Products Inc.]**
 - c. **[Marking Services Inc.]**
 - d. **[Pipemarker.com; Brimar Industries, Inc.]**
 - e. **[Seton Identification Products; a Brady Corporation company]**

- f. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [HellermannTyton]
 - b. [LEM Products Inc.]
 - c. [Marking Services Inc.]
 - d. [Pipemarker.com; Brimar Industries, Inc.]
 - e. [Seton Identification Products; a Brady Corporation company]
 - f. <Insert manufacturer's name>
- D. Floor Marking Tape: 2 inch (50 mm) wide, 5 mil (0.125 mm) pressure-sensitive vinyl tape, with [black and white][yellow and black] stripes and clear vinyl overlay.
 - 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Brady Corporation]
 - b. [Carlton Industries, LP]
 - c. [Seton Identification Products; a Brady Corporation company]
 - d. <Insert manufacturer's name>
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Brady Corporation]
 - b. [Carlton Industries, LP]
 - c. [Seton Identification Products; a Brady Corporation company]
 - d. <Insert manufacturer's name>
- E. Underground-Line Warning Tape:
 - 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Brady Corporation]
 - b. [Ideal Industries, Inc.]
 - c. [LEM Products Inc.]
 - d. [Marking Services Inc.]
 - e. [Pipemarker.com; Brimar Industries, Inc.]
 - f. [Reef Industries, Inc.]
 - g. [Seton Identification Products; a Brady Corporation company]
 - h. <Insert manufacturer's name>
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Brady Corporation]

- b. [Ideal Industries, Inc.]
 - c. [LEM Products Inc.]
 - d. [Marking Services Inc.]
 - e. [Pipemarker.com; Brimar Industries, Inc.]
 - f. [Reef Industries, Inc.]
 - g. [Seton Identification Products; a Brady Corporation company]
 - h. <Insert manufacturer's name>
3. Tape:
- a. Recommended by manufacturer for method of installation and suitable to identify and locate underground electrical **[and communications]** utility lines.
 - b. Printing on tape must be permanent and may not be damaged by burial operations.
 - c. Tape material and ink must be chemically inert and not be subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.
4. Color and Printing:
- a. Comply with APWA Uniform Color Code using NEMA Z535.1 safety colors.
 - b. Inscriptions for Red Tapes: **["CAUTION BURIED ELECTRIC LINE BELOW"]<Insert inscription>**.
 - c. Inscriptions for Orange Tapes: **["CAUTION BURIED CATV LINE BELOW"]**["CAUTION BURIED TELEPHONE LINE BELOW"]**["CAUTION BURIED FIBER OPTIC LINE BELOW"]**["CAUTION BURIED COMMUNICATION LINE BELOW"]<Insert inscription>****.****
5. Nonconducting Line-Warning Tape :
- a. Pigmented polyolefin, bright colored, **[continuous-printed on one side with inscription of utility]**, compounded for direct-burial service.
 - b. Width: **3 inch (75 mm)**.
 - c. Thickness: **4 mil (0.1 mm)**.
 - d. Weight: **18.5 lb/1000 sq. ft (9.0 kg/100 sq. m)**.
 - e. Tensile in accordance with ASTM D882: **30 lbf (133.4 N) and 2500 psi (17.2 MPa)**.
6. Reinforced Nonconducting Line-Warning Tape :
- a. Multilayer laminate, consisting of high-density polyethylene scrim coated with pigmented polyolefin; bright colored, **[continuous-printed on one side with inscription of utility]**, compounded for direct-burial service.
 - b. Width: **3 inch (75 mm)**.
 - c. Thickness: **12 mil (0.3 mm)**.
 - d. Weight: **36.1 lb/1000 sq. ft (17.6 kg/100 sq. m)**.
 - e. Tensile in accordance with ASTM D882: **400 lbf (1780 N) and 11,500 psi (79.2 MPa)**.
7. Detectable Line-Warning Tape :
- a. Detectable three-layer laminate, consisting of printed pigmented polyolefin film, solid aluminum-foil core, and clear protective film that allows inspection of continuity of conductive core; bright colored, **[continuous-printed on one side with inscription of utility]**, compounded for direct-burial service.
 - b. Width: **3 inch (75 mm)**.
 - c. Overall Thickness: **5 mil (0.125 mm)**.
 - d. Foil Core Thickness: **0.35 mil (8.9 m)**.
 - e. Weight: **28 lb/1000 sq. ft (13.7 kg/100 sq. m)**.
 - f. Tensile in accordance with ASTM D882: **70 lbf (311.3 N) and 4600 psi (31.7 MPa)**.

8. Reinforced Detectable Line-Warning Tape :

- a. Reinforced, detectable three-layer laminate, consisting of printed pigmented woven scrim, solid aluminum-foil core, and clear protective film that allows inspection of continuity of conductive core; bright-colored, [**continuous-printed on one side with inscription of utility**], compounded for direct-burial service.
- b. Width: **3 inch (75 mm)**.
- c. Overall Thickness: **8 mil (0.2 mm)**.
- d. Foil Core Thickness: **0.35 mil (8.9 m)**.
- e. Weight: **34 lb/1000 sq. ft (16.6 kg/100 sq. m)**.
- f. Tensile in accordance with ASTM D882: **300 lbf (1334 N)** and **12,500 psi (86.1 MPa)**.

F. Concrete Cable Route Markers :

1. Description: Concrete markers visually aid tracing the route of electrical cables. Monument markers are typically installed at grade. Protective cover markers are typically installed above the cables at grade or below grade.
2. Product Characteristics:

- a. Material: Precast reinforced concrete.
- b. Marker Type:
 - 1) Above-Ground Monument Post:
 - a) Nominal Dimensions (Height, Width, Depth): **30 inch (760 mm), 6 inch (150 mm), 3 inch (75 mm)**.
 - 2) Above-Ground Monument Block:
 - a) Nominal Dimensions (Height, Width, Depth): [**12 inch (300 mm), 12 inch (300 mm), 6 inch (150 mm)**][**24 inch (600 mm), 24 inch (600 mm), 4 inch (100 mm)**].
 - 3) In-Ground Protective Cover (Plank or Slab):
 - a) Nominal Dimensions (Length, Width, Depth): [**36 inch (914 mm), 6 inch (150 mm), 2 inch (50 mm)**][**36 inch (914 mm), 9 inch (230 mm), 2 inch (50 mm)**][**12 inch (305 mm), 12 inch (305 mm), 2 inch (50 mm)**][**24 inch (610 mm), 12 inch (305 mm), 2 inch (50 mm)**][**36 inch (914 mm), 12 inch (305 mm), 2 inch (50 mm)**].
- c. Legend: [**"DANGER - ELECTRICITY"**][**"ELECTRIC CABLES"**][**"ELECTRIC SPLICE"**].
- d. Lettering: Approximately **1/8 inch (3 mm)** deep, not less than [**1 inch (25 mm)**][**1.5 inch (38 mm)**] high, symmetrically spaced; marked on both sides to allow for reversal.

3. Required Product Options:

- a. Color: [**Red**]**<Insert color>** dye added to concrete during batching.
- b. Attach metal medallion or sign stamped with [**feeder number**]**<Insert required information>**.

G. Stenciled Legend: In nonfading, waterproof, [**black**]**<Insert color>** ink or paint. Minimum letter height must be [**1 inch (25 mm)**]**<Insert dimension>**.

2.5 TAGS

- A. Metal Tags: Brass or aluminum, **2 by 2 by 0.05 inch (50 by 50 by 1.3 mm)**, with stamped legend, punched for use with self-locking cable tie fastener.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Brady Corporation]**
 - b. **[Carlton Industries, LP]**
 - c. **[emedco]**
 - d. **[Marking Services Inc.]**
 - e. **[Seton Identification Products; a Brady Corporation company]**
 - f. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Brady Corporation]**
 - b. **[Carlton Industries, LP]**
 - c. **[emedco]**
 - d. **[Marking Services Inc.]**
 - e. **[Seton Identification Products; a Brady Corporation company]**
 - f. **<Insert manufacturer's name>**
- B. Nonmetallic Preprinted Tags: Polyethylene tags, **[0.015 inch (0.38 mm)][0.023 inch (0.58 mm)]** thick, color-coded for phase and voltage level, with factory **[screened][printed]** permanent designations; punched for use with self-locking cable tie fastener.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Brady Corporation]**
 - b. **[Carlton Industries, LP]**
 - c. **[emedco]**
 - d. **[Grafoplast Wire Markers]**
 - e. **[LEM Products Inc.]**
 - f. **[Marking Services Inc.]**
 - g. **[Panduit Corp]**
 - h. **[Seton Identification Products; a Brady Corporation company]**
 - i. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Brady Corporation]**
 - b. **[Carlton Industries, LP]**
 - c. **[emedco]**
 - d. **[Grafoplast Wire Markers]**

- e. [LEM Products Inc.]
- f. [Marking Services Inc.]
- g. [Panduit Corp]
- h. [Seton Identification Products; a Brady Corporation company]
- i. <Insert manufacturer's name>

C. Write-on Tags:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. [Brady Corporation]
 - b. [Carlton Industries, LP]
 - c. [LEM Products Inc.]
 - d. [Pipemarker.com; Brimar Industries, Inc.]
 - e. [Seton Identification Products; a Brady Corporation company]
 - f. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Brady Corporation]
 - b. [Carlton Industries, LP]
 - c. [LEM Products Inc.]
 - d. [Pipemarker.com; Brimar Industries, Inc.]
 - e. [Seton Identification Products; a Brady Corporation company]
 - f. <Insert manufacturer's name>
3. Polyester Tags: **[0.010 inch (0.25 mm)][0.015 inch (0.38 mm)]<Insert dimension>** thick, with corrosion-resistant grommet and cable tie for attachment.
4. Marker for Tags:
 - a. Permanent, waterproof, black ink marker recommended by tag manufacturer.
 - b. Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.6 SIGNS

A. Baked-Enamel Signs:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. [Brady Corporation]
 - b. [Carlton Industries, LP]
 - c. [Champion America]
 - d. [emedco]
 - e. [Marking Services Inc.]
 - f. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Brady Corporation]**
 - b. **[Carlton Industries, LP]**
 - c. **[Champion America]**
 - d. **[emedco]**
 - e. **[Marking Services Inc.]**
 - f. **<Insert manufacturer's name>**
3. Preprinted aluminum signs, **[high-intensity reflective,]**punched or drilled for fasteners, with colors, legend, and size required for application.
4. **1/4 inch (6.4 mm)** grommets in corners for mounting.
5. Nominal Size: **7 by 10 inch (180 by 250 mm)**.

B. Metal-Backed Butyrate Signs:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Brady Corporation]**
 - b. **[Champion America]**
 - c. **[emedco]**
 - d. **[Marking Services Inc.]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Brady Corporation]**
 - b. **[Champion America]**
 - c. **[emedco]**
 - d. **[Marking Services Inc.]**
 - e. **<Insert manufacturer's name>**
3. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs, with **0.0396 inch (1 mm)** galvanized-steel backing, punched and drilled for fasteners, and with colors, legend, and size required for application.
4. **1/4 inch (6.4 mm)** grommets in corners for mounting.
5. Nominal Size: **10 by 14 inch (250 by 360 mm)**.

C. Laminated Acrylic or Melamine Plastic Signs:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Brady Corporation]**
 - b. **[Carlton Industries, LP]**
 - c. **[emedco]**

- d. **[Marking Services Inc.]**
 - e. **[Seton Identification Products; a Brady Corporation company]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[Brady Corporation]**
 - b. **[Carlton Industries, LP]**
 - c. **[emedco]**
 - d. **[Marking Services Inc.]**
 - e. **[Seton Identification Products; a Brady Corporation company]**
 - f. **<Insert manufacturer's name>**
3. Engraved legend.
4. Thickness:
- a. For signs up to **20 sq. inch (129 sq. cm)**, minimum **1/16 inch (1.6 mm)** thick.
 - b. For signs larger than **20 sq. inch (129 sq. cm)**, **1/8 inch (3.2 mm)** thick.
 - c. Engraved legend with **[black letters on white face][white letters on dark gray background]<Insert colors>**.
 - d. **[Punched or drilled for mechanical fasteners with 1/4 inch (6.4 mm) grommets in corners for mounting][Self-adhesive]**.
 - e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.7 CABLE TIES

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[HellermannTyton]**
 2. **[Ideal Industries, Inc.]**
 3. **[Marking Services Inc.]**
 4. **[Panduit Corp]**
 5. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[HellermannTyton]**
 2. **[Ideal Industries, Inc.]**
 3. **[Marking Services Inc.]**
 4. **[Panduit Corp]**
 5. **<Insert manufacturer's name>**
- C. Performance Criteria:
1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 2. Listing Criteria: UL CCN ZODZ; including UL 1565 or UL 62275.
- D. UL ZODZ - General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, and

Type 6/6 nylon.

1. Minimum Width: **3/16 inch (5 mm)**.
2. Tensile Strength at **73 deg F (23 deg C)** in accordance with ASTM D638: **12,000 psi (82.7 MPa)**.
3. Temperature Range: **Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C)**.
4. Color: Black, except where used for color-coding.

E. UL ZODZ - UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.

1. Minimum Width: **3/16 inch (5 mm)**.
2. Tensile Strength at **73 deg F (23 deg C)** in accordance with ASTM D638: **12,000 psi (82.7 MPa)**.
3. Temperature Range: **Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C)**.
4. Color: Black.

F. UL ZODZ - Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.

1. Minimum Width: **3/16 inch (5 mm)**.
2. Tensile Strength at **73 deg F (23 deg C)** in accordance with ASTM D638: **7000 psi (48.2 MPa)**.
3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: **Minus 50 to plus 284 deg F (Minus 46 to plus 140 deg C)**.
5. Color: Black.

PART 3 - EXECUTION

3.1 PREPARATION

A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 SELECTION OF COLORS AND IDENTIFICATION MARKINGS

A. Comply with 29 CFR 1910.144 for color identification of hazards, and the following:

1. Fire-protection[**and fire-alarm**] equipment[, **including raceways**,] must be finished, painted, or suitably marked safety red.
2. Ceiling-mounted hangers, supports, cable trays, and raceways must be finished, painted, or suitably marked safety yellow where less than [7.7 ft (2.3 m)]<Insert height> above finished floor.

B. Pipe and Conduit Labeling: Comply with ASME A13.1[**and IEEE C2**].

C. Color-Coding for Phase- and Voltage-Level Identification, 1000 V or Less: Use colors listed below for ungrounded [service][feeder][and][branch-circuit] conductors.

1. Color must be factory applied[**or field applied for sizes larger than 6 AWG when permitted by authorities having jurisdiction**].
2. Colors for 208Y/120 V Circuits:
 - a. Phase A: Black.

- b. Phase B: Red.
 - c. Phase C: Blue.
- 3. Colors for 240 V Circuits:
 - a. Phase A: Black.
 - b. Phase B: Red.
- 4. Colors for 480Y/277 V Circuits:
 - a. Phase A: Brown.
 - b. Phase B: Orange.
 - c. Phase C: Yellow.
- 5. Color for Neutral (Grounded Conductor): **[White][or][gray]**.
- 6. Color for Equipment Ground: **[Bare copper][Green][Green with yellow stripe]**.
- 7. Color for Isolated Ground: Green with two or more yellow stripes.
- D. Color-Coding Raceways, Cable Trays, Junction Boxes, and Conductors for Intrinsically-Safe Circuits: Light blue. When used to identify intrinsically-safe circuits, Article 504 of NFPA 70 requires that the color light blue not be used for any other purpose.
- E. Color-Coding Instructional Signs: Self-adhesive labels, including color code for grounded and ungrounded conductors.
- F. Accessible Fittings for Raceways: Identify cover of junction and pull box of the following systems with wiring system legend and system voltage. System legends must be as follows:
 - 1. "EMERGENCY POWER."
 - 2. "POWER."
 - 3. "UPS."
 - 4. **<Insert name>**.
- G. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. Identify by system and circuit designation.
- H. Locations of Underground Lines: Underground-line warning tape for power and lighting.
- I. Vaults, Manholes, Handholes, and Pull and Junction Boxes, More Than 1000 V: For conductors in vaults, pull and junction boxes, manholes, and handholes, use **[write-on tags][nonmetallic preprinted tags colored and marked to indicate phase, and separate tag with circuit designation]**.
- J. Concealed Raceways, Duct Banks, More Than 1000 V, within Buildings: Tape and stencil. Stencil legend "DANGER - CONCEALED HIGH-VOLTAGE WIRING" with **3 inch (75 mm)** high, black letters on **20 inch (500 mm)** centers.
 - 1. Locate identification at changes in direction, at penetrations of walls and floors, and at **[10 ft (3 m)][30 ft (9 m)]** maximum intervals.
 - 2. Identify system voltage[**and system or service type**] with black letters on orange field.
 - 3. Apply floor marking tape to the following finished surfaces:
 - a. Floor surface directly above conduits running beneath and within **12 inch (300 mm)** of floor that is in contact with earth or is framed above unexcavated space.
 - b. Wall surfaces directly external to raceways concealed within wall.
 - c. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in building, or concealed above suspended ceilings.

- K. Accessible Raceways, Armored and Metal-Clad Cables, More Than 1000 V: **[Vinyl wraparound labels][Snap-around labels][Self-adhesive labels][Snap-around color-coding bands for raceway and cables]**.
1. Locate identification at changes in direction, at penetrations of walls and floors, at **50 ft (15 m)** maximum intervals in straight runs, and at **25 ft (7.6 m)** maximum intervals in congested areas.
 2. Identify system voltage[**and system or service type**] with black letters on orange field.
- L. Vaults, Manholes, Handholes, and Pull and Junction Boxes, 1000 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use **[vinyl wraparound labels][self-adhesive wraparound labels][snap-around labels][snap-around color-coding bands][self-adhesive vinyl tape]** to identify phase.
1. Locate identification at changes in direction, at penetrations of walls and floors, at **50 ft (15 m)** maximum intervals in straight runs, and at **25 ft (7.6 m)** maximum intervals in congested areas.
 2. Identify system voltage[**and system or service type**] with **[black letters on orange field]<Insert color scheme>**.
- M. Accessible Raceways and Metal-Clad Cables, 1000 V or Less, for Service, Feeder, and Branch Circuits, More Than **[30]<Insert number> A** and **[120]<Insert number> V** to Ground: Identify with self-adhesive **[raceway labels][vinyl tape applied in bands]**.
1. Locate identification at changes in direction, at penetrations of walls and floors, at **50 ft (15 m)** maximum intervals in straight runs, and at **25 ft (7.6 m)** maximum intervals in congested areas.
 2. Identify system voltage[**and system or service type**] with **[black letters on orange field]<Insert color scheme>**.
- N. Conductors to Be Extended in Future: Attach **[write-on tags][marker tape]** to conductors[**and list source**].
- O. Cover Plates: Label individual cover plates with self-adhesive labels. Place label at top of cover plate. Label cover plate with the following information, in the order listed:
1. Panelboard designation.
 2. Colon or dash.
 3. Branch circuit number.
- P. Workspace Indication: Apply **[floor marking tape][or][tape and stencil]** to finished surfaces. Show working clearances in direction of access to live parts. Workspace must comply with NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.
- Q. Equipment Identification Labels:
1. Black letters on white field.
 2. Indoor Equipment: **[Self-adhesive label][Baked-enamel signs][Metal-backed butyrate signs][Laminated acrylic or melamine plastic sign]**.
 3. Outdoor Equipment: **[Laminated acrylic or melamine sign][Stenciled legend 4 inch (100 mm) high]**.
 4. Equipment to Be Labeled:
 - a. Racks, Frames, and Enclosures: Identify front and rear of each with self-adhesive labels[**containing equipment designation**].
 - b. Panelboards: Typewritten directory of circuits in location provided by panelboard manufacturer. Panelboard identification must be in form of **[self-adhesive,**

- c. **engraved,][engraved,]** laminated acrylic or melamine label.
- d. Enclosures and electrical cabinets.
- e. Access doors and panels for concealed electrical items.
- f. Switchgear.
- g. Switchboards.
- h. Transformers: Label that includes tag designation indicated on Drawings for transformer, feeder, and panelboards or equipment supplied by secondary.
- i. Substations.
- j. Emergency system boxes and enclosures.
- k. Motor-control centers.
- l. Enclosed switches.
- m. Enclosed circuit breakers.
- n. Enclosed controllers.
- o. Variable-speed controllers.
- p. Push-button stations.
- q. Power-transfer equipment.
- r. Contactors.
- s. Remote-controlled switches, dimmer modules, and control devices.
- t. Uninterruptible power supplies.
- u. Battery-inverter units.
- v. Battery racks.
- w. Power-generating units.
- x. Monitoring and control equipment.
- x. **<Insert equipment>.**

R. Cable Ties: General purpose, for attaching tags, except as listed below:

- 1. Outdoors: UV-stabilized nylon.
- 2. In Spaces Handling Environmental Air: Plenum rated.

3.3 SELECTION OF SIGNS AND HAZARD MARKINGS

A. Comply with 29 CFR 1910.145 for danger, caution, warning, and safety instruction signs.

B. Signs, labels, and tags required for personnel safety must comply with the following standards:

- 1. Safety Colors: NEMA Z535.1.
- 2. Facility Safety Signs: NEMA Z535.2.
- 3. Safety Symbols: NEMA Z535.3.
- 4. Product Safety Signs and Labels: NEMA Z535.4.
- 5. Safety Tags and Barricade Tapes for Temporary Hazards: NEMA Z535.5.

C. Electrical Hazard Warnings:

- 1. Arc-Flash Hazard Warning: Self-adhesive labels. Comply with **[NFPA 70E][and][Section 260573 "Power System Studies"]** requirements for arc-flash hazard warning labels.
- 2. Raceways and Cables Carrying Circuits at More Than 1000 V:
 - a. Black letters on orange field.
 - b. Legend: "DANGER - CONCEALED HIGH VOLTAGE WIRING."
- 3. Multiple Power Sources Warning Legend: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
- 4. OSHA Workspace Clearance Warning Legend: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 3 FEET MINIMUM."



5. **<Insert names and wording of warning signs or labels (for example, multiple services and voltages, and others>.**
 - D. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: **[Self-adhesive labels][Baked-enamel warning signs][Metal-backed, butyrate warning signs]**.
 1. Apply to exterior of door, cover, or other access.
 2. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:
 - a. Power-transfer switches.
 - b. Controls with external control power connections.
 - c. **<Insert items>.**
 - E. Operating Instruction Signs: **[Self-adhesive labels][Baked-enamel warning signs][Metal-backed, butyrate warning signs][Laminated acrylic or melamine plastic signs]**.
 - F. Emergency Operating Instruction Signs: **[Self-adhesive labels][Baked-enamel warning signs][Metal-backed, butyrate warning signs][Laminated acrylic or melamine plastic signs]** with white legend on red background with minimum **3/8 inch (10 mm)** high letters for emergency instructions at equipment used for **[power transfer][load shedding]<Insert emergency operations>.**
- 3.4 SELECTION OF IDENTIFICATION PRODUCTS FOR COMMUNICATIONS, CONTROL, AUXILIARY, AND LIFE SAFETY SYSTEMS
- A. Comply with Section 270528 "Pathways for Communications Systems" and Section 271100 "Communications Equipment Room Fittings."
- 3.5 INSTALLATION
- A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.
 - B. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes typical for electrical equipment environments specified in Section 018116 "Facility Environmental Requirements" and Section 260010 "Supplemental Requirements for Electrical."
 - C. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).
 - D. Fasteners for Labels and Signs: Self-tapping, stainless steel screws or stainless steel machine screws with nuts and flat and lock washers.
 - E. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.
 - F. Install identifying devices before installing acoustical ceilings and similar concealment.
 - G. Verify identity of item before installing identification products.

- H. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.
- I. Apply identification devices to surfaces that require finish after completing finish work.
- J. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.
- K. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from floor.
- L. Vinyl Wraparound Labels:
 - 1. Secure tight to surface of raceway or cable at location with high visibility and accessibility.
 - 2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to location and substrate.
- M. Snap-Around Labels: Secure tight to surface at location with high visibility and accessibility.
- N. Self-Adhesive Wraparound Labels: Secure tight to surface at location with high visibility and accessibility.
- O. Snap-Around Color-Coding Bands: Secure tight to surface at location with high visibility and accessibility.
- P. Heat-Shrink, Preprinted Tubes: Secure tight to surface at location with high visibility and accessibility.
- Q. Marker Tapes: Secure tight to surface at location with high visibility and accessibility.
- R. Self-Adhesive Vinyl Tape: Secure tight to surface at location with high visibility and accessibility.
 - 1. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for minimum distance of **6 inch (150 mm)** where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding.
- S. Tape and Stencil: Comply with requirements in painting Sections for surface preparation and paint application.
- T. Floor Marking Tape: Apply stripes to finished surfaces following manufacturer's instructions.
- U. Underground Line Warning Tape:
 - 1. During backfilling of trenches, install continuous underground-line warning tape not less than **12 inch (300 mm)** directly above cables or raceways buried **18 inch (450 mm)** or more below grade. Use multiple tapes where width of multiple lines installed in common trench [**or concrete envelope**]exceeds **16 inch (400 mm)** overall.
 - 2. Limit use of underground-line warning tape to direct-buried cables.
 - 3. Install underground-line warning tape for direct-buried cables and cables in raceways.
- V. Concrete Cable Route Markers: **[As indicated on Drawings]<Insert Project-specific requirements>**.
- W. Metal Tags:
 - 1. Place in location with high visibility and accessibility.
 - 2. Secure using **[general-purpose][UV-stabilized][plenum-rated]** cable ties.



-
- X. Nonmetallic Preprinted Tags:
 - 1. Place in location with high visibility and accessibility.
 - 2. Secure using **[general-purpose][UV-stabilized][plenum-rated]** cable ties.
 - Y. Write-on Tags:
 - 1. Place in location with high visibility and accessibility.
 - 2. Secure using **[general-purpose][UV-stabilized][plenum-rated]** cable ties.
 - Z. Baked-Enamel Signs: Attach signs that are not self-adhesive type with mechanical fasteners appropriate to location and substrate.
 - AA. Metal-Backed Butyrate Signs: Attach signs that are not self-adhesive type with mechanical fasteners appropriate to location and substrate.
 - BB. Laminated Acrylic or Melamine Plastic Signs: Attach signs that are not self-adhesive type with mechanical fasteners appropriate to location and substrate.

END OF SECTION 26 05 53 00



Task	Specification	Specification Description
26 05 53 00	26 05 00 00	Sleeves and Sleeve Seals for Electrical Raceways and Cabling
26 05 83 00	26 05 13 00	Medium-Voltage Cables
26 05 83 00	26 05 19 00	Low-Voltage Electrical Power Conductors and Cables
26 05 83 00	26 05 00 00	Sleeves and Sleeve Seals for Electrical Raceways and Cabling



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SECTION 26 09 00 00 - ADDRESSABLE LUMINAIRE LIGHTING CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bus power supply.
2. Controller/gateways.
3. User interface.
4. Lighting control system management software.
5. Luminaire switching and dimming modules.
6. Ballast switching and dimming modules.
7. Sensors.
8. Relays.
9. Manual switches and plates.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.2 DEFINITIONS

- A. DALI: Digital addressable lighting interface.
- B. Data Bus: Two wires used to communicate with bus connected devices.
- C. Device: A collective term for DALI-compliant bus connected devices, including fluorescent ballasts, incandescent luminaires, manual switches, switching relays, and similar. Sometimes also called "slave unit."
- D. Group: A set of devices that respond at the same time to messages on the data bus.
- E. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.
- F. Scene: Digital light level associated with a preset; stored in the luminaire ballast.

1.3 ACTION SUBMITTALS

A. Product Data:

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for control modules, power distribution components, relays, manual switches

- and plates, and conductors and cables.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Sound data including results of operational tests of central dimming controls.
4. Operational documentation for software and firmware.

B. Shop Drawings:

1. Floor Plans: Location, orientation, and coverage area of each sensor; group designations; and other specific design symbols and designations as required to define the installation, location, and configuration of all control devices.
2. Address Drawing: Reflected ceiling plan and floor plans, showing data-bus-connected devices, address for each device, and device groups. The plans must be based on construction plans, using the same legend, symbols, and schedules.
3. Point List and Data Bus Load: Summary list of all control devices, sensors, ballasts, and other loads connected to each data bus and total connected load for each data bus. Include percentage of rated connected load and device addresses.
4. Wire Termination Diagrams and Schedules: Coordinate nomenclature and presentation with Drawings and block diagram. Differentiate between manufacturer-installed and field-installed wiring.
5. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices used. Describe characteristics of network and other data communication lines.
6. Submit evidence that lighting controls are compatible with connected monitoring and control devices and systems specified in **[Section 230923 "Direct Digital Control (DDC) System for HVAC."]****<Insert Section number and title.>**
 - a. Show interconnecting signal and control wiring, and interface devices that show compatibility of inputs and outputs.
 - b. For control interfaces and adapters, list network protocols and provide statements from manufacturers that input and output devices comply with interoperability requirements of the protocol.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.
- B. Sample Warranty: For manufacturer's special warranty.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Bus Power Supplies: Equal to **[two]<Insert number>** percent of amount installed, but no fewer than **[two]<Insert number>**.
 2. Controller/Gateways: Equal to **[two]<Insert number>** percent of amount installed, but no fewer than **[two]<Insert number>**.
 3. Incandescent Switching and Dimming Modules: Equal to **[two]<Insert number>** percent of amount installed, but no fewer than **[two]<Insert number>**.
 4. Fluorescent Ballasts: Equal to **[two]<Insert number>** percent of amount installed, but no fewer than **[two]<Insert number>**.

5. Lighting Control Relays: Equal to **[two]<Insert number>** percent of amount installed, but no fewer than **[two]<Insert number>**.

1.6 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of lighting controls that fail in materials or workmanship within specified warranty period.
 1. Failures include, but are not limited to, the following:
 - a. Software: Failure of input and output to execute switching or dimming commands.
 - b. Failure of modular relays to operate under manual or software commands.
 - c. Ballast failure.
 - d. Damage of electronic components due to transient voltage surges.
 2. Warranty Periods:
 - a. For DALI Ballasts: **[Three]<Insert number>** years from date of Substantial Completion.
 - b. For Control Components That Are Not Part of Ballasts: **[Three]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. DALI:
 1. Components: Individually addressable devices (such as ballasts, relays, dimmers, and switches) that are operated from digital signals received through a DALI-compliant bus, from data-entry and -retrieval devices (such as computers, Internet portals, hand-held IR programming devices, wired Ethernet hubs, wireless IEEE 802.11 hubs[, **and<Insert digital communications device>**]). Devices also report status to data-entry and -retrieval devices through the bus.
 2. Digital Control: Use peer-to-peer communication and distributed logic, where the failure of any single component must be automatically isolated and not affect global system functions.
- B. Ethernet LAN:
 1. Provide an Ethernet LAN to connect controller/gateways to a PC running a Microsoft Windows operating system. Comply with requirements in Section 271513 "Communications Copper Horizontal Cabling."
 2. Ethernet Protocols: Comply with and be compatible with 10/100 BaseT TCP/IP routers and networks.
 3. TCP/IP Modem: Capable of maintaining a secure Internet connection using VPN or equivalent protocol.
- C. Interface with HVAC DDC System: Hardware and software must interface with HVAC DDC system to monitor, control, display, and record data for use in processing reports. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC."
 1. Hardwired Points:
 - a. Monitoring: On-off status, **<Insert monitoring point>**.

- b. Control: On-off operation, **<Insert control point>**.
 2. Communication Interface: Comply with **[ASHRAE 135]<Insert type of interface>**.
Communication must interface with HVAC DDC system to remotely control and monitor lighting from HVAC DDC system operator workstation. Control features and monitoring points displayed locally at lighting panel must be available through DDC system for HVAC. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC."
 - D. Surge Protective Device: Factory installed as an integral part of control components or field-mounted surge protective device complying with UL 1449, SPD Type 2.
 - E. Operation: Input signal from digital signal sources switches or dims DALI devices associated with ballasts or luminaires, or switches field-deployed, DALI-compliant, control relays.
 1. Each device and relay is connected to a digital data bus.
 2. Each DALI device and relay has a digital address and can be operated by a digital signal.
 3. Each device or relay can be assigned to any or all of 16 available groups connected to a single data bus.
 4. Each dimming ballast may have as many as 16 preset lighting levels or scenes. Scenes can be programmed to ballasts and may be applied to groups.
 - F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - G. Comply with 47 CFR 15, Subparts A and B, for Class A digital devices.
 - H. Comply with protocol described in IEC 60929, Annexes E and G, for DALI lighting control devices, wiring, and computer hardware and software.
 - I. Comply with UL 916.
- 2.2 BUS POWER SUPPLY
- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 1. **[Leviton Manufacturing Co., Inc.]**
 2. **[Lutron Electronics Co., Inc]**
 3. **[nLight; Acuity Brands Lighting, Inc.]**
 4. **[Philips; Signify North America; Signify Holding]**
 5. **[Starfield Controls, Inc.]**
 6. **[Tridonic]**
 7. **<Insert manufacturer's name>**
 - B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 1. **[Leviton Manufacturing Co., Inc.]**
 2. **[Lutron Electronics Co., Inc]**
 3. **[nLight; Acuity Brands Lighting, Inc.]**
 4. **[Philips; Signify North America; Signify Holding]**
 5. **[Starfield Controls, Inc.]**
 6. **[Tridonic]**

7. <Insert manufacturer's name>

- C. Description: Supply power to data bus for 64 addressable devices, suitable for use with NFPA 70, Class 2 control circuit.
1. Primary Power: Field selectable, 120 and 277 V.
 2. Power Supply: Regulated to maintain the operating voltage above 15 V(dc) under full load, and rated for full charging load of 250 mA and a minimum maintained connected load of 190 mA.
 3. Pilot Lights: Indicate data bus ground-fault and data bus traffic.

2.3 CONTROLLER/GATEWAYS

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

1. **[Leviton Manufacturing Co., Inc.]**
2. **[Lutron Electronics Co., Inc]**
3. **[Philips; Signify North America; Signify Holding]**
4. **[RAB Lighting]**
5. **[Starfield Controls, Inc.]**
6. **[Tridonic]**
7. **<Insert manufacturer's name>**

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

1. **[Leviton Manufacturing Co., Inc.]**
2. **[Lutron Electronics Co., Inc]**
3. **[Philips; Signify North America; Signify Holding]**
4. **[RAB Lighting]**
5. **[Starfield Controls, Inc.]**
6. **[Tridonic]**
7. **<Insert manufacturer's name>**

- C. Description: DALI controller/gateways link the distributed data buses with an Ethernet network to provide computer configuration, control, analysis, and maintenance. Controller/gateways operate independently and continue to process local inputs and schedules when disconnected from the LAN. Controller/gateways must provide local intelligence and features including the following:

1. Integrated real-time clock with automatic daylight savings adjustment and leap-year correction.
2. Integrated sunrise/sunset support based on the site location (latitude and longitude).
3. Automatic time schedules, to control groups for scheduled occupancy with support for holiday exceptions.
4. Two digital outputs for additional control and interlocking with external equipment such as fans, valves, and security panels.
5. Support **[one][two]** data bus(es).
6. Computer Monitoring and Configuration: The controller/gateway must allow configuration, monitoring, and analysis from PCs on the Ethernet LAN.

- D. Each data bus must have the capacity to control 64 addressable devices, using NFPA 70, Class 2 control circuit.

1. Each data bus must have the capacity to control up to 16 groups and scenes.
2. 10 BaseT Ethernet port for DDC system for HVAC connection.

3. LED indicator lights for Ethernet status (link, send, and receive), power-on, and LAN failure.
4. Linking of switch and sensor inputs to relay and ballast outputs.
5. Viewing relay and ballast output status.
6. Controlling relay and ballast outputs.
7. Setting device addresses.
8. Assigning switch and sensor inputs and relay and ballast output modes.

E. Allow connection of the following DALI-compliant addressable devices:

1. Fluorescent luminaire switching and dimming, for linear and compact lamps.
2. Incandescent luminaire switching and dimming.
3. HID and HPS luminaire switching and dimming.
4. LED luminaire switching and dimming.
5. Occupancy and photoelectric sensors.
6. Emergency lighting interface complying with UL 924.

F. Stores system programming in nonvolatile memory.

1. Switch to enable or disable software programming.

2.4 USER INTERFACE

- A. Workstations: A laptop PC, with Microsoft Windows operating system and lighting control system management software installed. With automatic backup.
1. Include documentation, storage media, and licensing for a minimum of five concurrent users.
- B. Tablet Computer: Handheld, with custom graphical user-interface software, supplied by the controller/gateway supplier. The software must provide for all DALI-protocol programming commands to be applied to the controller/gateway via a tethered connection.
- C. Web Interface: Internet portal, with **[one][10]<Insert number>** unique username and password(s), and a custom graphical user interface, allowing DALI-protocol programming commands to be applied to the controller gateway via **[LAN][the Internet]**.
- D. IR Programming Assistant: Handheld, with custom graphical user-interface software, supplied by the controller/gateway supplier to program the manual switches.

2.5 LIGHTING CONTROL SYSTEM MANAGEMENT SOFTWARE

- A. The software must provide for programming, configuring, and monitoring all devices connected to all data buses of the lighting control system, using application-specific software with Microsoft Windows-based, user-friendly software with graphical user-interface designed screens.
1. The software must be object oriented with pop-up menus and built-in help screens. All specified features of the data-bus-connected devices and those associated with controller/gateways must be included in the software.

2.6 LUMINAIRE SWITCHING AND DIMMING MODULES

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide**

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

1. [Leviton Manufacturing Co., Inc.]
2. [Lutron Electronics Co., Inc]
3. [Philips; Signify North America; Signify Holding]
4. [Starfield Controls, Inc.]
5. <Insert manufacturer's name>

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

1. [Leviton Manufacturing Co., Inc.]
2. [Lutron Electronics Co., Inc]
3. [Philips; Signify North America; Signify Holding]
4. [Starfield Controls, Inc.]
5. <Insert manufacturer's name>

- C. Description: Comply with DALI exponential dimming curve calibrated for the connected lamp type, group, and scene settings, and with DALI light-level and configuration commands. Dimmer rise time must be not less than 15 microseconds.

2.7 BALLAST SWITCHING AND DIMMING MODULES

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

1. [Lutron Electronics Co., Inc]
2. [OSRAM SYLVANIA]
3. [Philips; Signify North America; Signify Holding]
4. [Tridonic]
5. <Insert manufacturer's name>

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

1. [Lutron Electronics Co., Inc]
2. [OSRAM SYLVANIA]
3. [Philips; Signify North America; Signify Holding]
4. [Tridonic]
5. <Insert manufacturer's name>

- C. Each ballast or group must be addressable and must include on-off, fade, dimming, scene settings, and other standard DALI control functions and as required to meet the sequence of operation.

- D. Ballasts: Comply with requirements in [Section 265116 "Fluorescent Interior Lighting" for ballasts for linear fluorescent lamps][and][Section 265123 "HID Interior Lighting" for ballasts for HID lamps]; electronic programmed-start; and the following:

1. Starting Method: Programmed rapid start with antilash (turns on at previously set light level).
2. Dimming Range: 100 to 10 percent of rated lumens unless otherwise indicated.
3. Ballast Factor: 1.0 at full output; 0.01 at full dim.
4. Input Voltage Range: 108 to 305 V.

2.8 SENSORS

- A. Comply with requirements in Section 260923 "Lighting Control Devices." All sensors must be DALI-protocol compliant.
- B. Daylight Harvesting Switching and Dimming Controls:
 - 1. Adjustments and Set Points: All adjustments with exception of sensor range must be made via the communication network.
 - 2. Remote Monitoring and Reporting: Sensor value must be displayed when queried by lighting management software or must automatically report based on a change of value or change of time period setting.
- C. Indoor Occupancy Sensors: May be powered directly from the lighting control network or with a standalone power supply. Units powered with a standalone power supply must interface with the lighting control system through an electrically isolated digital input.

2.9 RELAYS

- A. Relays: Electrically operated, mechanically held single-pole switch, rated at 20 A at 277 V. Short-circuit current rating must be not less than 5 kA. Pilot light indicates when relay is closed and latched. Control must be by DALI digital data bus. Relay status must be displayed when queried by lighting management software.
- B. Relay Panel: A single enclosure with incoming lighting branch circuits, relays, and connection to the DALI digital control network.
 - 1. Enclosure: NEMA 250, Type 1 unless otherwise indicated.
 - 2. Barriers to separate control-voltage and low-voltage components.
 - 3. Directory: Cover mounted, identifying each relay with its device address and naming the load controlled.
- C. Individually Mounted Relays:
 - 1. Enclosure: Standard outlet box or NEMA 250, Type 1 unless otherwise indicated.
 - 2. Directory: Cover mounted, identifying each relay with its device address.

2.10 MANUAL SWITCHES AND PLATES

- A. Connection Type: RS-485 protocol, **[Category 5][Category 5e]** UTP cable, using 8PSJ connectors. Power must be from the control unit.
- B. Push-Button Switches: Modular, operating over the DALI digital data bus.
 - 1. Each switch must control the following functions, in coordination with programmed sequence of operation and related sensors:
 - a. On.
 - b. Off.
 - c. Dimming, increase light level.
 - d. Dimming, decrease light level.
 - e. Return to preset light level.

2. LED Pilot Lights: On to indicate that the control is active, or when the manual control is operated.
 3. Match color and style specified in Section 262726 "Wiring Devices."
 4. Integral IR receiver for programming.
- C. Wall Plates: Single and multigang plates as specified in Section 262726 "Wiring Devices."
- D. Legend: Engraved or permanently silk-screened on wall plate where indicated. Use designations indicated on Drawings.

2.11 CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Class 2 Power Source: Not smaller than No. 12 AWG, complying with Section 260523 "Control-Voltage Electrical Power Cables."
- B. Class 2 Control Cables: Multiconductor cable with copper conductors not smaller than **[No. 18][No. 22][No. 24]** AWG, complying with Section 260523 "Control-Voltage Electrical Power Cables."
- C. Class 1 Control Cables: Multiconductor cable with copper conductors not smaller than **[No. 14][No. 16][No. 18]** AWG, complying with Section 260523 "Control-Voltage Electrical Power Cables."
- D. Digital and Multiplexed Signal Cables: UTP cable with copper conductors, complying with **[Category 5e][Category 6]** for horizontal copper cable and with Section 271513 "Communications Copper Horizontal Cabling."

PART 3 - EXECUTION

3.1 INSTALLATION OF WIRING

- A. Wiring Method: Comply with Section 260523 "Control-Voltage Electrical Power Cables" and Section 260523 "Control-Voltage Electrical Power Cables."
1. Comply with requirements for cable trays specified in Section 260536 "Cable Trays for Electrical Systems."
 2. Comply with requirements for raceways specified in Section 260533.13 "Conduits for Electrical Systems."
- B. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

3.2 IDENTIFICATION

- A. Identify system components, wiring, cabling, boxes, cabinets, and terminals. Comply with identification requirements specified in Section 260553 "Identification for Electrical Systems."
- B. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with Section 260553 "Identification for Electrical Systems."
- C. Identify all ceiling-mounted controls with data bus number and device address.
- D. Label each device cable within **6 inch (152 mm)** of connection to bus power supply or termination block.

3.3 FIELD QUALITY CONTROL

- A. Acceptance Testing Preparation:
 - 1. Test continuity of each circuit.
- B. Field tests must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.
- C. Tests and Inspections:
 - 1. Test each bus controller using local and remote controls.
 - 2. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
- D. Nonconforming Work:
 - 1. Lighting controls will be considered defective if they do not pass tests and inspections.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- E. Field Test Reports:
 - 1. Prepare test and inspection reports, including a certified report that identifies bus controllers included and describes query results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.
 - 2. Printed list of all points created from actual queries of all addressed control points to include lamps, ballasts, manual controls, and sensors.
 - 3. Event log verifying the performance of all devices generating event messages to include occupancy sensors, control buttons, alarm messages, and any other change of value messages.

3.4 STARTUP SERVICE

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Activate luminaires and verify that all lamps are operating at 100 percent.
 - 3. Burn-in fluorescent lamps at 100 percent for 100 hours.
 - 4. Confirm correct communications wiring, initiate communications between DALI devices and controller/gateways, and program the lighting control system according to approved configuration schedules, time-of-day schedules, and input override assignments.
 - 5. **<Insert startup steps if any>**.

3.5 ADJUSTING

- A. Occupancy Adjustments: When requested within **[12]<Insert number>** months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to **[two]<Insert number>** visits to Project during other-than-normal occupancy hours for this purpose.

3.6 SOFTWARE SERVICE AGREEMENT

- A. Technical Support: Beginning at Substantial Completion, service agreement must include software support for **[two]<Insert number>** years.
- B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within **[two]<Insert number>** years from date of Substantial Completion. Upgrading software must include operating system and new or revised licenses for using software.
 - 1. Upgrade Notice: At least **[30]<Insert number>** days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

END OF SECTION 26 09 00 00



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SECTION 26 09 00 00A - RELAY-BASED LIGHTING CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Lighting control relay panels.
2. Networked lighting control panels.
3. Manual switches and cover plates.
4. Field-mounted signal sources.
5. Conductors and cables.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.2 DEFINITIONS

- A. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.

1.3 ACTION SUBMITTALS

A. Product Data:

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for control modules, power distribution components, relays, manual switches and cover plates, and conductors and cables.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Sound data including results of operational tests of central dimming controls.
4. Operational documentation for software and firmware.

B. Shop Drawings: For each relay panel and related equipment.

1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types and details for types other than Type 1.
3. Detail wiring partition configuration, current, and voltage ratings.
4. Short-circuit current rating of relays.
5. Address Drawing: Reflected ceiling plan and floor plans, showing connected luminaires, address for each luminaire, and luminaire groups. Base plans on construction plans, using the same legend, symbols, and schedules.



6. Point List and Data Bus Load: Summary list of all control devices, sensors, ballasts, and other loads. Include percentage of rated connected load and device addresses.
7. Wire Termination Diagrams and Schedules: Coordinate nomenclature and presentation with Drawings and block diagram. Differentiate between manufacturer-installed and field-installed wiring.
8. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices to be used. Describe characteristics of network and other data communication lines.
9. Submit evidence that lighting controls are compatible with connected monitoring and control devices and systems specified in **[Section 230923 "Direct Digital Control (DDC) System for HVAC."]****<Insert Section number and title.>**
 - a. Show interconnecting signal and control wiring, and interface devices that show compatibility of inputs and outputs.
 - b. For control interfaces and adapters, list network protocols and provide statements from manufacturers that input and output devices comply with interoperability requirements of the protocol.

C. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

A. Sample warranties.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lighting Control Relays: Equal to **<Insert number>** percent of amount installed[**for each size indicated**], but no fewer than **<Insert number>**.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Handle and prepare panels for installation in accordance with NECA 407.

1.7 WARRANTY

A. Special Manufacturer Extended Warranty: Manufacturer warrants that components of standalone multipreset modular dimming controls perform in accordance with specified requirements and agrees to provide repair or replacement of components that fail to perform as specified within extended warranty period.

1. Initial Extended Warranty Period: **[Two][Three][Four]<Insert number>** year(s) from date of Substantial Completion, for labor, materials, and equipment.
2. Follow-on Extended Warranty Period: **[Eight]<Insert number>** year(s) from date of Substantial Completion, for materials that failed because of transient voltage surges only, f.o.b. the nearest shipping point to Project site.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Sequence of Operations: Input signal from field-mounted manual switches, or digital signal sources, must open or close one or more lighting control relays in the lighting control panels. Any combination of inputs must be programmable to any number of control relays.
- B. Interface with HVAC DDC System: Hardware and software must interface with HVAC DDC system to monitor, control, display, and record data for use in processing reports. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC."
 - 1. Hardwired Points:
 - a. Monitoring: On-off status, **<Insert monitoring point>**.
 - b. Control: On-off operation, **<Insert control point>**.
 - 2. Communication Interface: Comply with **[ASHRAE 135][ISO/IEC 14908-1]["**MODBUS **Application Protocol Specification"]<Insert type of interface>**. The communication interface must enable the HVAC DDC system operator to remotely control and monitor lighting from a HVAC DDC system operator workstation. Control features and monitoring points displayed locally at lighting panel must be available through the HVAC DDC system. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC."
- C. Surge Protective Device: Factory installed as an integral part of control components or field-mounted surge suppressors complying with UL 1449, SPD Type 2.
- D. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70 by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.
- E. Comply with 47 CFR 15, Subparts A and B, for Class A digital devices.
- F. Comply with UL 916.

2.2 LIGHTING CONTROL RELAY PANELS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[ABB, Electrification Business]**
 - 2. **[Intermatic, Inc]**
 - 3. **[Leviton Manufacturing Co., Inc.]**
 - 4. **[Lithonia Lighting; Acuity Brands Lighting, Inc.]**
 - 5. **[Lutron Electronics Co., Inc]**
 - 6. **[Philips; Signify North America; Signify Holding]**
 - 7. **[Siemens Industry, Inc., Energy Management Division]**
 - 8. **[Touch-Plate Technologies]**
 - 9. **[WattStopper; Legrand North America, LLC]**
 - 10. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. [ABB, Electrification Business]
2. [Intermatic, Inc]
3. [Leviton Manufacturing Co., Inc.]
4. [Lithonia Lighting; Acuity Brands Lighting, Inc.]
5. [Lutron Electronics Co., Inc]
6. [Philips; Signify North America; Signify Holding]
7. [Siemens Industry, Inc., Energy Management Division]
8. [Touch-Plate Technologies]
9. [WattStopper; Legrand North America, LLC]
10. <Insert manufacturer's name>

C. Description: Standalone lighting control panel using mechanically latched relays to control lighting and appliances.

D. Lighting Control Panel:

1. A single enclosure with incoming lighting branch circuits, control circuits, switching relays, and on-board timing and control unit.
2. A vertical barrier separating branch circuits from control wiring.

E. Control Unit: Contain the power supply and electronic control for operating and monitoring individual relays.

1. Timing Unit:

- a. 365-day calendar, astronomical clock, and automatic adjustments for daylight savings and leap year.
- b. Clock configurable for 12-hour (A.M./P.M.) or 24-hour format.
- c. [Four]<Insert number> independent schedules, each having [24]<Insert number> time periods.
- d. Schedule periods settable to the minute.
- e. Day-of-week, day-of-month, day-of-year with one-time or repeating capability.
- f. [10]<Insert number> special date periods.

2. Sequencing Control with Override:

- a. Automatic sequenced on and off switching of selected relays at times set at the timing unit, allowing timed overrides from external switches.
- b. Sequencing control must operate relays one at a time, completing the operation of all connected relays in not more than 10 seconds.
- c. Override control must allow any relay connected to it to be switched on or off by a field-deployed manual switch or by an automatic switch, such as an occupancy sensor.
- d. Override control "blink warning" must warn occupants approximately [five minutes]<Insert time> before actuating the off sequence.

3. Nonvolatile memory must retain all setup configurations. After a power failure, the controller must automatically reboot and return to normal system operation, including accurate time of day and date.

F. Relays:

1. Electrically operated, mechanically held single-pole switch, rated at 20 A at 277 V. Short-circuit current rating must be not less than 5 kA. Control must be three-wire, 24 V(ac).
2. Electrically operated, mechanically held single-pole switch, rated at 20 A at 120 V for tungsten, 30 A at 277 V for ballast, 1.5 hp at 120 V, and 3 hp at 277 V. Short-circuit current rating must be not

less than 14 kA. Control must be three-wire, 24 V(ac).

- G. Power Supply: NFPA 70, Class 2, sized for connected equipment, plus 20 percent spare capacity. Powered from a dedicated branch circuit of the panelboard that supplies power to the line side of the relays, sized to provide control power for the local panel-mounted relays, bus system, control-voltage inputs, field-installed occupancy sensors, and photo sensors.
- H. Operator Interface:
 - 1. Integral alphanumeric keypad and digital display, and intuitive drop-down menus to assist in programming.
 - 2. Log and display relay on-time.
 - 3. Connect relays to one or more time and sequencing schemes.

2.3 NETWORKED LIGHTING CONTROL PANELS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1. **[ABB, Electrification Business]**
 - 2. **[Intermatic, Inc]**
 - 3. **[Lithonia Lighting; Acuity Brands Lighting, Inc.]**
 - 4. **[Lutron Electronics Co., Inc]**
 - 5. **[Touch-Plate Technologies]**
 - 6. **[WattStopper; Legrand North America, LLC]**
 - 7. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[ABB, Electrification Business]**
 - 2. **[Intermatic, Inc]**
 - 3. **[Lithonia Lighting; Acuity Brands Lighting, Inc.]**
 - 4. **[Lutron Electronics Co., Inc]**
 - 5. **[Touch-Plate Technologies]**
 - 6. **[WattStopper; Legrand North America, LLC]**
 - 7. **<Insert manufacturer's name>**
- C. Description: Lighting control panels using mechanically latched relays to control lighting and appliances. The panels must be capable of being interconnected with digital communications to appear to the operator as a single lighting control system.
- D. Lighting Control Panels:
 - 1. A single enclosure with incoming lighting branch circuits, control circuits, switching relays, and on-board timing and control unit.
 - 2. A vertical barrier separating branch circuits from control wiring.
- E. Main Control Unit: Installed in the main lighting control panel only; powered from the branch circuit of the standard control unit.
 - 1. Ethernet Communications: Comply with **[TCP/IP]<Insert network protocol>** protocol. The main control unit must provide for programming of all control functions of the main and all networked slave lighting control panels including timing, sequencing, and overriding.

2. Protocol: Controllers must support serial MS/TP and Ethernet IP communications in accordance with **[ASHRAE 135][ISO/IEC 14908-1][MODBUS Application Protocol Specification]**, and must be able to communicate directly via DDC system for HVAC TIA-485 serial networks and Ethernet 10Base-T networks as a native device.
 3. Web Server: Display information listed below over a standard Web-enabled server for displaying information over a standard browser.
 - a. A secure, password-protected login screen for modifying operational parameters, accessible to authorized users via Web page interface.
 - b. Panel summary showing the master and slave panels connected to the controller.
 - c. Controller diagnostic information.
 - d. Show front panel mimic screens for setting up controller parameters, input types, zones, and operating schedules. These mimic screens must also allow direct breaker control and zone overrides.
 4. Timing Unit:
 - a. 365-day calendar, astronomical clock, and automatic adjustments for daylight savings and leap year.
 - b. Clock configurable for 12-hour (A.M./P.M.) or 24-hour format.
 - c. **[Four]<Insert number>** independent schedules, each having **[24]<Insert number>** time periods.
 - d. Schedule periods settable to the minute.
 - e. Day-of-week, day-of-month, day-of-year with one-time or repeating capability.
 - f. **[16]<Insert number>** special date periods.
 5. Time Synchronization: The timing unit must be updated not less than every **<Insert number>** hour(s) with the network time server.
 6. Sequencing Control with Override:
 - a. Automatic sequenced on and off switching of selected relays at times set at the timing unit, allowing timed overrides from external switches.
 - b. Sequencing control must operate relays one at a time, completing the operation of all connected relays in not more than 10 seconds.
 - c. Override control must allow any relay connected to it to be switched on or off by a field-deployed manual switch or by an automatic switch, such as an occupancy sensor.
 - d. Override control "blinking warning" must warn occupants approximately **[five minutes]<Insert time>** before actuating the off sequence.
 - e. Activity log, storing previous relay operation, including the time and cause of the change of status.
 - f. Download firmware to the latest version offered by manufacturer.
- F. Standard Control Unit, Installed in All Lighting Control Panels: Contain electronic controls for programming the operation of the relays in the control panel, contain the status of relays, and contain communications link to enable the digital functions of the main control unit. Comply with UL 916.
1. Electronic control for operating and monitoring individual relays, and display relay on-time.
 2. Nonvolatile memory must retain all setup configurations. After a power failure, the controller must automatically reboot and return to normal system operation.
 3. Integral keypad and digital-display front panel for local setup, including the following:
 - a. Blink notice, time adjustable from software.
 - b. Ability to log and display relay on-time.
 - c. Capability for accepting downloadable firmware so that the latest production features may be added in the future without replacing the module.

G. Relays:

1. Electrically operated, mechanically held single-pole switch, rated at 20 A at 277 V. Short-circuit current rating must be not less than 5 kA. Control must be **[three-wire, 24 V(ac)][digital control network]**.
2. Electrically operated, mechanically held single-pole switch, rated at 20 A at 120 V for tungsten, 30 A at 277 V for ballast, 1.5 hp at 120 V, and 3 hp at 277 V. Short-circuit current rating must be not less than 14 kA. Control must be **[three-wire, 24 V(ac)][digital control network]**.

H. Power Supply: NFPA 70, Class 2, UL listed, sized for connected equipment, plus not less than 20 percent spare capacity. Powered from a dedicated branch circuit of the panelboard that supplies power to the line side of the relays, sized to provide control power for the local panel-mounted relays, bus system, control-voltage inputs, field-installed occupancy sensors, and control-voltage photo sensors.

I. Operator Interface: At the main control unit, provide interface for a tethered connection of **[a portable PC running MS Windows]<Insert digital device and operating system>** for configuring all networked lighting control panels using setup software designed for the specified operating system. Include one portable device for initial programming of the system and training of Owner's personnel. That device must remain the property of Owner.

J. Software:

1. Menu-driven data entry.
2. Online and offline programming and editing.
3. Provide for entry of the room or space designation for the load side of each relay.
4. Monitor and control all relays, showing actual relay state and the name of the automatic actuating control, if any.
5. Size the software appropriate to the system.

2.4 MANUAL SWITCHES AND COVER PLATES

A. Push-Button Switches: Modular, momentary contact, three wire, for operating one or more relays and to override automatic controls.

1. Match color and style specified in Section 262726 "Wiring Devices."
2. Integral green LED pilot light to indicate when circuit is on.
3. Internal white LED locator light to illuminate when circuit is off.

B. Cover Plates: Single and multigang cover plates as specified in Section 262726 "Wiring Devices."

C. Legend: Engraved or permanently silk-screened on cover plate where indicated. Use designations indicated on Drawings.

2.5 FIELD-MOUNTED SIGNAL SOURCES

A. Daylight Harvesting Switching Controls: Comply with Section 260923 "Lighting Control Devices." Control power may be taken from the lighting control panel, and signal must be compatible with the relays.

B. Indoor Occupancy Sensors and Extreme-Temperature Occupancy Sensors: Comply with Section 260923 "Lighting Control Devices." Control power may be taken from the lighting control panel, and signal must be compatible with the relays.

2.6 CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Class 2 Power Source: Not smaller than No. 12 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Classes 2 and 3 Control Cables: Multiconductor cable with copper conductors not smaller than **[No. 18][No. 22][No. 24]** AWG. Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."
- C. Class 1 Control Cables: Multiconductor cable with copper conductors not smaller than **[No. 14][No. 16][No. 18]** AWG. Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."
- D. Twisted-Pair Data Cable: **[Category 5e][Category 6][Category 6a]**.
 - 1. Comply with requirements for twisted pair cabling in Section 260523 "Control-Voltage Electrical Power Cables."
 - 2. Comply with requirements in Section 271513 "Communications Copper Horizontal Cabling."

PART 3 - EXECUTION**3.1 EXAMINATION**

- A. Receive, inspect, handle, and store panels in accordance with NECA 407.
- B. Examine panels before installation. Reject panels that are damaged or rusted or have been subjected to water saturation.
- C. Examine elements and surfaces to receive panels for compliance with installation tolerances and other conditions affecting performance of the Work.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF WIRING

- A. Wiring Methods:
 - 1. Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters.
 - 2. Install cables in raceways and cable trays except within consoles, cabinets, desks, counters, accessible ceiling spaces, and gypsum board partitions where unenclosed wiring method may be used.
 - 3. Install conductors and cables concealed in accessible ceilings, walls, and floors where possible.
 - 4. Conceal raceway and cables except in unfinished spaces.
 - 5. Provide plenum-rated cable, where installed exposed or in open cable tray, within environmental airspaces, including plenum ceilings.
 - 6. Comply with requirements for cable trays specified in Section 260536 "Cable Trays for Electrical Systems."
 - 7. Comply with requirements for raceways specified in Section 260533.13 "Conduits for Electrical Systems."
- B. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and

without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

3.3 INSTALLATION OF PANELS

- A. Install panels and accessories in accordance with NECA 407.
- B. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- C. Mount top of trim [**90 inch (2286 mm)**]**<Insert dimension>** above finished floor unless otherwise indicated.
- D. Mount panel cabinet plumb and rigid without distortion of box.
- E. Install filler plates in unused spaces.

3.4 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Section 260553 "Identification for Electrical Systems."
- C. Create a directory to indicate loads served by each relay; incorporate Owner's final room designations. Obtain approval before installing. Use a PC or typewriter to create directory; handwritten directories are unacceptable.
- D. Lighting Control Panel Nameplates: Label each panel with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

- A. Field tests must be witnessed by [**Architect**][**Tenant**][**authorities having jurisdiction**]**<Insert names or titles of witnesses>**.
- B. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers described below[**and low-voltage surge arrestors**]. Certify compliance with manufacturer's test parameters.
 - a. Circuit-Breaker Tests:
 - 1) Compare nameplate with Drawings and Specifications.
 - 2) Inspect physical and mechanical conditions.
 - 3) Inspect anchorage and alignment.
 - 4) Verify that the units are clean.
 - 5) Operate the circuit breaker to ensure smooth operation.
 - 6) Inspect bolted electrical connections for high resistance using one or more of the following methods:

- a) A low-resistance ohmmeter.
- b) Verify tightness of bolted electrical connections by calibrated torque wrench.
- c) Thermographic survey.

- 7) Inspect operating mechanism, contacts, and arc chutes in unsealed units.
- 8) Perform adjustments for final protective device settings in accordance with the overcurrent protective device coordination study. Comply with requirements in Section 260573.16 "Coordination Studies."
- 9) Perform insulation resistance tests for one minute on each pole, phase-to-phase, and phase-to-ground with the circuit breaker closed and across each pole using manufacturer's published data.
- 10) Perform a contact/pole-resistance test.
- 11) Perform insulation-resistance tests on control wiring with respect to ground. Applied potential must be 500 V(dc) for 300 V rated cable and 1000 V(dc) for 600 V rated cable. Test duration must be for one minute. Follow manufacturer's instructions for solid-state units.
- 12) Determine long-time pickup and delay by primary current injection.
- 13) Determine short-time pickup and delay by primary current injection.
- 14) Determine ground-fault pickup and time delay by primary current injection.
- 15) Determine instantaneous pickup by primary current injection.
- 16) Test functions of the trip unit by means of secondary injection.
- 17) Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data.
- 18) Verify correct operation of auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, anti-pump function, and trip unit battery condition. Reset trip logs and indicators.
- 19) Verify operation of charging mechanism.

b. Surge Arrestor Tests:

- 1) Compare nameplate with the Contract Documents.
- 2) Inspect physical and mechanical conditions.
- 3) Inspect anchorage, alignment, grounding, and clearances.
- 4) Verify that the units are clean.
- 5) Inspect bolted electrical connections for high resistance using one or more of the following methods:
 - a) Low-resistance ohmmeter.
 - b) Verify tightness of bolted electrical connections by calibrated torque wrench.
- 6) Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.
- 7) Perform an insulation-resistance test on each arrestor, phase terminal-to-ground using voltage in accordance with manufacturer instructions.
- 8) Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems" for grounding tests.

C. Nonconforming Work:

- 1. Lighting control panel will be considered defective if it does not pass tests and inspections.
- 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

- D. Prepare test and inspection reports, including a certified report that identifies lighting control panels and describes scanning results. Include notation of deficiencies detected, remedial action taken, and

observations made after remedial action.

E. Manufacturer Services:

1. Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.

3.6 SYSTEM STARTUP

A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.

1. Complete installation and startup checks in accordance with manufacturer's instructions.
2. Confirm correct communications wiring, initiate communications between panels, and program the lighting control system in accordance with approved configuration schedules, time-of-day schedules, and input override assignments.
3. **<Insert startup steps if any>**.

3.7 ADJUSTING

- A. Occupancy Adjustments: When requested within **[12]<Insert number>** months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to **[two]<Insert number>** visits to Project during other-than-normal occupancy hours for this purpose.

3.8 MAINTENANCE

A. Software and Firmware Service Agreement:

1. Technical Support: Beginning at Substantial Completion, verify that software and firmware service agreement includes software support for **[two]<Insert number>** years.
2. Upgrade Service: At Substantial Completion, update software and firmware to latest version. Install and program software upgrades that become available within **[two]<Insert number>** years from date of Substantial Completion. Verify upgrading software includes operating system and new or revised licenses for using software.
 - a. Upgrade Notice: No fewer than **[30]<Insert number>** days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.
3. Upgrade Reports: Prepare written report after each update, documenting upgrades installed.

END OF SECTION 26 09 00 00A



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SECTION 26 09 13 00 - ELECTRICAL POWER MONITORING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Multifunction energy meters.
2. Power meters.
3. Circuit meters and monitors.
4. Circuit meter and explorer.
5. PC operating system software.
6. Networked PC operating system software.
7. Power monitoring and control software.
8. Network configuration software.
9. Monitoring and control of power distribution equipment.
10. System operator interfaces.
11. Desktop workstations.
12. Portable workstations.
13. Raceways and boxes.
14. Wires and cables.
15. Surge protection devices.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
3. Section 230923.13 "Energy Meters" for electricity meters for HVAC equipment.
4. Section 262713 "Electricity Metering" for equipment to meter electricity consumption and demand for tenant submetering.

1.2 DEFINITIONS

- A. Active Power: The average power consumed by a unit. Also known as "real power."
- B. Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.
- C. Apparent (Phasor) Power: " $S = VI$ " where "S" is the apparent power, "V" is the RMS value of the voltage, and "I" is the RMS value of the current.
- D. Firmware: Software (programs or data) that has been written onto read-only memory (ROM). Firmware is a combination of software and hardware. Storage media with ROMs that have data or programs recorded on them are firmware.
- E. KY Pulse: A method of measuring consumption of electricity that is based on a relay operating like a SPST switch.

- F. KYZ Pulse: A method of measuring consumption of electricity based on a relay operating like a SPDT switch.
- G. L-G: Line to ground.
- H. L-L: Line to line.
- I. L-N: Line to neutral.
- J. MODBUS TCP/IP: An open protocol for exchange of process data.
- K. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.
- L. N-G: Neutral to ground.
- M. Power Factor: The ratio of active power to apparent power, sometimes expressed in percentage.

1.3 ACTION SUBMITTALS

A. Product Data:

1. Multifunction energy meters.
2. Power meters.
3. Circuit meters and monitors.
4. Circuit meter and explorer.
5. PC operating system software.
6. Networked PC operating system software.
7. Power monitoring and control software.
8. Network configuration software.
9. Monitoring and control of power distribution equipment.
10. System operator interfaces.
11. Desktop workstations.
12. Portable workstations.
13. Raceways and boxes.
14. Wires and cables.
15. Surge protection devices.

B. Sustainable Design Submittals:

1. Product Data: Indicating that computers used by the system are certified by ENERGY STAR.

C. Shop Drawings: For power monitoring and control equipment.

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, method of field assembly, components, and location and size of each field connection.
 - a. Attach copies of approved Product Data submittals for products (such as switchboards, switchgear, and motor-control centers) that describe the following:
 - 1) Location of the meters and gateways, and routing of the connecting wiring.

- 2) Details of power monitoring and control features to illustrate coordination among related equipment and power monitoring and control.
3. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices to be used. Describe characteristics of network and other data communication lines.
4. Network naming and numbering scheme.
5. Include diagrams for power, signal, and control wiring. Coordinate nomenclature and presentation with a block diagram.
6. Specifications for workstations.
7. UPS sizing calculations for workstation.
8. Surge Suppressors: Data for each device used and where applied.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Design Data:

1. Manufacturer's system installation and setup guides, with data forms to plan and record options and setup decisions.
 - a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format on compact disk or portable storage device with a USB interface.
 - b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
 - c. As-built versions of submittal Product Data.
 - d. Names, addresses, e-mail addresses, and 24-hour telephone numbers of Installer and service representatives for the system and products.
 - e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing set points and variables.
 - f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
 - g. Engineering, installation, and maintenance manuals that explain how to do the following:
 - 1) Design and install new points, panels, and other hardware.
 - 2) Perform preventive maintenance and calibration.
 - 3) Debug hardware problems.
 - 4) Repair or replace hardware.
 - h. Documentation of programs created using custom programming language including set points, tuning parameters, and object database.
 - i. Backup copy of graphic files, programs, and database on compact disk or portable storage device with a USB interface.
 - j. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
 - k. Complete original-issue copies of furnished software, including operating systems, custom programming language, workstation software, and graphics software on compact disk or portable storage device with a USB interface.
 - l. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.

- m. Owner training materials.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Addressable Relays: One for every [10]<Insert number> installed. Furnish at least one of each type.
 - 2. Data Line Surge Suppressors: One for every [10]<Insert number> of each type installed. Furnish at least one of each type.
 - 3. <Insert material>.

1.6 COORDINATION

- A. Coordinate features of distribution equipment and power monitoring and control components to form an integrated interconnection of compatible components.
 - 1. Match components and interconnections for optimum performance of specified functions.
- B. Coordinate Work of this Section with those in Sections specifying distribution components that are monitored or controlled by power monitoring and control equipment.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Microprocessor-based monitoring and control of electrical power distribution system(s) that includes the following:
 - 1. Electrical meters that monitor, control, and connect to the data transmission network.
 - 2. LAN: High-speed, multi-access, open, nonproprietary, industry-standard communication protocols.
 - 3. Include [**PC-based workstation**][**multiple PC-based workstations**][**with web access**], with its operating system and application software, connected to data transmission network.
- B. The electrical power monitoring and control system must be Internet based.
 - 1. System software must be based on server thin-client architecture, designed around open standards of internet technology.
 - 2. Intent of thin-client architecture is to provide operators complete access to power monitoring and control system via an Internet browser. No special software other than an Internet browser must be required to access graphics, point displays, and trends; to configure trends, points, and controllers; and to edit programming.
 - 3. Internet access must be password protected.
- C. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with UL 61010-1 and marked for intended location and application.

2.2 PERFORMANCE REQUIREMENTS

- A. Surge Protection: For external wiring of each conductor entry connection to components to protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads.
1. Minimum Protection for Power Lines 120 V and More: **[SPDs complying with UL 1449, listed and labeled for intended use by an NRTL acceptable to authorities having jurisdiction.][Auxiliary panel suppressors complying with requirements in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."]**
 2. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Lines: Comply with requirements as recommended by manufacturer for type of line being protected.
- B. Addressable Devices: Transmitters and receivers must communicate unique device identification and status reports to monitoring and control clients.
- C. Interface with DDC System for HVAC: Provide factory-installed hardware and software to enable the DDC system for HVAC to monitor, display, and record data for use in processing reports.
1. Hardwired Monitoring Points: Electrical power demand (kilowatts), electrical power consumption (kilowatt-hours)[, **power factor**]**<Insert monitoring point>**.
 2. **[ASHRAE 135 (BACnet)][ISO/IEC 14908-1 (LonTalk)][MODBUS Application Protocol Specification][Industry-accepted, open-protocol]****<Insert type of interface>** communication interface with the DDC system for HVAC must enable the DDC system for HVAC operator to remotely monitor meter information from a DDC system for HVAC workstation. Control features and monitoring points displayed locally at metering panel must be available through the DDC system for HVAC.
- D. Backup Power Source:
1. Electrical power distribution equipment served by a backup power source for controls must have associated power monitoring and control system products that monitor and control such systems and equipment also served from a backup power source.

2.3 MULTIFUNCTION ENERGY METERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Eaton]**
 2. **[GE Power; General Electric Company]**
 3. **[Leviton Manufacturing Co., Inc.]**
 4. **[Schneider Electric USA, Inc.]**
 5. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Eaton]**
 2. **[GE Power; General Electric Company]**
 3. **[Leviton Manufacturing Co., Inc.]**
 4. **[Schneider Electric USA, Inc.]**
 5. **<Insert manufacturer's name>**



- C. Multifunction Energy Meter: Separately mounted, modular, permanently installed, solid-state, digital I/O instrument for power and energy metering and monitoring; complying with UL 61010-1.
 - 1. Capable of metering four-wire wye, three-wire wye, three-wire delta, and single-phase power systems.
 - 2. Equipped with security lock to protect revenue related metering from unauthorized and accidental changes.
- D. Comply with IEC 60529 degree of protection code of IP65 for the front of the meter, and code of IP30 for the body.
- E. Overvoltage: Comply with UL 61010-1 overvoltage withstand rating for CAT III.
- F. Accuracy:
 - 1. Comply with ANSI C12.20, Class 0.5.
 - 2. Neutral Current Measurement: Not more than 0.65 percent.
 - 3. Power Factor: 1.0 percent.
 - 4. Frequency: 0.1 percent.
 - 5. THD: 1.0 percent.
 - 6. Waveform Sampling: 64 per cycle.
- G. Data Link:
 - 1. MODBUS TIA-485, RTU protocol, [2][4]-wire connection to host devices with a compatible port.
 - 2. <Insert protocol>.
- H. Meter Physical Characteristics:
 - 1. Display: Backlit LCD with antiglare and scratch-resistant lens.
 - 2. Display of Metered Values:
 - a. One screen to show at least [three]<Insert number> user-selected values displayed at the same time. Selections available to display must include the following:
 - 1) Meters.
 - 2) Measurements.
 - 3) THD.
 - 4) Energy.
 - 5) Demand.
 - 6) Minimum and maximum values.
 - 7) Power demand.
- I. Sampling Rate: Continuously sample and record voltage and current at a rate not less than [64]<Insert number> samples per cycle, simultaneously on voltage and current channels of the meter.
- J. Meters:
 - 1. Instantaneous, RMS:
 - a. Current: Each phase, [neutral]and three-phase average.
 - b. Voltage: L-L each phase, L-L three-phase average, L-N each phase, and L-N three-phase average.
 - c. Active Power (kW): [Each phase and]three-phase total.
 - d. Reactive Power (kVAR): [Each phase and]three-phase total.

- e. Apparent Power (kVA): **[Each phase and]**three-phase total.
- f. Power Factor: **[Each phase and]**three-phase total.
- 2. Energy:
 - a. Active Energy (kWh): Three-phase total.
- 3. Demand, Derived from Instantaneous RMS Meters:
 - a. Current: Present and maximum.
 - b. Active: Present and maximum.
 - c. Reactive: Present and maximum.
 - d. Apparent: Present and maximum.
- 4. Power Quality Measurements:
 - a. THD: Current and voltage from measurements simultaneously from the same cycle, as can be calculated from the specified sampling rate.
- K. I/O: Two optically isolated digital outputs for KY pulsing or control. Output signal characteristics must be 150 mA at 200 V.
 - 1. KY Pulse: Generate standard KY pulses for a user-defined increment of metered active energy as follows:
 - a. User-defined pulse output, associated with kWh.
 - b. User-defined pulse output, associated with kVARh.
 - 2. **<Insert control function>**.
- L. Capacities and Characteristics:
 - 1. Power Supply: **[120 V(ac), 60 Hz]<Insert text>**.
 - 2. Circuit Connections:
 - a. Voltage: Measurement autoranging, 60 to 400 V(ac) L-N.**[Connect directly to low-voltage (600 V and less) without using voltage transformers.][Connect to instrument grade potential transformers secondary at 120 V.]** Meter impedance must be 2 megohm L-L or greater. Overload Tolerance: 1500 V(ac), RMS, continuously.
 - b. Current: Connect to instrument grade current transformer with a metering range of 5 mA to 6 A. Overcurrent tolerance of the instrument must be 10 A continuous, 50 A for 10 seconds once per hour, and 120 A for one second per hour.
 - c. Frequency: 45 to 65 Hz.
 - d. Time: Input from a GPS receiver to synchronize the internal clock of the instrument and to time-synchronize this instrument with the network to a deviation of not greater than 1 ms.

2.4 POWER METERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Eaton]**
 - 2. **[GE Power; General Electric Company]**

3. [Leviton Manufacturing Co., Inc.]
 4. [Schneider Electric USA, Inc.]
 5. [Siemens Industry, Inc., Energy Management Division]
 6. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [Eaton]
 2. [GE Power; General Electric Company]
 3. [Leviton Manufacturing Co., Inc.]
 4. [Schneider Electric USA, Inc.]
 5. [Siemens Industry, Inc., Energy Management Division]
 6. <Insert manufacturer's name>
- C. Description: Separately mounted, modular, permanently installed, solid-state, digital I/O instrument for power monitoring and control; complying with UL 61010-1.
1. Capable of metering four-wire wye, three-wire wye, three-wire delta, and single-phase power systems.
 2. Equipped with security lock to protect revenue related metering from unauthorized and accidental changes.
- D. Comply with IEC 60529 degree of protection code of IP51 for the front of the meter, and code of IP30 for the body.
- E. Overvoltage: Comply with UL 61010-1 overvoltage withstand rating for CAT III.
- F. Accuracy:
1. Comply with ANSI C12.20, Class 0.5.
 2. Neutral Current Measurement: Not more than 0.65 percent.
 3. Power: 0.6 percent.
 4. Power Factor: 0.5 percent.
 5. Active Energy: 0.6 percent.
 6. Reactive Energy: 2.5 percent.
 7. Frequency: 0.05 percent.
 8. THD: 1.0 percent.
 9. Waveform Sampling: 32 per cycle.
- G. Data Link:
1. MODBUS TIA-485 RTU protocol, [2][4]-wire connection.
 - a. Provide for firmware and software updates through the communications port.
 2. <Insert protocol>.
- H. Meter Physical Characteristics:
1. Display: Backlit LCD with antiglare and scratch-resistant lens.
 2. Display of Metered Values: One screen to show at least [four]<Insert number> lines of user-selected values on one screen at the same time. Provide graphical representation of user-selected values. The screen selections available at the display must include the following:

- a. Meters, including those listed under the following:
 - 1) Measurements.
 - 2) THD.
 - 3) Energy.
 - 4) Demand.
 - 5) Minimum and maximum values.
 - 6) Power demand.
- I. Sampling Rate: Continuously sample and record voltage and current at a rate not less than **[32 samples per cycle]<Insert number>**, simultaneously on voltage and current channels of the meter.
- J. Meters:
 - 1. Measurements: Instantaneous, in real time, RMS to the 15th harmonic.
 - a. Voltage: L-L each phase, L-N each phase, and three-phase average.
 - b. Current: Each phase, three-phase average, and neutral.
 - c. Unbalanced current, L-L V(ac) and L-N V(ac).
 - d. Active Power (+/- kW): Each phase and three-phase total.
 - e. Reactive Power (+/- kVAR): Each phase and three-phase total.
 - f. Apparent Power (+/- kVA): Each phase and three-phase total.
 - g. Displacement Power Factor: Each phase and three-phase total.
 - h. Distortion Power Factor: Each phase and three-phase total.
 - i. Frequency.
 - 2. THD from measurements simultaneously from the same cycle, through **[15th]<Insert number>** harmonic.
 - a. Voltage THD: L-L each phase, L-N each phase, and three-phase average.
 - b. Current THD: Each phase and three-phase average.
 - c. Total demand distortion.
 - 3. Energy: Accumulated, indicate whether in-flow or out-flow, net and absolute values. Store the values in instrument's nonvolatile memory.
 - a. Active kWh.
 - b. Reactive kVARh.
 - c. Apparent kVAh.
 - 4. Demand: Present, last, predicted, peak.
 - a. Three-phase average current.
 - b. Three-phase total active power (kW).
 - c. Reactive power (kVAR).
 - d. Apparent power (kVA).
 - 5. Minimum and Maximum Values:
 - a. L-L and L-N voltages.
 - b. Current in each phase.
 - c. Power factor.
 - d. Active power total.
 - e. Reactive power total.
 - f. Apparent power total.
 - g. THD L-L and L-N voltages.

- h. THD current in each phase.
- i. Frequency.

K. Power Demand, User Selectable:

1. Thermal Demand: Sliding window updated every second for the present demand and at end of the interval for the last interval. Adjustable window that can be set in 1-minute intervals, from 1 to 60 minutes.
2. Block Interval with Optional Subintervals: Adjustable for 1-minute intervals, from 1 to 60 minutes. User-defined parameters for the following block intervals:
 - a. Sliding block that calculates demand every second, with intervals less than 15 minutes, and every 15 seconds with an interval between 15 and 60 minutes.
 - b. Fixed block that calculates demand at end of the interval.
 - c. Rolling block subinterval that calculates demand at end of each subinterval and displays it at end of the interval.
3. Demand Calculation Initiated by a Synchronization Signal:
 - a. Signal is a pulse from an external source. Demand period begins with every pulse. Calculation must be configurable as either a block or rolling block calculation.
 - b. Signal is a communication signal. Calculation must be configurable as either a block or rolling block calculation.
 - c. Provide for synchronizing the demand with the internal of this instrument.

L. Data Recording: Store the listed values in instrument's nonvolatile memory, indicate which of the three phases relates to the value. Attach a date and time stamp to the peak values and the alarms.

1. Minimum and maximum of real-time RMS measurement.
2. Energy.
3. Demand values.
4. Alarms, store the last 40 events.

M. Alarms: Transmit a digital output and show on display when alarmed. Provide for no fewer than [15]<Insert number> metered items. Each alarm must be user configured, by using the following options:

1. Date and time stamp.
2. Enable-disable (default) or enable.
3. Pickup magnitude.
4. Pickup time delay.
5. Dropout magnitude.
6. Dropout time delay.
7. Alarm type.
8. Alarm label.

N. Output Signals: Provide two mechanical relays, rated not less than 250 V(ac), 2 A resistive, and rated for 200,000 cycles or more. The relays must be user configurable in one of the following listed modes:

1. Normal contact closure where the contacts change state for as long as the signal exists.
2. Latched mode when the contacts change state when a pickup signal is received and are held until a dropout signal is received.
3. Timed mode when the contacts change state when a pickup signal is received and are held for a preprogrammed duration.

- O. Meter Face:
 - 1. Display: Backlit LCD display, six lines, with antiglare and scratch-resistant lens.
 - 2. Display of Metered Values: One screen to show at least **[four]<Insert number>** user-selected values on one screen at the same time.
 - 3. Provide for the reset of metered peak values.
- P. Capacities and Characteristics:
 - 1. Power Supply: **[120 V(ac), 60 Hz]<Insert text>**.
 - 2. Circuit Connections:
 - a. Voltage: Measurements autoranging, 60 to 400 V(ac) L-N. **[Connect directly to low-voltage (600 V and less) without using voltage transformers.][Connect to instrument grade potential transformers secondary at 120 V.]** Meter impedance must be 2 megohm L-L or greater. Overload Tolerance: 1500 V(ac), RMS, continuously.
 - b. Current: Connect to instrument grade current transformer with a metering range of 5 mA to 6 A. Overcurrent tolerance of the instrument must be 10 A continuous, 50 A for 10 seconds once per hour, and 120 A for one second per hour.
 - c. Frequency: 45 to 65 Hz.
 - d. Time: Input from a GPS receiver to synchronize the internal clock of the instrument and to time-synchronize this instrument with the network to a deviation of not greater than 1 ms.

2.5 CIRCUIT METERS AND MONITORS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Eaton]**
 - 2. **[GE Power; General Electric Company]**
 - 3. **[Schneider Electric USA, Inc.]**
 - 4. **[Siemens Industry, Inc., Energy Management Division]**
 - 5. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Eaton]**
 - 2. **[GE Power; General Electric Company]**
 - 3. **[Schneider Electric USA, Inc.]**
 - 4. **[Siemens Industry, Inc., Energy Management Division]**
 - 5. **<Insert manufacturer's name>**
- C. Description: Separately mounted, modular, permanently installed, solid-state, digital I/O instrument for power monitoring and control; complying with UL 61010-1. Capable of metering four-wire wye, three-wire wye, three-wire delta, and single-phase power systems.
 - 1. Equipped with security lock to protect revenue related metering from unauthorized and accidental changes.
- D. Comply with IEC 60529 degree of protection code of IP52 for the front of the meter, and code of IP30 for the back.
- E. Overvoltage: Comply with UL 61010-1 overvoltage withstand rating for CAT III.

F. Accuracy:

1. Comply with ANSI C12.20, Class 0.5.
2. For Voltage and Current: 0.5 percent of reading.
3. For Active Power: 0.2 percent.
4. For Active and Reactive Energy: ANSI 12.20, Class 0.2.
5. For Frequency: 0.01 Hz in the range of 45 to 65 Hz.
6. For Power Factor: 0.2 percent from 0.5 leading to 0.5 lagging.

G. Data Links:

1. MODBUS TIA-485 RTU protocol, [2][4]-wire connection.
2. MODBUS TIA-232/TIA-485 RTU/ASCII protocol, [2][4]-wire connection.
3. MODBUS TCP:
 - a. 10/100BaseTX balanced twisted pair cabling. 8PSJ connector, 100 m link.
 - b. Optical fiber 100BaseFX, LC duplex connector, 1300 m link. Multimode 62.5/125 microsecond, 2000 m link.
4. Provide for firmware and software updates through the communications port.
5. Ethernet 10/100BaseTX balanced twisted pair cabling and MODBUS TIA-485 serial master port.
6. Ethernet 10/100BaseTX balanced twisted pair cabling and MODBUS TIA-485 serial master port, Ethernet to serial line gateway, and embedded web server.
7. **<Insert protocol>.**

H. Meter Physical Characteristics:

1. Display: Backlit LCD screen with antiglare and scratch-resistant lens.
2. Display of Metered Values: One screen to show at least **[four]<Insert number>** lines of user-selected values on one screen at the same time. Provide graphical representation of user-selected values.
3. Allow user to select a date/time format and the ability to create additional screens for user-specified views and custom quantities without overwriting existing standard screens.

I. Sampling Rate:

1. Continuously sample and record voltage and current at a rate not less than **[128 samples per cycle]<Insert number>**, simultaneously on voltage and current channels of the meter.

J. Meters must measure, record with time stamp, calculate, and on request display the following:

1. Measurements: Instantaneous, in real time, RMS to the **[31st][63rd]** harmonic:
 - a. Voltage: L-L each phase, L-L three-phase average, L-N each phase, and L-N three-phase average.
 - b. Current: Each phase, three-phase average, and neutral.
 - c. Active Power (kW): Each phase and three-phase total.
 - d. Reactive Power (kVAR): Each phase and three-phase total.
 - e. Apparent Power (kVA): Each phase and three-phase total.
 - f. Displacement Power Factor: Each phase and three-phase total.
 - g. Distortion Power Factor: Each phase and three-phase total.
 - h. Frequency.
2. THD from measurements simultaneously from the same cycle, through **[31st][63rd]<insert number>** harmonic:

- a. Voltage: L-L each phase, L-L three-phase average, L-N each phase, and L-N three-phase average.
 - b. Current: Each phase, three-phase average, and neutral.
 3. Energy: Accumulated, indicate in-flow or out-flow, net and absolute values. Store the values in instrument's nonvolatile memory. Provide for storing accumulated energy at user-defined intervals, up to three intervals per day.
 - a. Active kWh.
 - b. Reactive kVARh.
 - c. Apparent kVAh.
 4. Demand: Three-phase totals, present, predicted, peak.
 - a. Average current.
 - b. Active power (kW).
 - c. Reactive power (kVAR).
 - d. Apparent power (kVA).
 5. Average, Minimum and Maximum Values:
 - a. Record, date and time stamp, and save the minimum and maximum values of RMS metered values since the last reset.
 - b. **<Insert values>**.
- K. Power Demand, User Selectable:
 1. Thermal Demand: Sliding window updated every second for the present demand and at end of the interval for the last interval. Adjustable window that can be set in 1-minute intervals, from 1 to 60 minutes.
 2. Block Interval with Optional Subintervals: Adjustable for 1-minute intervals, from 1 to 60 minutes. User-defined parameters for the following block intervals:
 - a. Sliding block that calculates demand every second, with intervals less than 15 minutes, and every 15 seconds with an interval between 15 and 60 minutes.
 - b. Fixed block that calculates demand at end of the interval.
 - c. Rolling block subinterval that calculates demand at end of each subinterval and displays it at end of the interval.
 3. Demand Calculation Initiated by a Synchronization Signal:
 - a. Synchronize demand with receipt of a signal pulse from an external source. Demand period begins with every pulse. Calculation must be configurable as either a block or rolling block calculation.
 - b. Synchronize demand with receipt of a communication signal. Calculation must be configurable as either a block or rolling block calculation.
 - c. Provide for synchronization to the clock in the instrument.
- L. Trend Curves: Provide for recording four trend curves at intervals of one minute, one hour, one day, or one month; and forecast values for the trended parameters.
 1. Record minimum, maximum, and average values of eight user-selected parameters as follows:
 - a. Every second for one minute for the one-minute curve.
 - b. Every minute for one hour for the one-hour curve.
 - c. Every hour for one day for the one-day curve.

- d. Every day for one month for the one-month curve.
- 2. Forecast the trended parameters for the following:
 - a. The next four hours.
 - b. The next four days.

M. Waveform Capture:

- 1. Steady State Waveform Capture: Manually initiated.
 - a. Capture, record with time stamp, and store voltage and current waveforms for two cycles.
 - b. Capture, record with time stamp, and store 128 digitally sampled data points for each cycle of each phase voltage. The number of waveform captures stored onboard must be user configurable.
 - c. Harmonic analysis performed on the captured waveforms must resolve harmonics through the 63rd.
 - d. Captured waveforms must be recorded from actual circuit performance.
- 2. Disturbance Waveform Capture:
 - a. Capture, record with time stamp, and store 128 digitally sampled data points for each cycle of each phase voltage. Disturbance waveform capture may be initiated manually, by an external contact closure, or by an alarm. The waveform captures must be user configurable from 185 cycles on 1 channel at 16 points per cycle, to 3 cycles on 6 channels at 128 points per cycle.

N. Disturbance Detection and Alarm:

- 1. Detect and initiate alarm when detecting voltage or current sag and swell.
 - a. Detect disturbance events of less than half-cycle in length, by monitoring and calculating RMS magnitude of each half-cycle.
 - b. Event detection must be with user-defined parameters of threshold and delay. The threshold must be user defined as a fixed or relative set point. With relative set point, the instrument will alarm based on the nominal current or voltage equal to its present average value. The instrument must automatically adjust the nominal current and voltage values to avoid nuisance alarms caused by gradual daily variations of currents and voltages.
 - c. When detecting an alarm condition:
 - 1) Initiate disturbance waveform capture.
 - 2) Record the disturbance parameters into an onboard alarm log with a date and time stamp to the millisecond.
 - 3) Alarm on must be visible on the display and be transmitted over the data link.
 - 4) Display the voltage sag/swell events on ITIC or SEMI graphs to quantify the event for accepted industry standards.

O. Harmonics Information:

- 1. Calculate the harmonic magnitudes and angles for each phase voltage and current through the 63rd harmonic. Provide harmonic power flows up to the 41st harmonic for active, reactive, and apparent power.
- 2. The current and voltage information for phases must be obtained simultaneously from the same cycle.
- 3. Report harmonic information as a percentage of the fundamental or as a percentage of the RMS

values, as selected by the user.

P. Alarms: Alarm events must be user definable. Provide a minimum of 40 user-defined alarm conditions.

1. User Configuration Options:

- a. Date and time stamp.
- b. Enable-disable (default) or enable.
- c. Pickup magnitude.
- d. Pickup time delay.
- e. Dropout magnitude.
- f. Dropout time delay.
- g. Alarm type.
- h. Alarm label.

2. The following classes of events must be available to be programmed as alarm events:

- a. Over/under current.
- b. Over/undervoltage.
- c. Current imbalance.
- d. Phase loss, current.
- e. Phase loss, voltage.
- f. Voltage imbalance.
- g. Over kVA.
- h. Over kW or kVAR into/out of load.
- i. Over/under frequency.
- j. Under power factor, true or displacement.
- k. Over THD.
- l. Over demand, current or power.
- m. Reverse power.
- n. Phase reversal.
- o. Status input change.
- p. End of incremental energy interval.
- q. End of demand interval.
- r. Over/under analog inputs.
- s. Current sag/swell.
- t. Voltage sag/swell.

3. For each over/under metered alarm value, provide for the user to define a pickup, dropout, and delay.
4. The circuit meter and monitor alarms response time must be not less than one second.
5. Provide for up to four alarms to be combined to give a single result using Boolean algebra operations.

Q. EN 50160 Evaluation: Report EN 50160 evaluation data in the following formats: summary of active evaluations, summary of evaluation status, detailed information for each evaluated parameter, and detailed information for each abnormal event.

R. I/O Module: Modular, with multiple I/O options to accomplish specified performance and one or more spare positions for future.

1. KY Pulse: Generate a standard KY pulses for a user-defined increment of metered active energy as follows:
 - a. User-defined pulse output, associated with kWh.
 - b. Alarm pulse output, which turns on the pulsing at user-defined point.

2. Digital Inputs: As follows:

- a. One input connection rated 24 to 125 V(ac) or V(dc), +/- 10 percent, less than 5 mA burden, 1350 V RMS isolation.
- b. Six input connections rated 19 to 30 V(dc), 5 mA maximum at 24 V(dc). Provide an onboard 24 V(dc) power supply.
- c. Two input connections rated 20 to 150 V(dc) or V(ac), 2 mA maximum.

3. Analog inputs, no fewer than two, adjustable from zero to 5 V(dc) or 4 to 20 mA.

4. Outputs to operate field-installed relays, no fewer than two, providing 6 to 240 V(ac) or 6 to 30 V(dc), 2 A RMS. 5 A maximum for 10 seconds per hour.

5. Analog outputs, no fewer than two, 4 to 20 mA(dc) into 600 ohms maximum.

S. Data Recording: Store the listed values in instrument's nonvolatile memory, indicate which of the three phases relates to the value. Attach a date and time stamp to the peak values and the alarms.

1. Data Logs, General: User configurable. Automatically stamp each entry to the millisecond with date and time.

- a. Each log entry must hold data of up to 96 parameters each.
- b. Each log must be user configurable to log data at a different user-defined schedule interval.
- c. Provide each log with user-defined event or a minimum/maximum condition that will trigger log file entries.
- d. Configure log entries to be recorded as Fill & Hold or Circular (First in, First out, or FIFO), as defined by the user.

2. Minimum/Maximum Logs:

- a. Minimum/Maximum/Average interval log also logs minimum/maximum/average of selected parameters on a selected interval from a user-selected interval length from 1 to 1440 seconds.
- b. Minimum/Maximum log must include the time, date, and value for the minimum and maximum of each of the real-time metered values.

3. Alarm Log: Record time, date, event information, and coincident information for each user-defined and automatically initiated alarm or event. Record selected parameters at 100 ms intervals during events and alarms. Automatically stamp each entry to the millisecond with date and time.

4. Waveform Logs: Capture and store waveforms, from 185 cycles on one channel at 16 samples per cycle, up to 3 cycles on six channels at 128 samples per cycle as defined by the user. Waveform log entries must be externally triggered or forced in response to a user-defined event. Configure log entries to be recorded as Fill & Hold or Circular (FIFO), as defined by the user.

T. Capacities and Characteristics:

1. Power Supply: [120 V(ac), 60 Hz]<Insert text>.

2. Circuit Connections:

- a. Voltage: Measurement autoranging, zero to 600 V(ac) L-L, zero to 347 V(ac) L-N.[
Connect directly to low-voltage (600 V and less) without using voltage transformers.][Connect to instrument grade potential transformers secondary at 120 V.] Meter impedance must be 2 megohm L-L or greater. Overload Tolerance: 1500 V(ac), RMS, continuously.
- b. Current: Connect to instrument grade current transformer with a metering range of 5 mA to 6 A. Overcurrent tolerance of the instrument must be 10 A continuous, 50 A for 10 seconds

- once per hour, and 120 A for one second per hour.
- c. Frequency: 45 to 65 Hz.
- d. Time: Input from a GPS receiver to synchronize the internal clock of the instrument and to time-synchronize this instrument with the network to a deviation of not greater than 1 ms.

2.6 CIRCUIT METER AND EXPLORER

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Eaton]**
 - 2. **[GE Power; General Electric Company]**
 - 3. **[Schneider Electric USA, Inc.]**
 - 4. **[Siemens Industry, Inc., Energy Management Division]**
 - 5. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Eaton]**
 - 2. **[GE Power; General Electric Company]**
 - 3. **[Schneider Electric USA, Inc.]**
 - 4. **[Siemens Industry, Inc., Energy Management Division]**
 - 5. **<Insert manufacturer's name>**
- C. Description: Separately mounted, modular, permanently installed, solid-state, digital I/O instrument for power monitoring, control, and power quality explorer; complying with UL 61010-1.
 - 1. Provide for metering four-wire wye, three-wire wye, and three-wire delta power systems.
 - 2. Equip the instrument with security lock to protect revenue related metering from unauthorized and accidental changes.
- D. Comply with IEC 60529 degree of protection code of IP52.
- E. The circuit meter and monitor must meet UL 61010-1 overvoltage withstand rating of CAT IV.
- F. Accuracy to the following plus/minus values:
 - 1. Voltage and Current Meter: 0.04 percent of reading plus 0.025 percent of full scale.
 - 2. Power and Energy Meter: 0.075 percent of reading plus 0.025 percent of full scale.
 - 3. Energy Meter: Comply with ANSI C12.20, Class 0.20.
 - 4. Frequency Meter: 0.01 Hz in the range of 45 to 67 Hz and accurate to 0.1 Hz in the range of 350 to 450 Hz.
 - 5. Power Factor: 0.002 from 0.5 leading to 0.5 lagging.
- G. Data Links:
 - 1. TIA-232 port.
 - 2. MODBUS TIA-485 RTU protocol, **[2][4]**-wire connection.
 - 3. MODBUS Ethernet TCP/IP protocol:
 - a. 10/100BaseTX balanced twisted pair cabling. 8PSJ connector, 100 m link.
 - b. Optical fiber 100BaseFX, LC duplex connector, 1300 m link. Multimode 62.5/125 microsecond, 2000 m link.

- c. HTML server, with standard home page and five customizable pages.
 4. Firmware and software updates must be accessible through the communications port.
 5. **<Insert protocol>**.
- H. Physical Characteristics:
1. Display: Backlit LCD screen with antiglare and scratch-resistant lens.
 2. Display of Metered Values: One screen to show at least **[four]<Insert number>** lines of user-selected values on one screen at the same time. Provide graphical representation of user-selected values.
 3. Allow user to select a date/time format and the ability to create additional screens for user-specified views and custom quantities without overwriting existing standard screens.
- I. Sampling Rate:
1. Sample current and voltage to provide RMS accuracy to 255th harmonic of the fundamental frequency of 60 Hz.
 2. Continuously sample and record voltage and current at a rate not less than **[512 samples per cycle][83,333 points per cycle]<Insert rate>**, simultaneously on voltage and current channels of the meter.
- J. Measure, record with time stamp, and calculate; and, on request, display the following:
1. Measurements: Instantaneous, in real time, RMS to the 63rd harmonic:
 - a. Voltage: L-L each phase, L-L three-phase average, L-N each phase, L-N three-phase average, and percent unbalanced.
 - b. Current: Each phase, neutral, ground, three-phase average, apparent RMS, and percent unbalanced.
 - c. Active Power (kW): Each phase and three-phase total.
 - d. Reactive Power (kVAR): Each phase and three-phase total.
 - e. Apparent Power (kVA): Each phase and three-phase total.
 - f. Displacement Power Factor: Each phase and three-phase total.
 - g. Distortion Power Factor: Each phase and three-phase total.
 - h. Frequency.
 - i. K-factor for each phase.
 2. THD from measurements simultaneously from the same cycle, through **[255th]<Insert number>** harmonic:
 - a. Voltage: L-L each phase, L-L three-phase average, L-N each phase, and L-N three-phase average.
 - b. Current: Each phase, three-phase average, and neutral.
 - c. Power: Active, reactive, and apparent power including power of up to **[41st]<Insert number>**.
 3. Energy: Accumulated, indicate whether in-flow or out-flow, net and absolute values. Store the values in instrument's nonvolatile memory. Provide for storing accumulated energy at user-defined intervals, up to three intervals per day.
 - a. Active kWh.
 - b. Reactive kVARh.
 - c. Apparent kVAh.

4. Demand:
- a. Voltage: L-L each phase, L-L three-phase average, L-N each phase, and L-N three-phase average.
 - 1) Present.
 - 2) Running average.
 - 3) Last completed interval.
 - 4) Peak.
 - b. Current: Each phase, three-phase average, and neutral.
 - 1) Present.
 - 2) Last completed interval.
 - 3) Minimum.
 - 4) Peak.
 - c. Active Power (kW): Three-phase totals.
 - 1) Last completed interval.
 - 2) Predicted.
 - 3) Peak.
 - 4) Coincident with peak kVA demand.
 - 5) Coincident with peak kVAR demand.
 - d. Reactive Power (kVAR): Three-phase totals.
 - 1) Last completed interval.
 - 2) Predicted.
 - 3) Peak.
 - 4) Coincident with peak kW demand.
 - 5) Coincident with peak kVA demand.
 - e. Apparent Power (kVA): Three-phase totals.
 - 1) Last completed interval.
 - 2) Predicted.
 - 3) Peak.
 - 4) Coincident with peak kW demand.
 - 5) Coincident with peak kVA demand.
 - f. Distortion Power Factor: Three-phase totals.
 - 1) Last completed interval.
 - 2) Predicted.
 - 3) Peak.
 - 4) Coincident with peak kVA demand.
 - 5) Coincident with peak kVAR demand.

K. Average, Minimum and Maximum Values:

- 1. Record, date and time stamp, and save the minimum and maximum values of RMS metered values since the last reset.
- 2. Record, date and time stamp, and save maximum, minimum and average over a user-defined interval for the following metered values:

- a. Voltage: L-L each phase, L-L three-phase average, L-N each phase, and L-N three-phase average.
- b. Voltage Unbalance: L-L each phase and L-N each phase.
- c. Current:
 - 1) RMS each phase, three-phase average, and calculated neutral current.
 - 2) Apparent, RMS average.
 - 3) Active Power (kW): Each phase and three-phase total.
- d. Demand Current: RMS each phase and three-phase average.
- e. Reactive Power (kVAR): Each phase and three-phase total.
- f. Apparent Power (kVA): Each phase and three-phase total.
- g. Demand Active Power: Each phase and three-phase total.
- h. Demand Reactive Power: Each phase and three-phase total.
- i. Demand Apparent Power: Each phase and three-phase total.
- j. Accumulated Energy: MWh, MVAh, and MVARh.
- k. Reactive energy (MVARh) by quadrant.
- l. Power Factor: Three-phase displacement and distortion power factors.
- m. K-factor for each phase.
- n. THD L-L and L-N voltages.
- o. THD current in each phase and neutral.
- p. Frequency.

L. Power Demand, User Selectable:

1. Thermal Demand: Sliding window updated every second for the present demand and at end of the interval for the last interval. Adjustable window that can be set in 1-minute intervals, from 1 to 60 minutes.
2. Block Interval with Optional Subintervals: Adjustable for 1-minute intervals, from 1 to 60 minutes. User-defined parameters for the following block intervals:
 - a. Sliding block that calculates demand every second, with intervals less than 15 minutes, and every 15 seconds with an interval between 15 and 60 minutes. The default setting must be the 15-minute continuous sliding block.
 - b. Fixed block that calculates demand at end of the interval.
 - c. Rolling block subinterval that calculates demand at end of each subinterval and displays it at end of the interval.
3. Demand Calculation Initiated by a synchronization signal. Synchronize demand with clock in the circuit meter and monitor.
 - a. Synchronize demand with receipt of a signal pulse from an external source. Demand period begins with every pulse. Calculation must be configurable as either a block or rolling block calculation.
 - b. Synchronize demand with receipt of a communication signal. Calculation must be configurable as either a block or rolling block calculation.
 - c. Provide for synchronization to the clock in the instrument.
4. Record, date and time stamp, and save the following demand values of RMS metered values since the last reset, including the following:
 - a. Average demand current, per phase.
 - b. Peak demand current, per phase.
 - c. Average demand for active power, reactive power, and apparent power.
 - d. Predicted demand for active power, reactive power, and apparent power.

- e. Peak demand for active power, reactive power, and apparent power.
- M. Trend Curves: Provide for recording four trend curves at intervals of one minute, one hour, one day, or one month; and forecast values for the trended parameters:
 - 1. Record minimum, maximum, and average values of eight user-selected parameters as follows:
 - a. Every second for one minute for the one-minute curve.
 - b. Every minute for one hour for the one-hour curve.
 - c. Every hour for one day for the one-day curve.
 - d. Every day for one month for the one-month curve.
 - 2. Forecast the trended parameters for the following:
 - a. The next four hours.
 - b. The next four days.
- N. Power Analysis Values:
 - 1. THD Voltage: L-L each phase, L-N each phase, and L-N three-phase average.
 - 2. THD Current: Each phase, three-phase average, and neutral current.
 - 3. Total demand distortion.
 - 4. K-factor for each phase.
 - 5. Crest factor, each phase.
 - 6. Displacement power factor.
 - 7. Fundamental voltage, magnitude and angle, each phase.
 - 8. Fundamental currents, magnitude and angle, each phase.
 - 9. Fundamental active power, each phase and three-phase total.
 - 10. Fundamental reactive power, each phase and three-phase total.
 - 11. Harmonic power, each phase and three-phase total.
 - 12. Phase rotation.
 - 13. Voltage and current unbalances.
 - 14. Harmonic magnitudes and angles, each phase.
 - 15. Distortion power.
 - 16. Distortion power factor.
- O. Waveform Capture:
 - 1. Steady State Waveform Capture: Manually initiated over the communications network.
 - a. Capture, record with time stamp, and store voltage and current waveforms at a user-defined resolution of 16 to 512 samples/cycle for up to 30 seconds.
 - b. Capture, record with time stamp, and store 512 digitally sampled data points for each cycle of each phase voltage. The number of waveform captures stored onboard must be user configurable.
 - c. Harmonic analysis performed on the captured waveforms must resolve harmonics through the 255th for the following:
 - 1) Voltage: L-N and L-G each phase.
 - 2) Current: Of each phase and neutral current.
 - d. Captured waveforms must be recorded from actual circuit performance.
 - 2. Disturbance Waveform Capture:
 - a. Capture, record with time stamp, and store digitally sampled data points for each cycle of

each phase voltage. Disturbance waveform capture may be initiated manually, by an external contact closure, or by an alarm. The captured waveform must be at a user-defined resolution of 16 to 512 samples/cycle per second. The number of pre-alarm cycles must be adjustable.

3. Waveform samples must be available for transmission over the communications network, for display, archival, and analysis at computer workstations.

P. Transient Detection:

1. Detect and capture transient voltage surge events up to 10 kV L-L with a duration as short as 200 ns.

Q. Flicker Detection:

1. Detect and capture flicker events, defined by IEEE 1453, at three levels: instantaneous, short term, and long term.
2. Display the flicker event as plots of magnitude versus time on semi-log graph background.

R. Sag and Swell Detection and Alarm:

1. Detect and initiate alarm when detecting voltage or current sag and swell.
 - a. Detect disturbance events of less than half-cycle in length, by monitoring and calculating RMS magnitude of each half-cycle.
 - b. Event detection must be with user-defined parameters of threshold and delay. The threshold must be user defined as a fixed or relative set point. With relative set point, the instrument will alarm based on the nominal current or voltage equal to its present average value. The instrument must automatically adjust the nominal current and voltage values to avoid nuisance alarms caused by gradual daily variations of currents and voltages.
 - c. When detecting an alarm condition:
 - 1) Initiate disturbance waveform capture.
 - 2) Initiate 100 ms event recording.
 - 3) Recording the disturbance parameters into an onboard alarm log with a date and time stamp to the millisecond.
 - 4) Causing an alarm on the display and transmit the alarm over the data link.
 - 5) The user must have the ability to display the voltage sag/swell events on ITIC or SEMI graphs to quantify the event for accepted industry standards.

S. 100 ms Event Recording: Capture, record with time stamp, and store.

1. Initiate recording by an alarm or external contact closure.
2. User-configured recording, to record for the duration of the alarm up to 300 seconds and can be delayed for 1 to 10 seconds.
3. Records current per-phase and neutral, voltage L-L each phase and L-N each phase, active power per-phase and three-phase total, reactive power each phase and three-phase total, apparent power each phase and three-phase total, and true power factor three-phase total.
4. Operate an output relay in the I/O module of the instrument.

T. Harmonics Information:

1. Calculate the harmonic magnitudes and angles for each phase voltage and current in each phase and neutral, through the 255th harmonic. Provide harmonic power flows up to the 41st harmonic for active, reactive, and apparent power.

2. The current and voltage information for phases must be obtained simultaneously from the same cycle.
3. Report harmonic information as a percentage of the fundamental or as a percentage of the RMS values, as selected by the user.

U. Alarms:

1. Alarm events may be either user defined or preconfigured by manufacturer from the applicable standards. Provide for multiple levels for each alarm that is based on metered data.
2. The instrument must calculate the listed key electrical parameters at not less than 100 ms intervals to initiate and record an alarm event. Provide for user-selected range of 1 to 10 seconds of pre-event and up to five minutes of post-event data recording.
3. The following classes of events must be available to be programmed as alarm events:
 - a. Over/under current.
 - b. Over/undervoltage.
 - c. Current imbalance.
 - d. Phase loss, current.
 - e. Phase loss, voltage.
 - f. Voltage imbalance.
 - g. Wave shape alarm.
 - h. Over kVA.
 - i. Over kW or kVAR into/out of load.
 - j. Over/under frequency.
 - k. Under power factor, true or displacement.
 - l. Over THD.
 - m. Over K-factor.
 - n. Over demand, current or power.
 - o. Reverse power.
 - p. Phase reversal.
 - q. Status input change.
 - r. End of incremental energy interval.
 - s. End of demand interval.
 - t. Over/under analog inputs.
 - u. Current sag/swell.
 - v. Voltage sag/swell.
 - w. Transient events.
4. For each over/under metered alarm value, the user must define a pickup, dropout, and delay.
5. Waveform Alarms:
 - a. The instrument must detect anomalous waveform events that are less than half-cycle in length.
 - b. Provide for the user to set a threshold value and an upper limit to determine whether the waveform triggers an alarm. The threshold value and upper limit must be a value between 1 and 100. The threshold value is the limit at which a waveform triggers the alarm. The upper limit defines the highest waveform value that triggers a waveform alarm. The settable values are as follows:
 - 1) Phase voltages.
 - 2) N-G voltages.
 - 3) Phase currents.
 - 4) Neutral currents.
 - c. In response to a waveform alarm, the instrument must:

- 1) Log the event and record phase currents and voltages as defined in the 100 ms event recording.
 - 2) Determine the source of the disturbance (upstream or downstream from the meter) and a statistical level of confidence (low, medium, or high) of the accuracy of the source location.
6. Provide four alarm severity levels to allow the user to respond to the most important events first.
 7. Indicate an alarm condition on the front panel of the instrument, as well as reported over the data link to designated workstations.
 8. The circuit meter and monitor alarms response time must be not less than the following:
 - a. Standard, one second.
 - b. High speed, 100 ms.
 - c. Disturbance, half-cycle.
 9. Up to four alarms may be combined to give a single result using Boolean algebra operations.
 10. Provide e-mail notification of alarm conditions.
 11. Automatic Alarm Set-Point Adjustment:
 - a. The instrument software must provide for recognizing and learning the characteristics of the normal operation of the electrical power system it is connected to, and to select and adjust alarm set points based on that recognition.
 - b. The metered data to be recognized and learned, and the period of time for learning for alarms, disturbances, and waveform alarms, must be set by the user by selection one of the following two modes:
 - 1) Fixed Learning: Initially configured user set points are used during the entire learning period.
 - 2) Dynamic Learning: Initially configured user set points are temporarily replaced by learned set points at the interval specified by the user in the learning setup. The set points continue to be updated at the specified interval until the learning period expires.
 - c. The learning period must be user configurable. If the learned set points do not change over a predefined period, the learning process can be stopped and the set points either installed or held for review.
- V. EN 50160 Evaluation: Report EN 50160 evaluation data in the following formats: summary of active evaluations, summary of evaluation status, detailed information for each evaluated parameter, and detailed information for each abnormal event.
- W. I/O Module: Modular, with multiple I/O options, programmable to accomplish specified performance and one or more spare positions for future. At minimum, the instrument must provide the following:
1. KYZ Pulse: Solid-state output relay, programmed to generate a standard KYZ pulses for a user-defined increment of metered active energy as follows:
 - a. User-defined pulse output, associated with kWh.
 - b. Alarm pulse output, which turns on the pulsing at user-defined point.
 2. Digital inputs, each having the following operating modes:
 - a. Normal: Simple on/off digital inputs.
 - b. Demand Interval Synch Pulse Accept a demand synch pulse from a utility demand meter.
 - c. Conditional Energy Control input to control conditional energy accumulation.

3. Output Relays and Control: Output relays must have normally open and normally closed contacts and must operate in response to a user sent command over the data link, or automatically responding to an alarm event. The relays must be user configured in one of the following listed modes:
 - a. Normal contact closure where the contacts change state for as long as the signal exists.
 - b. Latched mode when the contacts change state when a pickup signal is received and are held until a dropout signal is received.
 - c. Timed mode when the contacts change state when a pickup signal is received and are held for a preprogrammed duration.
 - d. End of Power Demand Interval: When the relay operates as a synch pulse for other devices.
 - e. Energy Pulse Output: Relay will pulse quantities used for Absolute kWh, Absolute kVARh, kVAh, kWh In, kVARh In, kWh Out, and kVARh Out.
 - f. Programmed Output: Relay will operate in response to multiple alarms that are arranged to give a single result using Boolean algebra operations.
- X. Onboard Data Logs:
 1. Log data, alarms and events, and waveforms in onboard solid-state nonvolatile memory.
 2. Onboard data logs must be available for transmission over the communications network for display, archival, and analysis at computer workstations on demand.
 3. Data Logs, General: User configurable. Automatically stamp each entry to the millisecond with date and time.
 - a. Each log entry must hold data of up to 96 parameters each.
 - b. Each log must be user configurable to log data at a different user-defined schedule interval.
 - c. Provide each log with user-defined event or a minimum/maximum condition that will trigger log file entries.
 - d. Configure log entries to be recorded as Fill & Hold or Circular (FIFO), as defined by the user.
 4. Minimum/Maximum Logs:
 - a. Minimum/Maximum/Average interval log also logs minimum/maximum/average of selected parameters on a selected interval from a user-selected interval length from 1 to 1440 seconds.
 - b. Minimum/Maximum log must include the time, date, and value for the minimum and maximum of each of the active-time metered values.
 5. Alarm Log: Record time, date, event information, and coincident information for each user-defined and automatically initiated alarm or event. The log capacity must be not less than 1000 events. Record selected parameters at 100 ms intervals during events and alarms. Automatically stamp each entry to the millisecond with date and time.
 6. Waveform Logs: Capture and store waveforms as follows:
 - a. One cycle, 512 samples, to the 255th harmonic. Manually triggered.
 - b. Adjustable from 8 seconds at 18 samples per cycle, to 264 seconds at 16 samples per cycle. Triggered manually or by a user set alarm.
 - c. Voltage sampling at 5 MHz (83,333 samples per cycle) more than 2 ms to capture transient peaks of less than 1 microsecond.
- Y. Programming: Programming of instrument functions must be similar to BASIC syntax. Provide for initial programming and changes to programs through the communications links.

1. Programming language must include the following capabilities:
 - a. Scheduled tasks.
 - b. Event tasks.
 - c. Math functions including add, subtract, multiple, divide, sine, cosine, and square root.
 - d. Logical functions including: AND, OR, XOR, NOT, shift, and so forth.
 - e. Loop commands.
 - f. Compare statements.
 - g. Counters and timers.
2. Manufacturer must provide custom programs to meet Project requirements that are described in "Capacities and Characteristics" Paragraph below.
3. Metering of specialized utility rate structures, including real-time pricing and curtailable rates.
4. Data reduction using smart data logging.
5. Automatic monthly logging/reset of kWh and peak demand.
6. Statistical profile analysis of metered quantities.
7. ITIC/SEMI power quality analysis.
8. Calculations for IEEE 519 verification.
9. Metering of combined utilities: gas, water, steam, and electric.
10. Non-critical control schemes, such as load control or power factor correction, based on multiple conditions, for example, time of day and input status.

Z. Capacities and Characteristics:

1. Power Supply: **[120 V(ac), 60 Hz]<Insert text>**.
2. Circuit Connections:
 - a. Voltage: Measurements autoranging, zero to 600 V(ac) L-L, zero to 347 V(ac) L-N.[
Connect directly to low-voltage (600 V and less) without using voltage transformers.][Connect to instrument grade potential transformers secondary at 120 V.] Meter impedance must be 2 megohm L-L or greater.
 - b. Current: Connect to instrument grade current transformer with a metering range of 5 mA to 6 A. Overcurrent tolerance of the instrument must be 15 A continuous, 50 A for 10 seconds once per hour, and 120 A for one second per hour.
 - c. Frequency: 45 to 67 Hz, and 350 to 450 Hz.
 - d. Time: Input from a GPS receiver to synchronize the internal clock of the instrument and to time-synchronize this instrument with the network to a deviation of not greater than 1 ms.
3. Onboard, Field-Upgradeable, Solid-State Nonvolatile Memory: **[8]<Insert number>** MB.
4. Number of Onboard Data Logs: **[14]<Insert number>**.
5. Number of Minimum/Maximum Log Files: **[Two]<Insert number>**.
6. Alarm Log Capacity: Not less than 1000 events.
7. Custom Programs: Provide the following programs with the instrument:
 - a. Metering of specialized utility rate structures, including real-time pricing and curtailable rates.
 - b. Data reduction using smart data logging.
 - c. Automatic monthly logging/reset of kWh and peak demand.
 - d. Statistical profile analysis of metered quantities.
 - e. Calculations for IEEE 519 verification.
 - f. Metering of combined utilities: gas, water, steam, and electric.
 - g. Non-critical control schemes, such as load control or power factor correction, based on multiple conditions such as time of day and input status.
 - h. **<Insert requirements>**.

2.7 PC OPERATING SYSTEM SOFTWARE

- A. Description: System software must monitor, analyze, display, control, and save the parameters and features available at the connected meter.
- B. Software: Configured to run on a portable laptop computer, a single PC, or a tablet computer, with capability for accessing a single meter at a time, at the location of the meter. System is not connected to LAN.
- C. Minimum Requirements:
 - 1. Real-time multitasking and multiuser [32-][or][64-]bit operating system that allows execution of multiple real-time programs and custom program development.
 - 2. Operating system must be capable of operating Microsoft Windows applications.
 - 3. Scheduling software must schedule centrally based time and event, temporary, and exception day programs.

2.8 NETWORKED PC OPERATING SYSTEM SOFTWARE

- A. Description: System software must monitor, analyze, display, control, and save parameters and features available at each of the connected meters.
- B. Software: Configured to run on a single PC, with capability for accessing multiple devices simultaneously. Software must include interactive graphics client and must be web enabled.
- C. System Software Minimum Requirements:
 - 1. Real-time multitasking and multiuser [32-][or][64-]bit operating system that allows concurrent multiple workstations operating and concurrent execution of multiple real-time programs and custom program development.
 - 2. Operating system must be capable of operating Microsoft Windows applications.
 - 3. Database management software must manage data on an integrated and non-redundant basis. Additions and deletions to database must be without detriment to existing data. Include cross linkages so no data required by a program can be deleted by an operator until that data have been deleted from respective programs.
 - 4. Scheduling software must schedule centrally based time and event, temporary, and exception day programs.
- D. Operator Interface Software:
 - 1. Minimize operator training through use of English language pronouncing and English language point identification.
 - 2. Minimize use of a typewriter-style keyboard through use of a pointing device, touchscreen, or mouse.
 - 3. Operator sign-off must be a manual operation or, if no keyboard or mouse activity takes place, an automatic sign-off.
 - 4. Automatic sign-off period must be programmable from 1 to 60 minutes in 1-minute increments on a per operator basis.
 - 5. Record operator sign-on and sign-off activity.
 - 6. Security Access:
 - a. Operator access to electrical monitoring and control system must be under password control.
 - b. An alphanumeric password must be user assignable to each operator.
 - c. Software must have at least five access levels.



- 1) View - View information. No change privileges allowed.
 - 2) User - Same as View, but is able to initiate control functions.
 - 3) Controller - Same as User, but is able to initiate communications.
 - 4) Operator - Same as Controller, but is able to modify configurations.
 - 5) Supervisor - Same as Operator, but is able to administer security privileges.
- d. Each menu item must be assigned an access level so that a one-for-one correspondence between operator-assigned access level(s) and menu-item access level(s) is required to gain access to menu item.
 - e. Display menu items to operator with those menu items capable of access highlighted. Menu and operator access level assignments must be online programmable and under password control.

E. Graphic Interface Software:

1. Include a full interactive graphical selection means of accessing and displaying system data to operator.
2. Descriptors for graphics, points, alarms, and such must be modified through workstation under password control.
3. Display operator accessed data on the monitor.
4. Help Features: On-line context-sensitive help utility to facilitate operator training and understanding.

2.9 POWER MONITORING AND CONTROL SOFTWARE

A. Data Storage and Data Sharing:

1. Query and download logs of interval data stored on metering devices.
2. Query and download logs of alarm and event data stored on metering devices.
3. Query and download logs of waveform capture data stored on metering devices.
4. Query and download logs of interval data generated by the software and calculated by the meters.
5. Query and download logs of alarm and event data generated by the software and calculated by the meters.
6. Automatically re-arm the waveform recorders, on upload of information.
7. Provide a facility to archive, trim, and back up the database on demand, or on a schedule.
8. Provide a facility to view historical data from archived databases.
9. Support user changes to the database.
 - a. Support on-line changes while the data storage/retrieval application is running.
 - b. Suffer no interruption to its operation while changes are being made.
 - c. Require no restart once the configuration has been performed.

B. Project-Specific Graphics: Graphics documentation including, but not limited to, the following:

1. Site plan showing each building, and additional site elements, which are being controlled or monitored by the electrical power monitoring and control system.
2. Plan for each building floor, showing the following:
 - a. Locations and identification of monitored and controlled electrical equipment.
 - b. **<Insert requirements>.**
3. Control schematic for each device that is controlled by the meters of this Section, including a graphic system schematic representation[, **similar to that indicated on Drawings,**] with device

identification.

4. Graphic display for each piece of equipment connected to the electrical monitoring and control system through a data link.
5. Electrical power monitoring and control system network riser diagram that shows schematic layout for entire system including meters, **[gateways][and][other network devices]**.

2.10 NETWORK CONFIGURATION SOFTWARE

A. Network Management Graphical Interface Features:

1. Add and remove devices in the power monitoring and control network.
2. Application for naming devices based on a user-defined naming scheme.
3. Add and remove I/O servers in the power monitoring and control network.
4. Edit communication properties for devices including timeouts and delays.
5. Display mandatory fields when adding a new device.
6. Allow to manually connect and disconnect serial, Ethernet, modem, and Ethernet gateway sites.
7. Enable and disable devices and sites in the power monitoring and control network without interruption to other devices or sites.
8. Pool modem resources so that the software uses any available modem.
9. Monitor the following diagnostics:
 - a. Communication request/response and error rates, and timeouts.
 - b. Log acquisition services.

B. Database Maintenance Features:

1. Backup, archive, and trim data, event, and waveform logs.
 - a. Record start and end date for operation.
 - b. Allow copying data to another database.
 - c. Be capable of selecting logs specified for the meters that are Work of this Section.
 - 1) Data logs.
 - 2) Event logs.
 - 3) Waveform logs.

C. Web Reporter: Allow viewing historical data in preformatted report templates via a web browser.

1. Features:
 - a. User-configurable report generator to trigger on event, based on a schedule, or manual initiation.
 - b. Format reports in HTML, PDF, TIF, Excel, XML, or user-selected printer, or network folder.
 - c. Distribution of reports via email.
2. Report on power and demand profiles.
3. Power quality report with CBEMA evaluation.
4. EN 50160 compliance report.
5. 100 ms PQ report.
6. Energy over Period Report:
 - a. User-defined rollup interval by day, week, month, or year.
 - b. Compare daily energy to the following:
 - 1) Previous day.

- 2) Same day, previous week.
 - 3) Same day, previous month.
 - 4) User-defined specific day.
 - c. Compare weekly energy to the following:
 - 1) Previous week.
 - 2) Same week from previous month.
 - 3) Same week from previous year.
 - 4) User-defined specific week.
 - d. Compare monthly energy to the following:
 - 1) Previous month.
 - 2) Same month from previous year.
 - 3) User-defined specific month.
 - e. Compare annual energy to the following:
 - 1) Previous year.
 - 2) User-defined specific year.
- 7. Energy by daily period report for the user-defined periods. Aggregate consumption of the periods by the day, week, and year.
- 8. Tabular Report: Show values for multiple measurements and measurements from multiple devices in tabular format.
- 9. Trend Report:
 - a. Show values for multiple measurements and measurements from multiple devices in the following graphical formats:
 - 1) Line chart.
 - 2) Pie graph.
 - 3) Bar chart.
 - 4) Column chart.
 - 5) Smooth line chart.
 - 6) Stacked column chart.
 - 7) Stacked bar chart.
- 10. Alarm and Event History: User formatted, based on the meters and priority; and with user-defined alarm and event reports.
- 11. System Configuration Report:
 - a. Device name.
 - b. Device type.
 - c. Device address.
 - d. Connection status.
 - e. Device protocol.
 - f. Device description.
- 12. Each default report must include the following:
 - a. Summary aggregation of data from the selected devices.
 - b. Individual device information.
 - c. Raw data.

13. The reporting tool must provide a graphical interface to create and manage multiple Time of Use schedules:
 - a. Tariffs including energy cost rates per kWh, kVARh, and kVAh, and demand charges per kW, kVAR, and kVA.
 - b. Off-peak and on-peak times.

2.11 MONITORING AND CONTROL OF POWER DISTRIBUTION EQUIPMENT

- A. Power Distribution Equipment: Web-enabled, direct connected to the LAN or intranet.
- B. Instrument Transformers: Comply with IEEE C57.13.
 1. Potential Transformers: Secondary voltage rating of 120 V and NEMA C12.11 accuracy class of 0.3 with burdens of W, X, and Y.
 2. Current Transformers: Burden and accuracy class suitable for connected relays, meters, and instruments.
- C. Ethernet Connectivity:
 1. A multipoint, MODBUS TIA-485 serial communications network must be included within the equipment to interconnect breaker trip units, protective relays, drives, and metering devices equipped with communications.
 2. Serial communications network must be wired to an Ethernet server in the incoming section of the equipment. Hardware and cabling required for the connection to the network must be included within the power distribution equipment.
 3. Serial communications devices within the equipment must be factory addressed and tested to verify reliable communications to the equipment's Ethernet Server.
- D. Ethernet Gateways:
 1. User configurable; complying with UL 60950-1, and IEEE 802.3, Class 3 PoE.
 2. Include provisions to set initial Ethernet parameters via a local operator interface, or standard (8PSJ) Ethernet port, that is accessible from the front of the equipment. Initial setup must be limited to basic Ethernet addressing parameters, as assigned by Owner.
 3. Common Gateway Features:
 - a. User configurable, with secure password-protected login process.
 - b. Include communications diagnostic information for serial and Ethernet ports as well as internal health status and memory management information through embedded HTML web pages for viewing using a standard web browser.
 - c. Include embedded HTML pages providing real-time information from devices connected to the Ethernet gateway's TIA-485 port(s) through a standard web browser.
 - d. Allow firmware upgrades through the communications port.
 4. Include a "Quick-Start" guide with the equipment to describe the commissioning process for setting the equipment's Ethernet network address and for ensuring trouble-free data access from any PC on the network, using a standard web browser.
 5. Implement a common user interface ("look and feel") across different styles of power equipment.
- E. Distribution Equipment Monitoring:
 1. Main menu and summary pages, factory configured, to display data for each communicating device within the power equipment lineup.
 2. Display Data:

- a. Circuit summary page to display circuit name, three-phase average RMS current, real power (kW), power factor, and breaker status (if applicable).
- b. Load current summary page to display circuit name, and phase a, b, and c RMS current values.
- c. Demand current summary page to display circuit name, and phase a, b, and c average demand current values.
- d. Power summary page to display circuit name, present demand power (kW), peak demand power (kW), and recorded time and date.
- e. Energy summary page to display circuit name, real energy (kWh), reactive energy (kVARh), and time/date of last reset.
- f. For unit substations equipped with dry-type transformer(s) and microbased temperature controller(s), the circuit summary web page listed above must be augmented with transformer coil temperatures, phase a, b and c current values, and cooling fan status (on/off).
- g. For motor-control centers, the circuit summary web page must be tailored specifically for this application, to display circuit name, three-phase average RMS current, thermal capacity (percentage), drive output frequency (in Hertz, where applicable), and contactor status.

2.12 SYSTEM OPERATOR INTERFACES

- A. Operator means of system access must be through the following:
 1. Desktop workstation with hardwired connection through LAN port.
 2. Portable terminal with hardwired connection through LAN port at each meter.
 3. Remote connection using outside of system PC, tablet, or phone using an internet portal.

2.13 DESKTOP WORKSTATIONS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 1. **[Dell Technologies Inc.]**
 2. **[HP Inc.]**
 3. **[Lenovo Holding Co., Inc.; Lenovo Group Ltd.]**
 4. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 1. **[Dell Technologies Inc.]**
 2. **[HP Inc.]**
 3. **[Lenovo Holding Co., Inc.; Lenovo Group Ltd.]**
 4. **<Insert manufacturer's name>**
- C. Performance Requirements:
 1. Performance requirements may dictate equipment exceeding minimum requirements indicated.
 2. Capable of running **[Microsoft Windows]<Insert operating system name>**.
 3. ENERGY STAR compliant.
- D. Personal Computer:

1. Minimum Processor Speed: <Insert gigahertz>, [Core i3][Core i5][Core i7].
2. RAM:
 - a. Capacity: [2][4][8]<Insert value>[GB].
 - b. Speed and Type: [1333]<Insert value> MHz, <Insert type>.
3. Primary Hard Drive:
 - a. Media: [Solid state][Rotating disc, nominal rotational speed of 7200 rpm][Hybrid solid-state and rotating disc].
 - b. Number of Hard Drives: [One][Two]<Insert number>.
 - c. Capacity: <Insert number and measurement unit>.
 - d. Minimum Average Seek Time: <Insert number and measurement unit>.
 - e. Cache Buffer Size: <Insert number and measurement unit>.
 - f. <Insert requirements>.
4. Second Hard Drive:
 - a. Media: [Solid state][Rotating disc, nominal rotational speed of 7200 rpm][Hybrid solid-state and rotating disc].
 - b. Capacity: <Insert number and measurement unit>.
 - c. Minimum Average Seek Time: <Insert number and measurement unit>.
 - d. Cache Buffer Size: <Insert number and measurement unit>.
 - e. <Insert requirements>.
5. Optical Drive:
 - a. Type: <Insert type>.
 - b. Minimum Average Access Time: <Insert number> ms.
 - c. Data Transfer Speed: <Insert number>[MB][TB]/s.
 - d. Reading Formats: Data, audio, recordable, <Insert other> and rewritable.
6. Optical Read and Write Drive:
 - a. Include with at least 2 MB of data buffer.
 - b. Type: <Insert type>.
 - c. Minimum Data Buffer Capacity: <Insert number and measurement unit>.
 - d. Minimum Average Access Time: <Insert number> ms.
 - e. Nominal Data Transfer Rates:
 - 1) Reading: <Insert number>[MB][TB]/s.
 - 2) Writing: <Insert number>[MB][TB]/s.
 - f. Average access time of 150 ms or less.
 - g. MTBF of at least 100,000 power-on hours.
7. Expansion Slots: Minimum of 4, [32][64]<Insert number> bit.
8. Video Card:
 - a. Capable of supporting [one][two][three][four] monitors.
 - b. Resolution: [1920 by 1200]<Insert values> pixels minimum for each monitor.
 - c. RAM: <Insert number>[GB][TB].
 - d. Controller Speed: <Insert number>[MHz][GHz].
 - e. On-Board Memory Speed: <Insert number>[MHz][GHz].
 - f. On-Board Memory Data Width: <Insert number> bit.

9. Sound Card:
 - a. At least 128 voice wavetable synthesis.
 - b. Capable of delivering three-dimensional sound effects.
 - c. High-resolution 16-bit stereo digital audio recording and playback with user-selectable sample rates up to 48,000 Hz.
10. Network Interface Card: Include card with connection, as applicable.
 - a. 10-100-1000 base TX Ethernet with 8PSJ connector port.
 - b. 100 base FX Ethernet with SC or ST port.
11. Wireless Ethernet, 802.11 a/b/g/n.
12. Optical Modem: Full duplex link for connection to optical fiber cable provided.
13. I/O Ports:
 - a. Two USB 3.0 ports on front panel, six on back panel, and three internal on motherboard.
 - b. One serial port.
 - c. One parallel port.
 - d. Two PS/2 ports.
 - e. One 8PSJ.
 - f. One stereo line-in and line-out on back panel.
 - g. One microphone and headphone connector on front panel.
 - h. One IEEE 1394 on front and back panel with PCI-e card.
 - i. One ESATA port on back panel.
14. Battery: Life of at least three years to maintain system clock/calendar and ROM, as a minimum.

E. Keyboard:

1. 101-key enhanced keyboard.
2. Full upper- and lowercase ASCII keyset, numeric keypad, dedicated cursor control keypad, and 12 programmable function keys.
3. Wireless operation within up to **72 inch (1800 mm)** in front of workstation.

F. Pointing Device:

1. Either a two- or three-button mouse.
2. Wireless operation within up to **72 inch (1800 mm)** in front of workstation.

G. Flat Panel Display Monitor:

1. Number of Displays: **[One][Two]<Insert number>**.
 - a. Display Support: **[Individual tilt adjustable base.][Desk mounted, adjustable bracket capable of supporting number of monitors specified above with integral power and display cable organization.][Wall mounted, adjustable bracket capable of supporting number of monitors specified above with integral power and display cable organization.]<Insert description.>**
2. Color display with **<Insert inch (mm)>** diagonal viewable area.
3. Aspect Ratio: **[16 to 9]<Insert value>**.
4. Resolution: **[1920 by 1080]<Insert value>** pixels at 60 Hz with pixel size of **[0.277]<Insert number>** mm or smaller.
5. **[Digital][or][analog]** input signal.

6. Response Time: <Insert number> ms.
7. Dynamic Contrast Ratio: [50000 to 1]<Insert ratio>.
8. Brightness: [250 cd/sq. m]<Insert value>.
9. ENERGY STAR compliant.
10. Antiglare display.

H. Speakers:

1. Two, with individual controls for volume, bass, and treble.
2. Signal to Noise Ratio: At least 65 dB.
3. Power: At least 4 W per speaker/channel.
4. Magnetic shielding to prevent distortion on the video monitor.

I. I/O Cabling: Include applicable cabling to connect I/O devices.

J. Software:

1. Factory-installed operating system.

2.14 PORTABLE WORKSTATIONS

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

1. [Dell Technologies Inc.]
2. [HP Inc.]
3. [Lenovo Holding Co., Inc.; Lenovo Group Ltd.]
4. <Insert manufacturer's name>

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

1. [Dell Technologies Inc.]
2. [HP Inc.]
3. [Lenovo Holding Co., Inc.; Lenovo Group Ltd.]
4. <Insert manufacturer's name>

C. Performance Requirements:

1. Performance requirements may dictate equipment exceeding minimum requirements indicated.
2. ENERGY STAR compliant.
3. Hardware and software must support local downloading to DDC controllers.
4. Data transfer rate to DDC controller must be at network speed.

D. Processor:

1. Minimum Processor Speed: <Insert gigahertz>.
2. RAM:
 - a. Capacity: <Insert value>[GB][TB].
 - b. Speed and Type: <Insert value> MHz, <Insert type>.
3. Hard Drive:

- a. Media: **[Solid state][Rotating disc, nominal rotational speed of 7200 rpm][Hybrid solid-state and rotating disc]**.
 - b. Number of Hard Drives: **[One][Two]<Insert number>**.
 - c. Capacity: **<Insert number and measurement unit>**.
 - d. Minimum Average Seek Time: **<Insert number and measurement unit>**.
 - e. Cache Buffer Size: **<Insert number and measurement unit>**.
 - f. **<Insert requirements>**.
4. Video Card: **<Insert number and measurement unit>** of RAM.
- E. Input and Output Ports:
1. Serial port.
 2. Shared port for external keyboard or mouse.
 3. Four USB 3.0 ports.
 4. Ethernet port.
 5. HDMI port.
 6. IEEE 1394 port.
- F. Battery:
1. Capable of supporting operation of portable workstation for a minimum of **[8]<Insert number>** hours.
 2. Battery life of at least three years.
 3. Battery charge time of less than three hours.
 4. Spare Batteries: **[One][Two]**.
- G. Keyboard:
1. 85-key **[backlit]** keyboard.
 2. Full upper- and lowercase ASCII keyset.
- H. Integral Pointing Device: Touchpad with two buttons. Gesture enabled.
- I. Display:
1. **<Insert inch (mm)>** diagonal or larger high-definition WLED color display.
 2. Antiglare screen.
 3. **[1920 by 1080]<Insert value>** pixel resolution.
 4. Brightness: 300 nits.
- J. Network Interfaces:
1. Network Interface Card: Include card with connection, as application.
 - a. 10-100-1000 base TX Ethernet with 8PSJ connector port.
 - b. 100 base FX Ethernet with SC or ST port.
 2. Wireless:
 - a. Internal with integrated antenna, capable of supporting 802.11 a/b/g/n.
- K. Digital Video Disc Rewrite Recorder (DVD+/-RW):

1. Compatible with DVD disks and data, audio, recordable and rewritable compact disks.
2. Nominal Data Transfer Rates:
 - a. Reading: <Insert number>[MB][TB]/s.
 - b. Writing: <Insert number>[MB][TB]/s.
3. 160 ms access time.

L. Accessories:

1. Nylon carrying case.
2. Docking station.
3. Mobile broadband card.
4. Wireless optical mouse.
5. <Insert value>[GB][TB] portable hard drive.
6. Light-sensitive web cam and noise-cancelling digital array microphone.
7. Category 6a patch cable. Minimum cable length must be <Insert length>.
8. HDMI cable. Minimum cable length must be <Insert length>.

2.15 RACEWAYS AND BOXES

- A. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems" for raceways for electrical power wiring and NFPA 70 Class 1 remote-control and signaling circuits.
- B. Comply with requirements in Section 270528 "Pathways for Communications Systems" for control wiring, TIA-232 cable, and NFPA 70 Class 2 remote-control and signaling circuits.

2.16 WIRES AND CABLES

- A. Electrical Power Wiring: Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
 1. Copper conductors are Type THHN/THWN-2.
- B. Control Wiring: Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."
 1. Optical-Fiber Cable: Multimode, 50/125 micrometer OM3, six-fiber, [nonconductive,]tight-buffer, optical-fiber cable, with aqua jacket.
 2. Balanced Twisted Pair Cable: 100 ohm, four-pair [Category 5e][Category 6].
 3. Workstation Outlets: Four-port-connector assemblies mounted in single or multigang faceplate. Coordinate color and labels with Section 262726 "Wiring Devices."
 4. TIA-485 Cable: Paired, [one pair][two pairs], twisted, No. 22 AWG, stranded (7x30) tinned-copper conductors.
 5. Control-Voltage Cable: Multiple conductor, color-coded, No. 20 AWG copper, minimum.
 - a. Sheath: PVC; except in plenum-type spaces, use sheath listed for plenums.
 - b. Ordinary Switching Circuits: Three conductors unless otherwise indicated.
 - c. Switching Circuits with Pilot Lights or Locator Feature: Five conductors unless otherwise indicated.
- C. TIA-232 Cable:
 1. PVC-Jacketed, TIA-232 Cable: Paired, two pairs, No. 22 AWG, stranded (7x30) tinned copper

conductors, polypropylene insulation, and individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage; PVC jacket. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.

- a. Type CM.
 - b. Flame Resistance: UL 1581, vertical tray.
2. Plenum-Type, TIA-232 Cable: Paired, two pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, plastic insulation, and individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage; plastic jacket. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
 - a. Type CMP.
 - b. Flame Resistance: NFPA 262, flame test.

2.17 SURGE PROTECTION DEVICES

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

1. **[ABB, Electrification Business]**
2. **[Advanced Protection Technologies Inc. (APT)]**
3. **[ALLTEC LLC]**
4. **[Eaton]**
5. **[Emerson Electric Co., Automation Solutions]**
6. **[LEA International]**
7. **[Leviton Manufacturing Co., Inc.]**
8. **[Mersen USA]**
9. **[PowerLogics, Inc./PQ Protection]**
10. **[Schneider Electric USA, Inc.]**
11. **[Siemens Industry, Inc., Energy Management Division]**
12. **<Insert manufacturer's name>**

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

1. **[ABB, Electrification Business]**
2. **[Advanced Protection Technologies Inc. (APT)]**
3. **[ALLTEC LLC]**
4. **[Eaton]**
5. **[Emerson Electric Co., Automation Solutions]**
6. **[LEA International]**
7. **[Leviton Manufacturing Co., Inc.]**
8. **[Mersen USA]**
9. **[PowerLogics, Inc./PQ Protection]**
10. **[Schneider Electric USA, Inc.]**
11. **[Siemens Industry, Inc., Energy Management Division]**
12. **<Insert manufacturer's name>**

- C. SPDs: Comply with UL 1449, **[Type 1][Type 2]**.

1. Include LED indicator lights for power and protection status.
2. Internal thermal protection that disconnects the SPD before damaging internal suppressor

- components.
3. Include Form-C contacts rated at 5 A and 250 V(ac), one normally open and one normally closed, for remote monitoring of protection status. [**Contacts must reverse on failure of surge diversion module or on opening of current-limiting device. Coordinate with building power monitoring and control system.**]
 - D. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase must not be less than [**100 kA**] <Insert value>. The peak surge current rating must be the arithmetic sum of the ratings of the individual metal-oxide varistors in a given mode.
 - E. Comply with UL 1283.
 - F. Protection modes and UL 1449 SPD for grounded wye circuits with [**480Y/277 V**] [**208Y/120 V**], three-phase, four-wire circuits must not exceed the following:
 1. L-N: [**1200 V for 480Y/277 V**] [**700 V for 208Y/120 V**].
 2. L-G: [**1200 V for 480Y/277 V**] [**700 V for 208Y/120 V**].
 3. N-G: [**1200 V for 480Y/277 V**] [**700 V for 208Y/120 V**].
 4. L-L: [**2000 V for 480Y/277 V**] [**1200 V for 208Y/120 V**].
 - G. Protection modes and UL 1449 SPD for 240/120 V, single-phase, three-wire circuits must not exceed the following:
 1. L-N: 700 V.
 2. L-G: 700 V.
 3. N-G: 700 V.
 4. L-L: 1200 V.
 - H. SCCR: Equal or exceed [**100**] [**200**] <Insert value> kA.
 - I. Nominal Rating: [**20**] [**10**] kA.
 - J. Indoor Enclosures: NEMA 250, Type 1.
 - K. Outdoor Enclosures: NEMA 250, [**Type 3R**] [**Type 4**] [**Type 4X**].

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine pathway elements intended for cables. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF POWER MONITORING AND CONTROL SYSTEMS

- A. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters. Conceal raceway and cables except in unfinished spaces.
- B. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and

without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

C. Wiring and Cabling Installation:

1. Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for electrical power wiring.
2. Comply with Section 260523 "Control-Voltage Electrical Power Cables" for control wiring.

D. Raceways Installation:

1. Comply with Section 260533.13 "Conduits for Electrical Systems" for electrical power wiring and NFPA 70 Class 1 remote-control and signaling circuits.
2. Comply with Section 270528 "Pathways for Communications Systems" for control wiring, TIA-232 cable, and NFPA 70 Class 2 remote-control and signaling circuits.

E. Identification Installation:

1. Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for electrical power wiring.
2. Comply with Section 271513 "Communications Copper Horizontal Cabling" for identification products and cable management system requirements for twisted pair cable, TIA-485 cable, control-voltage cable, and TIA-232 cable.
3. Comply with Section 271523 "Communications Optical Fiber Horizontal Cabling" for identification products and cable management system requirements for optical-fiber cable.

3.3 INSTALLATION OF WORKSTATIONS

A. Desktop Workstations Installation:

1. Install workstation(s) at location(s) directed by Owner.
2. Install multiple-receptacle power strip with cord for use in connecting multiple workstation components to a single, duplex electrical power receptacle.
3. Install software on workstation(s) and verify that software functions properly.
4. Develop Project-specific graphics, trends, reports, logs, and historical database.
5. Power workstation through a UPS unit. Locate UPS adjacent to workstation.

B. Portable Workstations Installation:

1. Turn over portable workstations to Owner at Substantial Completion.
2. Install software on workstation(s) and verify that software functions properly.

C. Graphics Application:

1. Use system schematics indicated as starting point to create graphics.
2. Develop Project-specific library of symbols for representing system equipment and products.
3. Incorporate digital images of Project-completed installation into graphics where beneficial to enhance effect.
4. Submit sketch of graphic layout with description of text for each graphic for Owner's[**and Architect's**] review before creating graphic using graphics software.
5. Seek Owner input in graphics development once using graphics software.
6. Final editing must be done on-site with Owner's review and feedback.
7. Refine graphics as necessary for Owner acceptance.
8. On receiving Owner acceptance, print a hard copy to include in operation and maintenance manual. Prepare a scanned copy PDF file of each graphic and include with softcopy of the

system operation and maintenance manual.

3.4 NETWORK NAMING AND NUMBERING

- A. Coordinate with Owner and provide unique naming and addressing for networks and devices.

3.5 GROUNDING

- A. For data communication wiring, comply with BICSI N1.
- B. For control-voltage wiring and cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.6 FIELD QUALITY CONTROL

- A. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.
- B. Tests and Inspections:
 - 1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 2. Visually inspect balanced twisted pair cabling and optical-fiber cable jacket materials for UL or third-party certification markings. Inspect cabling terminations to confirm color-coding for pin assignments, and inspect cabling connections to confirm compliance with TIA-568-C.1.
 - 3. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of components.
 - 4. Test balanced twisted pair cabling for direct-current loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination, but not after cross-connection.
 - a. Test instruments must meet or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in its "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in its "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
 - b. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.
 - 5. Optical-Fiber Cable Tests:
 - a. Test instruments must meet or exceed applicable requirements in TIA-568-C.0. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
 - b. Link End-to-End Attenuation Tests:
 - 1) Multimode Link Measurements: Test at 850 or 1300 nm in one direction according to IEC 61280-4-1.
 - 2) Attenuation test results for links must be less than **[2.0 dB][that calculated according to equation in TIA-568-C.0]**.

- c. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.

6. Power Monitoring and Control System Tests.

a. Test Analog Signals:

- 1) Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
- 2) Check analog current signals using a precision current meter at zero, 50, and 100 percent.
- 3) Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

b. Test Digital Signals:

- 1) Check digital signals using a jumper wire.
- 2) Check digital signals using an ohmmeter to test for contact making or breaking.

c. I/O Control Loop Tests:

- 1) Test every I/O point to verify that safety and operating control set points are as indicated and as required to operate controlled system safely and at optimum performance.
- 2) Test every I/O point throughout its full operating range.
- 3) Test every control loop to verify that operation is stable and accurate.
- 4) Adjust control loop proportional, integral, and derivative settings to achieve optimum performance while complying with performance requirements indicated. Document testing of each control loop's precision and stability via trend logs.
- 5) Test and adjust every control loop for proper operation according to sequence of operation.
- 6) Test software and hardware interlocks for proper operation.
- 7) Operate each analog point at the following:
 - a) Upper quarter of range.
 - b) Lower quarter of range.
 - c) At midpoint of range.
- 8) Exercise each binary point.
- 9) For every I/O point in the system, read and record each value at workstation, at controller, and at field instrument simultaneously. Value displayed at workstation and at field instrument must match.
- 10) Prepare and submit a report documenting results for each I/O point in the system, and include in each I/O point a description of corrective measures and adjustments made to achieve desired results.

C. Nonconforming Work:

- 1. Wiring and cabling will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.7 FINAL REVIEW

- A. Submit written request to Architect **[and][Construction Manager]** when the power monitoring and control system is ready for final review. Written request must state the following:
 - 1. The system has been thoroughly inspected for compliance with Contract Documents and found to be in full compliance.
 - 2. The system has been calibrated, adjusted, and tested and found to comply with requirements of operational stability, accuracy, speed, and other performance requirements indicated.
 - 3. The system monitoring and control of electrical distribution systems results in operation according to sequences of operation indicated.
 - 4. The system is complete and ready for final review.
- B. Review by **[Architect][and][Construction Manager]** will be made after receipt of written request. A field report must be issued to document observations and deficiencies.
- C. Take prompt action to remedy deficiencies indicated in field report and submit a second written request when deficiencies have been corrected. Repeat process until no deficiencies are reported.
- D. Final review must include a demonstration to parties participating in final review.

3.8 MAINTENANCE SERVICE

- A. Beginning at Substantial Completion, maintenance service must include **[three][six][nine][12]** months' full maintenance by manufacturer's authorized service representative. Include **[quarterly][semiannual][annual]** preventive maintenance, repair or replacement of defective components, cleaning, and adjusting as required for proper system operation. Parts and supplies must be manufacturer's authorized replacement parts and supplies.

3.9 SOFTWARE SERVICE AGREEMENT

- A. Technical Support: Beginning at Substantial Completion, service agreement must include software support for **[two]<Insert number>** years.
- B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within **[two]<Insert number>** years from date of Substantial Completion. Upgrading software must include operating system and new or revised licenses for using software.
 - 1. Upgrade Notice: At least **[30]<Insert number>** days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.10 TRAINING

- A. Attendee Training Manuals:
 - 1. Provide each attendee with a color hard copy of training materials and visual presentations.
 - 2. Hard-copy materials must be organized in a three-ring binder with table of contents and individual divider tabs marked for each logical grouping of subject matter. Organize material to provide space for attendees to take handwritten notes within training manuals.
 - 3. In addition to hard-copy materials included in training manual, provide each binder with a sleeve or pocket that includes a DVD or flash drive with PDF copy of hard-copy materials.

- B. On-Site Training:
1. Owner will provide conditioned classroom or workspace with ample desks or tables, chairs, power, and data connectivity for instructor and each attendee.
 2. Instructor must provide training materials, projector, and other audiovisual equipment used in training.
 3. Provide as much of training located on-site as deemed feasible and practical by Owner.
 4. On-site training must include regular walk-through tours, as required, to observe each unique product type installed with hands-on review of operation, calibration, and service requirements.
 5. The workstation provided with the system must be used in training. If workstation is not indicated, provide a temporary workstation to convey training content.
- C. Off-Site Training:
1. Provide conditioned training rooms and workspace with ample tables, chairs, power, and data connectivity for each attendee.
 2. Provide capability to remotely access to Project monitoring and control system for use in training.
 3. Provide a workstation for use by each attendee.
- D. At Completion of Training: Staff familiar with the system installed are capable of demonstrating operation of the system during final review.
- E. Demonstration must include, but not be limited to, the following:
1. Accuracy and calibration of [10]<Insert number> I/O points randomly selected by reviewers. If review finds that some I/O points are not properly calibrated and not satisfying performance requirements indicated, additional I/O points may be selected by reviewers until total I/O points being reviewed that satisfy requirements equals quantity indicated.
 2. Reporting of alarm conditions for randomly selected alarms, including different classes of alarms, to ensure that alarms are properly received by operators and workstations.
 3. Trends, summaries, logs, and reports set-up for Project.
 4. Software's ability to communicate with controllers, workstations, and uploading and downloading of control programs.
 5. Software's ability to edit control programs off-line.
 6. Data entry to show Project-specific customizing capability including parameter changes.
 7. Step through penetration tree, display graphics, demonstrate dynamic update, and direct access to graphics.
 8. Execution of digital and analog commands in graphic mode.
 9. Spreadsheet and curve plot software and its integration with database.
 10. Online user guide and help functions.
 11. For Each Meter:
 - a. Memory: Programmed data, parameters, trend, and alarm history collected during normal operation is not lost during power failure.
 - b. Operator Interface: Ability to connect directly to each meter with a portable workstation.
 - c. Wiring Labels: Match control drawings.
 - d. Network Communication: Ability to locate a meter on the network. Communication architecture matches Shop Drawings.
 - e. Nameplates and Tags: Accurate and permanently attached to control panel doors, instrument, actuators, and devices.
 12. For Each Workstation:
 - a. I/O point lists agree with naming conventions.
 - b. Graphics are complete.



- c. UPS unit, if applicable, operates.

END OF SECTION 26 09 13 00



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Task	Specification	Specification Description
26 09 13 00	26 09 00 00	Addressable Luminaire Lighting Controls
26 09 13 00	26 09 00 00a	Relay-Based Lighting Controls



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SECTION 26 09 23 00 - LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Time switches.
2. Outdoor photoelectric switches.
3. Daylight-harvesting controls.
4. Business occupancy and vacancy sensors.
5. Storage occupancy sensors.
6. Outdoor motion sensors.
7. Industrial control switches.
8. Emergency lighting controls.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies temperature, humidity, acoustical, and other field conditions applicable to the Work specified in this Section.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies seismic hazard, wind hazard, other structural design conditions applicable to the Work specified in this Section.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional coordination, scheduling, sequencing, submittal, and installation requirements applicable to the Work for electrical, communications, and electronic safety and security systems on the Project, including wiring methods.
4. Section 260526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding of lighting control devices referenced by this Section.
5. Section 260529 "Hangers and Supports for Electrical Systems" specifies hangers and supports referenced by this Section.
6. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs referenced by this Section.
7. **[Section 262726 "Wiring Devices"]****[Section 262726.11 "General-Use Switches, Dimmer Switches, and Fan-Speed Controller Switches"]** for wall-box dimmers and manual light switches.

1.2 DEFINITIONS

- A. BCELTS: Branch circuit emergency lighting transfer switch.
- B. DPDT: Double pole double throw.
- C. DPST: Double pole single throw.
- D. N.C.: Normally closed.
- E. N.O.: Normally open.
- F. PIR: Passive infrared.

- G. SPDT: Single pole double throw.
- H. SPST: Single pole single throw.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing agency, certifying product's compliance with specified listing criteria.
 - a. If listed manufacturer differs from selling manufacturer, indicate relationship between entities on submittal. Clearly indicate which entity warrants product performance and fitness for purpose.
 - b. Listing criteria identified in approval letter must match specified listing criteria. UL label indicating approval of equipment's enclosure is not considered approval of equipment for intended application.
 - c. Product identification in approval letter must match product branding and model numbers in submittal. Approval letters for discontinued or superseded products are unacceptable for submitted product.
 - 2. Include manufacturer's sample extended warranty language.
- B. Shop Drawings: Prepare and submit the following:
 - 1. Show installation details for the following:
 - a. Occupancy sensors.
 - b. Vacancy sensors.
 - 2. Interconnection diagrams showing field-installed wiring.
 - 3. Diagrams for power, signal, and control wiring.
- C. Sustainable Design Submittals:
 - 1. ASHRAE/IES 90.1 LPD Compliance Documentation: Prepare plans and calculations demonstrating that as-constructed lighting power density complies with mandatory provisions of ASHRAE/IES 90.1 and that as-constructed lighting, including daylighting and controls, improves on baseline energy performance. If included with Project, indicate locations of energy meters for lighting loads.
 - 2. Lighting Control Documentation: Floor plans indicating the following information:
 - a. As-installed locations of switches and dimmers.
 - b. Lighting zones and control strategy for each switch or dimmer, including unoccupied time-delay setting for shut-off and override time-delay setting for shut-off.
 - c. Multilevel or dimming range capability for each switch or dimmer.
 - d. Which switches or dimmers are operated by occupancy sensors, vacancy sensors, daylighting sensors, or time clocks.
- D. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

- A. Manufacturer's published instructions.
- B. Field Reports:
 - 1. Manufacturer's field reports for field quality-control support.
 - 2. Field reports for software and firmware upgrades.

1.5 CLOSEOUT SUBMITTALS

- A. Warranty documentation.
- B. Software and firmware service agreement.

1.6 QUALIFICATIONS

- A. Electrical Power Testing (EPT) Technician III: Possessing active NICET EPT Level III certification. Able to manage switching procedures, conduct tests of complex equipment, analyze test and equipment data, plan a job, and lead a team. Has experience performing NFPA 70B, IEEE, and NETA electrical tests.
- B. Electrical Power Testing (EPT) Technician IV: Possessing active NICET EPT Level IV certification. Able to conduct tests of complex metering and relay systems; evaluate tests, test equipment, test results, and power system performance; recommend actions to maintain or improve system performance; and lead multiteam projects.
- C. Electrical Power Testing and Inspecting Agency: Entities possessing active credentials from qualified electrical testing laboratory recognized by authorities having jurisdiction.
 - 1. On-site electrical testing supervisors must possess active NICET EPT Technician [III][IV] certification.
- D. Lighting Testing and Inspecting Agency: Entity possessing active qualifications specified in Section 014000 "Quality Requirements" with documented training and experience with testing and inspecting lighting installations in accordance with applicable IES standards.

1.7 WARRANTY

- A. Special Installer Extended Warranty: Installer warrants that installed lighting control devices perform in accordance with specified requirements and agrees to repair or replace components or products that fail to perform as specified within extended-warranty period. Warranty must convey to Owner upon acceptance of the Work.
 - 1. Extended-Warranty Period: **[Two][Three][Four]<Insert number>** years from date of Substantial Completion; full coverage for labor, materials, and equipment.
- B. Special Manufacturer Extended Warranty: Manufacturer warrants that lighting control devices perform in accordance with specified requirements and agrees to provide repair or replacement of components or products that fail to perform as specified within extended-warranty period. Warranty must convey to Owner upon acceptance of the Work.

1. Failures include, but are not limited to, the following:
 - a. Faulty operation of lighting control software.
 - b. Faulty operation of lighting control devices.
 - c. **<Insert failure modes>**.
2. Initial Extended-Warranty Period: **[Three][Four][Five]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for labor, materials, and equipment.
3. Follow-On Extended-Warranty Period: **[Eight]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for materials only, free on board **[origin][destination]**, freight prepaid.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Regulatory Requirements:

1. Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
2. Must comply with CCR Title 24.

2.2 TIME SWITCHES

A. UL WGZR - Electronic Time Switch :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Eaton]**
 - b. **[Intermatic, Inc]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[nLight; Acuity Brands Lighting, Inc.]**
 - e. **[NSi Industries LLC]**
 - f. **[Schneider Electric USA, Inc.]**
 - g. **[TE Connectivity Ltd.]**
 - h. **[Touché Lighting Control]**
 - i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Eaton]**
 - b. **[Intermatic, Inc]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[nLight; Acuity Brands Lighting, Inc.]**
 - e. **[NSi Industries LLC]**
 - f. **[Schneider Electric USA, Inc.]**

- g. [TE Connectivity Ltd.]
 - h. [Touché Lighting Control]
 - i. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
- a. Clock-Operated Switches: UL CCN WGZR, including UL 917.
5. Standard Features:
- a. Contact Configuration: [SPST][DPST][DPDT]<Insert configuration>.
 - b. Contact Rating: [30 A inductive or resistive, 240 V(ac)][20 A driver load, 120/240 V(ac)]<Insert rating>.
 - c. Programs:
 - 1) Eight on-off set points on a 24-hour schedule[**and an annual holiday schedule that overrides the weekly operation on holidays**].
 - 2) Two on-off set points on a 24-hour schedule, allowing different set points for each day of the week[**and an annual holiday schedule that overrides the weekly operation on holidays**].
 - 3) <Insert number> channels; each channel is individually programmable with eight on-off set points on a 24-hour schedule.
 - 4) <Insert number> channels; each channel is individually programmable with two on-off set points on a 24-hour schedule with a skip-a-day weekly schedule.
 - 5) <Insert number> channels; each channel is individually programmable with two on-off set points on a 24-hour schedule, allowing different set points for each day of the week.
 - 6) <Insert number> channels; each channel is individually programmable with 40 on-off operations per week and an annual holiday schedule that overrides the weekly operation on holidays.
 - 7) <Insert number> channels; each channel is individually programmable with 40 on-off operations per week, plus four seasonal schedules that modify the basic program and an annual holiday schedule that overrides the weekly operation on holidays.
 - 8) <Insert configuration>[**and an annual holiday schedule that overrides the weekly operation on holidays**].
 - d. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program[**on selected channels**].
 - e. Astronomic Time: [All][Selected] channels.
 - f. Automatic daylight savings time changeover.
 - g. Battery Backup: Not less than seven days' reserve, to maintain schedules and time clock.

B. UL WGZR - Electromechanical-Dial Time Switch :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
- a. [Eaton]
 - b. [Intermatic, Inc]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [NSi Industries LLC]

- e. **[Schneider Electric USA, Inc.]**
 - f. **[TE Connectivity Ltd.]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[Eaton]**
 - b. **[Intermatic, Inc]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[NSi Industries LLC]**
 - e. **[Schneider Electric USA, Inc.]**
 - f. **[TE Connectivity Ltd.]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
- a. Clock-Operated Switches: UL CCN WGZR, including UL 917.
5. Standard Features:
- a. Contact Configuration: **[SPST][DPST][SPDT][DPDT]<Insert configuration>**.
 - b. Contact Rating: **[30 A inductive or resistive, 240 V(ac)][20 A driver load, 120/240 V(ac)]<Insert rating>**.
 - c. Circuitry: Allows connection of a photoelectric relay as a substitute for the on-off function of a program.
 - d. Astronomic time dial.
 - e. Eight-Day Program: Uniquely programmable for each weekday and holidays.
 - f. Skip-a-day mode.
 - g. Wound-spring reserve carryover mechanism to keep time during power failures, minimum of **[16]<Insert number>** hours.

C. UL WGZR - Digital Timer Light Switch :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
- a. **[Eaton]**
 - b. **[Intermatic, Inc]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[nLight; Acuity Brands Lighting, Inc.]**
 - e. **[NSi Industries LLC]**
 - f. **[Schneider Electric USA, Inc.]**
 - g. **[TE Connectivity Ltd.]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[Eaton]**
 - b. **[Intermatic, Inc]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[nLight; Acuity Brands Lighting, Inc.]**
 - e. **[NSi Industries LLC]**
 - f. **[Schneider Electric USA, Inc.]**
 - g. **[TE Connectivity Ltd.]**
 - h. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Clock-Operated Switches: UL CCN WGZR, including UL 917.
5. Standard Features:
 - a. Combination digital timer and conventional switch lighting control unit. Switchbox-mounted, backlit LCD display, with selectable time interval in **[10][20]**-minute increments.
 - b. Rated 960 W at 120 V(ac) for tungsten lighting, 10 A at 120 V(ac) or 10 A at 277 V(ac) for fluorescent or LED lighting, and 1/4 hp at 120 V(ac).
 - c. Standards: Comply with UL 20.
 - d. Integral relay for connection to BAS.
 - e. Voltage: **[Match the circuit voltage][120 V][277 V][Dual voltage - 120 and 277 V]**.
 - f. Color: **[White][Black]<Insert color>**.
 - g. Faceplate: Color matched to switch.

2.3 OUTDOOR PHOTOELECTRIC SWITCHES

A. UL WJFX - Solid-State Outdoor Photoelectric Switch, Flexible Mounting :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Eaton]**
 - b. **[Intermatic, Inc]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[nLight; Acuity Brands Lighting, Inc.]**
 - e. **[NSi Industries LLC]**
 - f. **[TE Connectivity Ltd.]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Eaton]**
 - b. **[Intermatic, Inc]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[nLight; Acuity Brands Lighting, Inc.]**
 - e. **[NSi Industries LLC]**
 - f. **[TE Connectivity Ltd.]**

- g. **<Insert manufacturer's name>**
- 3. Source Limitations: Obtain products from single manufacturer.
- 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Plug-in, Locking-Type Photocontrols: UL CCN WJFX, including UL 773.
- 5. Standard Features:
 - a. Solid state, with **[SPST][DPST]<Insert configuration>** dry contacts rated for **[1000 W incandescent][or][1800 VA inductive]<Insert value>**, to operate connected relay, contactor coils, or microprocessor input; and compatible with drivers and LED lamps.
 - b. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - c. Light-Level Monitoring Range: **1.5 to 10 fc (16.14 to 108 lx)**, with an adjustment for turn-on and turn-off levels within that range[, and a directional lens in front of the photocell to prevent fixed light sources from causing turn-off].
 - d. Time Delay: Fifteen-second minimum, to prevent false operation.
 - e. Surge Protection: Metal-oxide varistor.
 - f. Mounting: Twist lock complies with ANSI C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure[**from same source and manufacturer as switch**].
 - g. Failure Mode: Luminaire stays ON.

B. UL WJFX - Solid-State Outdoor Photoelectric Switch, Luminaire-Mounted :

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Eaton]**
 - b. **[Intermatic, Inc]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[nLight; Acuity Brands Lighting, Inc.]**
 - e. **[NSi Industries LLC]**
 - f. **[TE Connectivity Ltd.]**
 - g. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Eaton]**
 - b. **[Intermatic, Inc]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[nLight; Acuity Brands Lighting, Inc.]**
 - e. **[NSi Industries LLC]**
 - f. **[TE Connectivity Ltd.]**
 - g. **<Insert manufacturer's name>**
- 3. Source Limitations: Obtain products from single manufacturer.

4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Plug-in, Locking-Type Photocontrols: UL CCN WJFX, including UL 773.
 5. Standard Features:
 - a. Solid state, with **[SPST][DPST]** dry contacts rated for **[1000 W incandescent][or][1800 VA inductive]**, to operate connected load, and compatible with CFL and LED lamps.
 - b. Light-Level Monitoring Range: **1.5 to 10 fc (16.14 to 108 lx)**, with an adjustment for turn-on and turn-off levels within that range.
 - c. Time Delay: Thirty-second minimum, to prevent false operation.
 - d. Lightning Arrester: Air-gap type.
 - e. Mounting: Twist lock complying with ANSI C136.10, with base **[from same source and manufacturer as switch]**.
 - f. Failure Mode: Luminaire stays ON.
- C. UL WJFX - Solid-State, Low-Voltage, Outdoor Photoelectric Switch :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Eaton]**
 - b. **[Intermatic, Inc]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[nLight; Acuity Brands Lighting, Inc.]**
 - e. **[NSi Industries LLC]**
 - f. **[TE Connectivity Ltd.]**
 - g. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Eaton]**
 - b. **[Intermatic, Inc]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[nLight; Acuity Brands Lighting, Inc.]**
 - e. **[NSi Industries LLC]**
 - f. **[TE Connectivity Ltd.]**
 - g. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Plug-in, Locking-Type Photocontrols: UL CCN WJFX, including UL 773.
 5. Standard Features:
 - a. Solid state; one set of N.O. dry contacts rated for **[24 V(dc) at 1 A][24 V(ac) at 1 A]**, to operate connected load, and compatible with **[luminaire][power pack][lighting control**

- panelboard].**
- b. Light-Level Monitoring Range: **1.5 to 10 fc (16.14 to 108 lx)**, with an adjustment for turn-on and turn-off levels within that range.
 - c. Time Delay: Thirty-second minimum, to prevent false operation.
 - d. Mounting: **1/2 inch (13 mm)** threaded male conduit.
 - e. Failure Mode: Luminaire stays ON.
 - f. Power Pack:
 - 1) Dry contacts rated for **[20 A]<Insert value>[driver][or][LED]** load at 120 and 277 V(ac), for **[13 A]<Insert value>** tungsten at 120 V(ac), and for **[1 hp]<Insert value>** at 120 V(ac). Sensor has 24 V(dc), 150 mA, Class 2 power source.
 - a) LED status lights to indicate load status.
 - b) Plenum rated.
 - 2) Digital controller capable of accepting **[three][four]<Insert number>** 8PSJ inputs with **[one][two]** outputs rated for **[20 A]<Insert value>** incandescent **[or LED]** load at 120 and 277 V(ac), for **[13 A][16 A]<Insert value>[driver][or][LED]** at 120 and 277 V(ac), and for **[1 hp]<Insert value>** at 120 V(ac). Sensor has 24 V(dc), Class 2 power source.
 - a) With integral current monitoring.
 - b) Compatible with digital addressable lighting interface.
 - c) Plenum rated.

2.4 DAYLIGHT-HARVESTING CONTROLS

A. UL WJCT - Daylight-Harvesting Control Switch :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Eaton]**
 - b. **[Hubbell Control Solutions; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Lithonia Lighting; Acuity Brands Lighting, Inc.]**
 - e. **[nLight; Acuity Brands Lighting, Inc.]**
 - f. **[NSi Industries LLC]**
 - g. **[Sensor Switch, Inc]**
 - h. **[TE Connectivity Ltd.]**
 - i. **[WattStopper; Legrand North America, LLC]**
 - j. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Eaton]**
 - b. **[Hubbell Control Solutions; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**

- d. [Lithonia Lighting; Acuity Brands Lighting, Inc.]
 - e. [nLight; Acuity Brands Lighting, Inc.]
 - f. [NSi Industries LLC]
 - g. [Sensor Switch, Inc]
 - h. [TE Connectivity Ltd.]
 - i. [WattStopper; Legrand North America, LLC]
 - j. <Insert manufacturer's name>
 3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Photoelectric Switches: UL CCN WJCT, including UL 773A.
 5. Standard Features:
 - a. System operates indoor lighting.
 - b. Ceiling-Mounted Switching Controls:
 - 1) Solid-state, light-level sensor unit, with [integrated]power pack, that detects changes in indoor lighting levels that are perceived by the eye.
 - 2) Solid-state, light-level sensor unit, with separate power pack[mounted on luminaire], that detects changes in indoor lighting levels that are perceived by the eye.
 - c. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F (0 to 49 deg C).
 - d. Sensor Output:
 - 1) Contacts rated to operate the associated power pack, complying with UL 773A. Sensor must be powered by the power pack.
 - 2) Digital signal compatible with power pack.
 - e. Sensor Type: [Open loop][Closed loop].
 - f. Zone: [Single][Multi].
 - g. Power Pack:
 - 1) Dry contacts rated for [20 A]<Insert value>[driver][or][LED] load at 120 and 277 V(ac), for [13 A]<Insert value> tungsten at 120 V(ac), and for [1 hp]<Insert value> at 120 V(ac). Sensor has 24 V(dc), 150 mA, Class 2 power source.
 - a) LED status lights to indicate load status.
 - b) Plenum rated.
 - 2) Digital controller capable of accepting [three][four]<Insert number> 8PSJ inputs with [one][two] outputs rated for [20 A]<Insert value> incandescent [or][LED] load at 120 and 277 V(ac), for [13 A][16 A]<Insert value>[driver][or LED] at 120 and 277 V(ac), and for [1 hp]<Insert value> at 120 V(ac). Sensor has 24 V(dc) Class 2 power source.
 - a) With integral current monitoring
 - b) Compatible with digital addressable lighting interface.
 - c) Plenum rated.
 - h. General Space Sensors Light-Level Monitoring Range: 10 to 200 fc (108 to 2152 lx), with an adjustment for turn-on and turn-off levels within that range.

- i. Atrium Space Sensors Light-Level Monitoring Range: **100 to 1000 fc (1080 to 10 800 lx)**, with an adjustment for turn-on and turn-off levels within that range.
 - j. Skylight Sensors Light-Level Monitoring Range: **1000 to 10 000 fc (10 800 to 108 000 lx)**, with an adjustment for turn-on and turn-off levels within that range.
 - k. Time Delay: Adjustable from 5 to 300 seconds to prevent cycling.
 - l. Set-Point Adjustment: Equip with deadband adjustment of 25, 50, and 75 percent above the "on" set point, or provide with separate adjustable "on" and "off" set points.
 - m. Test Mode: User selectable, overriding programmed time delay to allow settings check.
 - n. Control Load Status: User selectable to confirm that load wiring is correct.
 - o. Indicator: Two digital displays to indicate the beginning of on-off cycles.
6. Sequence of Operation: As daylight increases, the lights are turned off at a predetermined level. As daylight decreases, the lights are turned on at a predetermined level.
- a. Lighting control set point is based on two lighting conditions:
 - 1) When no daylight is present.
 - 2) When significant daylight is present (target level).
 - b. System programming is done with two handheld, remote-control tools.

B. UL WJCT - Daylight-Harvesting Analog Control Dimmer :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Deep Roof Lighting]**
 - b. **[Eaton]**
 - c. **[Hubbell Control Solutions; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - d. **[Leviton Manufacturing Co., Inc.]**
 - e. **[Lithonia Lighting; Acuity Brands Lighting, Inc.]**
 - f. **[WattStopper; Legrand North America, LLC]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Deep Roof Lighting]**
 - b. **[Eaton]**
 - c. **[Hubbell Control Solutions; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - d. **[Leviton Manufacturing Co., Inc.]**
 - e. **[Lithonia Lighting; Acuity Brands Lighting, Inc.]**
 - f. **[WattStopper; Legrand North America, LLC]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

- a. Photoelectric Switches: UL CCN WJCT, including UL 773A.
- 5. Standard Features:
 - a. Sensing daylight and electrical lighting levels, the system adjusts the indoor electrical lighting levels. As daylight increases, the lights are dimmed.
 - b. System programming is done with two handheld, remote-control tools.
 - 1) Initial setup tool.
 - 2) Tool for occupants to adjust the target levels by increasing the set point up to 25 percent, or by minimizing the electric lighting level.
 - c. Ceiling-Mounted Dimming Controls: Solid-state, light-level sensor unit, with **[integrated][separate]** power pack **[mounted on luminaire]**, to detect changes in indoor lighting levels that are perceived by the eye.
 - d. Sensor Output: 0-10 V(dc) to operate luminaires. Sensor is powered by controller unit.
 - e. Light-Level Sensor Set-Point Adjustment Range: **20 to 60 fc (120 to 640 lx)**.
 - f. Power Pack: Dry contacts rated for **[20 A]<Insert value>[driver][or][LED]** load at 120 and 277 V(ac), for **[13 A]<Insert value>** tungsten at 120 V(ac), and for **[1 hp]<Insert value>** at 120 V(ac). Sensor has 24 V(dc), 150 mA, Class 2 power source.
 - 1) LED status lights to indicate load status.
 - 2) Plenum rated.
- 6. Sequence of Operation: Lighting control set point is based on two lighting conditions:
 - a. When no daylight is present (target level).
 - b. When significant daylight is present.
- C. UL WJCT - Daylight-Harvesting Digital Control Dimmer :
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Deep Roof Lighting]**
 - b. **[Eaton]**
 - c. **[Hubbell Control Solutions; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - d. **[Leviton Manufacturing Co., Inc.]**
 - e. **[Lithonia Lighting; Acuity Brands Lighting, Inc.]**
 - f. **[nLight; Acuity Brands Lighting, Inc.]**
 - g. **[WattStopper; Legrand North America, LLC]**
 - h. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Deep Roof Lighting]**
 - b. **[Eaton]**
 - c. **[Hubbell Control Solutions; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - d. **[Leviton Manufacturing Co., Inc.]**
 - e. **[Lithonia Lighting; Acuity Brands Lighting, Inc.]**

- f. [nLight; Acuity Brands Lighting, Inc.]
 - g. [WattStopper; Legrand North America, LLC]
 - h. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
- a. Photoelectric Switches: UL CCN WJCT, including UL 773A.
5. Standard Features:
- a. Sensing daylight and electrical lighting levels, the system adjusts the indoor electrical lighting levels. As daylight increases, lights are dimmed.
 - b. System programming is done with two handheld, remote-control tools.
 - 1) Initial setup tool.
 - 2) Tool for occupants to adjust the target levels by increasing the set point up to 25 percent, or by minimizing the electric lighting level.
 - c. Ceiling-Mounted Dimming Controls: Solid-state, light-level sensor unit, with [integrated][separate] power pack[mounted on luminaire], to detect changes in indoor lighting levels that are perceived by the eye.
 - d. Sensor Output: 0-10 V(dc) to operate luminaires. Sensor is powered by controller unit.
 - e. Light-Level Sensor Set-Point Adjustment Range: **20 to 60 fc (120 to 640 lx)**.
 - f. Power Pack: Digital controller capable of accepting [three][four]<Insert number> 8PSJ inputs with [one][two] output(s) rated for [20 A]<Insert value> incandescent [or][LED] load at 120 and 277 V(ac), for [13 A][16 A]<Insert value>[driver load][or][LED] at 120 and 277 V(ac), and for [1 hp]<Insert value> at 120 V(ac). Sensor has 24 V(dc) Class 2 power source.
 - 1) With integral current monitoring.
 - 2) Compatible with digital addressable lighting interface.
 - 3) Plenum rated.
6. Sequence of Operation: Lighting control set point is based on the following two lighting conditions:
- a. When no daylight is present (target level).
 - b. When significant daylight is present.

2.5 BUSINESS OCCUPANCY AND VACANCY SENSORS

A. Passive-Infrared (PIR) Occupancy or Vacancy Sensor :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
- a. [Ademco; Honeywell]
 - b. [ADT Security Services, Inc]
 - c. [Cooper Lighting Solutions; Signify North America Corp.]

- d. [Crestron Electronics, Inc.]
 - e. [Honeywell Security Group]
 - f. [Hubbell Control Solutions; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - g. [Leviton Manufacturing Co., Inc.]
 - h. [Lithonia Lighting; Acuity Brands Lighting, Inc.]
 - i. [Lutron Electronics Co., Inc]
 - j. [Napco Security Technologies, Inc.]
 - k. [Pass & Seymour; Legrand North America, LLC]
 - l. [RAB Lighting]
 - m. [WattStopper; Legrand North America, LLC]
 - n. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Ademco; Honeywell]
 - b. [ADT Security Services, Inc]
 - c. [Cooper Lighting Solutions; Signify North America Corp.]
 - d. [Crestron Electronics, Inc.]
 - e. [Honeywell Security Group]
 - f. [Hubbell Control Solutions; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - g. [Leviton Manufacturing Co., Inc.]
 - h. [Lithonia Lighting; Acuity Brands Lighting, Inc.]
 - i. [Lutron Electronics Co., Inc]
 - j. [Napco Security Technologies, Inc.]
 - k. [Pass & Seymour; Legrand North America, LLC]
 - l. [RAB Lighting]
 - m. [WattStopper; Legrand North America, LLC]
 - n. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for one of the following UL product categories:
 - a. Photoelectric Controls: UL CCN WJCT, including UL 773A.
 - b. Energy Management Equipment: UL CCN PAZX, including UL 916 or UL 60730-1.
 - c. Intrusion Detection Units: UL CCN ANSR, including UL 639.
5. Standard Features:
 - a. [Wall][Ceiling]-mounted, solid-state indoor [occupancy][and][vacancy] sensors.
 - b. [Integrated][Separate] power pack.
 - c. [Hardwired][Wireless] connection to switch[and BAS][; and BAS and lighting control system].
 - d. Sensor Output: [Contacts rated to operate the connected relay, complying with UL 773A][Sensor is powered from the power pack][Wireless].
 - e. Power: [Line voltage][Integral photovoltaic collector].
 - f. Power Pack: Dry contacts rated for 20 A [driver][or][LED] load at 120 and 277 V(ac), for 13 A tungsten at 120 V(ac), and for 1 hp at 120 V(ac). Sensor has 24 V(dc), 150 mA, Class 2 power source.
 - g. Mounting:

- 1) Sensor: Suitable for mounting in any position in a standard device box or outlet box.
 - 2) Relay: Externally mounted through a **1/2 inch (13 mm)** knockout in a standard electrical enclosure.
 - 3) Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
- h. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
 - i. Bypass Switch: Override the "on" function in case of sensor failure.
 - j. Automatic Light-Level Sensor: Adjustable from **2 to 200 fc (21.5 to 2152 lx)**; turn lights off when selected lighting level is present.
 - k. Detector Sensitivity: Detect occurrences of **6 inch (150 mm)** minimum movement of any portion of a human body that presents a target of not less than **36 sq. inch (23 200 sq. mm)**.
- 1) Detection Coverage (Room, Ceiling Mounted): Detect occupancy anywhere in a circular area of **1000 sq. ft (93 sq. m)** when mounted on a **96 inch (2440 mm)** high ceiling.
 - 2) Detection Coverage (Corridor, Ceiling Mounted): Detect occupancy within **90 ft (27.4 m)** when mounted on a **10 ft (3 m)** high ceiling.
 - 3) Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of [**1000 sq. ft (110 sq. m)**][**2000 sq. ft (220 sq. m)**][**3000 sq. ft (330 sq. m)**] when mounted **48 inch (1200 mm)** above finished floor.
6. Operation:
- a. Occupancy Sensor: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
 - b. Vacancy Sensor: Unless otherwise indicated, lights are manually turned on and sensor turns lights off when the room is unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
 - c. Combination Sensor: Unless otherwise indicated, sensor must be programmed to turn lights on when coverage area is occupied and turn them off when unoccupied, or to turn off lights that have been manually turned on; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
- B. Ultrasonic Occupancy or Vacancy Sensor :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Cooper Lighting Solutions; Signify North America Corp.]**
 - b. **[Eaton]**
 - c. **[Hubbell Control Solutions; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - d. **[Lutron Electronics Co., Inc]**
 - e. **[WattStopper; Legrand North America, LLC]**
 - f. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the

following:

- a. [Cooper Lighting Solutions; Signify North America Corp.]
 - b. [Eaton]
 - c. [Hubbell Control Solutions; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - d. [Lutron Electronics Co., Inc]
 - e. [WattStopper; Legrand North America, LLC]
 - f. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for one of the following UL product categories:
- a. Appliance Controls: UL CCN ATNZ, including UL 60730-1.
 - b. Energy Management Equipment: UL CCN PAZX, including UL 916 or UL 60730-1.
 - c. Intrusion Detection Units: UL CCN ANSR, including UL 639.
5. Standard Features:
- a. [Wall][Ceiling]-mounted, solid-state indoor [occupancy][and][vacancy] sensors.
 - b. [Integrated][Separate] power pack.
 - c. [Hardwired][Wireless] connection to switch[and BAS][; and BAS and lighting control system].
 - d. Power: Line voltage.
 - e. Power Pack: Dry contacts rated for 20 A [driver][or][LED] load at 120 and 277 V(ac), for 13 A tungsten at 120 V(ac), and for 1 hp at 120 V(ac). Sensor has 24 V(dc), 150 mA, Class 2 power source.
 - f. Mounting:
 - 1) Sensor: Suitable for mounting in any position in a standard device box or outlet box.
 - 2) Relay: Externally mounted through a 1/2 inch (13 mm) knockout in a standard electrical enclosure.
 - 3) Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
 - g. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
 - h. Bypass Switch: Override the "on" function in case of sensor failure.
 - i. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc (21.5 to 2152 lx); turn lights off when selected lighting level is present.
 - j. Detector Sensitivity: Detect a person of average size and weight moving not less than 12 inch (305 mm) in either a horizontal or a vertical manner at an approximate speed of 12 inch/s (305 mm/s).
 - 1) Detection Coverage (Small Room): Detect occupancy anywhere within a circular area of 600 sq. ft (56 sq. m) when mounted on a 96 inch (2440 mm) high ceiling.
 - 2) Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft (93 sq. m) when mounted on a 96 inch (2440 mm) high ceiling.
 - 3) Detection Coverage (Large Room): Detect occupancy anywhere within a circular area of 2000 sq. ft (186 sq. m) when mounted on a 96 inch (2440 mm) high ceiling.
 - 4) Detection Coverage (Corridor): Detect occupancy anywhere within 90 ft (27.4 m) when mounted on a 10 ft (3 m) high ceiling in a corridor not wider than 14 ft (4.3 m).
 - 5) Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of [1000 sq. ft

(110 sq. m)][2000 sq. ft (220 sq. m)][3000 sq. ft (330 sq. m)] when mounted 84 inch (2100 mm) above finished floor.

6. Operation:

- a. Occupancy Sensor: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
- b. Vacancy Sensor: Unless otherwise indicated, lights are manually turned on and sensor turns lights off when the room is unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
- c. Combination Sensor: Unless otherwise indicated, sensor must be programmed to turn lights on when coverage area is occupied and turn them off when unoccupied, or to turn off lights that have been manually turned on; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.

C. Dual-Technology, Passive-Infrared (PIR) and Ultrasonic, Occupancy or Vacancy Sensor :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Cooper Lighting Solutions; Signify North America Corp.]**
 - b. **[HLI Solutions; brand of GE Current, a Daintree Company]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Cooper Lighting Solutions; Signify North America Corp.]**
 - b. **[HLI Solutions; brand of GE Current, a Daintree Company]**
 - c. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for one of the following UL product categories:
 - a. Energy Management Equipment: UL CCN PAZX, including UL 916 or UL 60730-1.
 - b. Appliance Controls: UL CCN ATNZ, including UL 60730-1.
 - c. Intrusion Detection Units: UL CCN ANSR, including UL 639.
5. Standard Features:
 - a. **[Wall][Ceiling]-mounted, solid-state indoor [occupancy][and][vacancy] sensors.**
 - b. **[Integrated][Separate] power pack.**
 - c. **[Hardwired][Wireless] connection to switch[and BAS][; and BAS and lighting control system].**
 - d. Sensitivity Adjustment: Separate for each sensing technology.
 - e. Detector Sensitivity: Detect occurrences of **6 inch (150 mm)** minimum movement of any portion of a human body that presents a target of not less than **36 sq. inch (23 200 sq. mm)**, and detect a person of average size and weight moving not less than **12 inch (305 mm)** in either a horizontal or a vertical manner at an approximate speed of

12 inch/s (305 mm/s).

- 1) Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of **1000 sq. ft (93 sq. m)** when mounted on a **96 inch (2440 mm)** high ceiling.
- 2) Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of **[1000 sq. ft (110 sq. m)][2000 sq. ft (220 sq. m)][3000 sq. ft (330 sq. m)]** when mounted **48 inch (1200 mm)** above finished floor.

6. Operation:

- a. Occupancy Sensor: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
- b. Vacancy Sensor: Unless otherwise indicated, lights are manually turned on and sensor turns lights off when the room is unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
- c. Combination Sensor: Unless otherwise indicated, sensor must be programmed to turn lights on when coverage area is occupied and turn them off when unoccupied, or to turn off lights that have been manually turned on; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.

D. Dual-Technology, Passive-Infrared (PIR) and Passive-Acoustic, Occupancy or Vacancy Sensor :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[HLI Solutions; brand of GE Current, a Daintree Company]**
 - b. **[Lithonia Lighting; Acuity Brands Lighting, Inc.]**
 - c. **[SensorWorx; brand of BLP Technologies, Inc.]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[HLI Solutions; brand of GE Current, a Daintree Company]**
 - b. **[Lithonia Lighting; Acuity Brands Lighting, Inc.]**
 - c. **[SensorWorx; brand of BLP Technologies, Inc.]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for one of the following UL product categories:
 - a. Energy Management Equipment: UL CCN PAZX, including UL 916 or UL 60730-1.
 - b. Appliance Controls: UL CCN ATNZ, including UL 60730-1.
 - c. Intrusion Detection Units: UL CCN ANSR, including UL 639.
5. Standard Features:
 - a. **[Wall][Ceiling]-mounted, solid-state indoor [occupancy][and][vacancy] sensors.**
 - b. **[Integrated][Separate] power pack.**

- c. **[Hardwired][Wireless]** connection to switch **[and BAS][; and BAS and lighting control system]**.
- d. Sensitivity Adjustment: Separate for each sensing technology.
- e. Detector Sensitivity: Detect occurrences of **6 inch (150 mm)** minimum movement of any portion of a human body that presents a target of not less than **36 sq. inch (23 200 sq. mm)**, and detect a person of average size and weight moving not less than **12 inch (305 mm)** in either a horizontal or a vertical manner at an approximate speed of **12 inch/s (305 mm/s)**.
 - 1) Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of **1000 sq. ft (93 sq. m)** when mounted on a **96 inch (2440 mm)** high ceiling.
 - 2) Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of **[1000 sq. ft (110 sq. m)][2000 sq. ft (220 sq. m)][3000 sq. ft (330 sq. m)]** when mounted **48 inch (1200 mm)** above finished floor.

6. Operation:

- a. Occupancy Sensor: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
- b. Vacancy Sensor: Unless otherwise indicated, lights are manually turned on and sensor turns lights off when the room is unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
- c. Combination Sensor: Unless otherwise indicated, sensor must be programmed to turn lights on when coverage area is occupied and turn them off when unoccupied, or to turn off lights that have been manually turned on; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.

E. Wall-Switch Occupancy Sensor :

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Bryant; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Douglas Lighting Controls]**
 - c. **[Eaton]**
 - d. **[Hubbell Control Solutions; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - e. **[Intermatic, Inc]**
 - f. **[Leviton Manufacturing Co., Inc.]**
 - g. **[Lithonia Lighting; Acuity Brands Lighting, Inc.]**
 - h. **[Lutron Electronics Co., Inc]**
 - i. **[nLight; Acuity Brands Lighting, Inc.]**
 - j. **[NSi Industries LLC]**
 - k. **[Philips; Signify North America; Signify Holding]**
 - l. **[RAB Lighting]**
 - m. **[Sensor Switch, Inc]**
 - n. **[Square D; Schneider Electric USA]**
 - o. **[WattStopper; Legrand North America, LLC]**
 - p. **<Insert manufacturer's name>**

- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert**

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

- a. [Bryant; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - b. [Douglas Lighting Controls]
 - c. [Eaton]
 - d. [Hubbell Control Solutions; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - e. [Intermatic, Inc]
 - f. [Leviton Manufacturing Co., Inc.]
 - g. [Lithonia Lighting; Acuity Brands Lighting, Inc.]
 - h. [Lutron Electronics Co., Inc]
 - i. [nLight; Acuity Brands Lighting, Inc.]
 - j. [NSi Industries LLC]
 - k. [Philips; Signify North America; Signify Holding]
 - l. [RAB Lighting]
 - m. [Sensor Switch, Inc]
 - n. [Square D; Schneider Electric USA]
 - o. [WattStopper; Legrand North America, LLC]
 - p. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for one of the following UL product categories:
 - a. Photoelectric Controls: UL CCN WJCT, including UL 773A.
 - b. Energy Management Equipment: UL CCN PAZX, including UL 916 or UL 60730-1.
 - c. Intrusion Detection Units: UL CCN ANSR, including UL 639.
 5. Standard Features:
 - a. Automatic-wall-switch occupancy sensor with manual on-off switch, suitable for mounting in single gang switchbox[, with provisions for connection to BAS][using hardwired connection][using wireless connection].
 - 1) Occupancy Sensor Operation: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn lights off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
 - 2) Operating Ambient Conditions: Dry interior conditions, **32 to 120 deg F (0 to 49 deg C)**.
 - 3) Switch Rating: Not less than 800 VA [driver][or][LED] load at 120 V, 1200 VA [driver][or][LED] load at 277 V, and 800 W incandescent.
 - b. Standard Range: **[180-degree field of view, field adjustable from 180 to 40 degrees][210-degree field of view]**; with a minimum coverage area of **[900 sq. ft (84 sq. m)][2100 sq. ft (196 sq. m)]**.
 - c. Sensing Technology: **[PIR][Dual technology - PIR and ultrasonic]**.
 - d. Switch Type: **[Single pole.][Single pole, dual circuit.][Single pole, manual "on," automatic "off."][Single pole, field-selectable automatic "on," or manual "on," automatic "off."]**
 - e. Capable of controlling load in three-way application.
 - f. Voltage: **[Match circuit voltage][120 V][277 V][Dual voltage - 120 and 277 V]**.
 - g. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from **10 to 150 fc (108 to 1600 lx)**. Switch prevents lights from turning on when light level is higher than set point of sensor.

- h. Time Delay:
 - 1) Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
 - 2) Concealed, "off" time-delay selector at 30 seconds and 5, 10, and 20 minutes.
- i. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.
- j. Color: **[White][Black]<Insert color>**.
- k. Faceplate: Color matched to switch.

2.6 STORAGE OCCUPANCY SENSORS

A. High-Bay Occupancy Sensor :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Hubbell Control Solutions; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[nLight; Acuity Brands Lighting, Inc.]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Hubbell Control Solutions; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[nLight; Acuity Brands Lighting, Inc.]**
 - c. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Photoelectric Controls: UL CCN WJCT, including UL 773A.
5. Standard Features:
 - a. Solid-State Unit: Designed to operate with the lamp and ballasts or drivers indicated.
 - b. Power: Line voltage.
 - 1) Operating Ambient Conditions: **32 to 149 deg F (0 to 65 deg C)**.
 - 2) Mounting: Threaded pipe.
 - 3) Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
 - 4) Detector Technology: PIR.
 - c. Detector Coverage: User selectable by interchangeable PIR lenses, suitable for mounting heights from **12 to 50 ft (3.7 to 15.2 m)**.

6. Other Available Features Required for the Project:
 - a. HID Continuous Lamp Monitoring: When lamps are dimmed continuously for 24 hours, automatically turn lamps on to full power for 15 minutes for every 24 hours of continuous dimming.
 - b. HID Dimming Adapter: Power and dimming control from the luminaire ballast that has been modified to include the dimming capacitor[**and MyzerPORT option**].
7. Operation: Turn lights on when coverage area is occupied, and to half-power when unoccupied; with a time delay for turning lights to half-power that is adjustable over a minimum range of 1 to 16 minutes.
8. Accessories: Obtain manufacturer's installation and maintenance kit with laser alignment tool for sensor positioning and power port connectors.

B. Ceiling-Mounted, Solid-State, Extreme-Temperature Occupancy Sensor :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Eaton]**
 - b. **[nLight; Acuity Brands Lighting, Inc.]**
 - c. **[Sensor Switch, Inc]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Eaton]**
 - b. **[nLight; Acuity Brands Lighting, Inc.]**
 - c. **[Sensor Switch, Inc]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Photoelectric Controls: UL CCN WJCT, including UL 773A.
5. Standard Features:
 - a. Operating Ambient Conditions: From **minus 40 to plus 125 deg F (minus 40 to plus 52 deg C)**.
 - b. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor is powered from the power pack.
 - c. Separate Power Pack: Dry contacts rated for 20 A **[driver][or][LED]** load at 120 and 277 V(ac), for 13 A tungsten at 120 V(ac), and for 1 hp at 120 V(ac). Sensor has 24 V(dc), 150 mA, Class 2 power source.
 - d. Mounting:
 - 1) Sensor: Suitable for mounting in any position in a standard device box or outlet box.
 - 2) Relay: Externally mounted through a **1/2 inch (13 mm)** knockout in a standard electrical enclosure.

- 3) Time-Delay and Sensitivity Adjustments: Recessed and concealed behind cover.
- e. Bypass Switch: Override the "on" function in case of sensor failure.
- f. Automatic Light-Level Sensor: Adjustable from **2 to 10 fc (21.5 to 108 lx)**; keep lighting off when selected lighting level is present.
- g. Detector Technology: PIR. Ceiling mounted; detect occupants in coverage area by their heat and movement.
 - 1) Detector Sensitivity: Detect occurrences of **6 inch (150 mm)** minimum movement of any portion of a human body that presents a target of not less than **36 sq. inch (23 200 sq. mm)**.
 - 2) Detection Coverage (Room): Detect occupancy anywhere in a circular area of **1500 sq. ft (139 sq. m)** when mounted on a **96 inch (2440 mm)** high ceiling.
 - 3) Detection Coverage (High Bay): Detect occupancy within **25 ft (7.6 m)** when mounted on a **25 ft (7.6 m)** high ceiling.
6. Operation: Turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 30 minutes.

2.7 OUTDOOR MOTION SENSORS

A. Solid-State Outdoor Motion Sensor :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Bryant; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Eaton]**
 - c. **[Hubbell Control Solutions; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - d. **[Leviton Manufacturing Co., Inc.]**
 - e. **[Lithonia Lighting; Acuity Brands Lighting, Inc.]**
 - f. **[nLight; Acuity Brands Lighting, Inc.]**
 - g. **[NSi Industries LLC]**
 - h. **[RAB Lighting]**
 - i. **[Sensor Switch, Inc]**
 - j. **[WattStopper; Legrand North America, LLC]**
 - k. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Bryant; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Eaton]**
 - c. **[Hubbell Control Solutions; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - d. **[Leviton Manufacturing Co., Inc.]**
 - e. **[Lithonia Lighting; Acuity Brands Lighting, Inc.]**
 - f. **[nLight; Acuity Brands Lighting, Inc.]**
 - g. **[NSi Industries LLC]**
 - h. **[RAB Lighting]**

- i. **[Sensor Switch, Inc]**
- j. **[WattStopper; Legrand North America, LLC]**
- k. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for one of the following UL product categories:
 - a. Plug-in, Locking-Type Photocontrols: UL CCN WJFX, including UL 773.
 - b. Energy Management Equipment: UL CCN PAZX, including UL 916 or UL 60730-1.
 - c. Intrusion Detection Units: UL CCN ANSR, including UL 639.
5. Standard Features:
 - a. **[PIR][Dual-technology (PIR and ultrasonic)]** type, weatherproof. Detect occurrences of **6 inch (150 mm)** minimum movement of any portion of a human body that presents a target of not less than **36 sq. inch (23 200 sq. mm)**.
 - b. Switch Rating:
 - 1) Luminaire-Mounted Sensor: **[1000 W incandescent, 500 VA fluorescent/LED]<Insert rating>**.
 - 2) Separately Mounted Sensor: Dry contacts rated for 20 A **[driver][or][LED]** load at 120 and 277 V(ac), for 13 A tungsten at 120 V(ac), and for 1 hp at 120 V(ac). Sensor has 24 V(dc), 150 mA, Class 2 power source.
 - 3) Switch Type: **[Single pole.][Single pole, dual circuit.][Single pole, manual "on," automatic "off."][Single pole, field-selectable automatic "on," or manual "on," automatic "off."][With bypass switch to override the "on" function in case of sensor failure.]**
 - c. Voltage: **[Match the circuit voltage][120 V][277 V][Dual voltage, 120 and 277 V]** type.
 - d. Detector Coverage:
 - 1) Standard Range: 210-degree field of view, with a minimum coverage area of **900 sq. ft (84 sq. m)**.
 - 2) Long Range: 180-degree field of view and **110 ft (34 m)** detection range.
 - 3) **<Insert coverage area>**.
 - e. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from **10 to 150 fc (108 to 1600 lx)**. The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
 - f. Time Delay:
 - 1) Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
 - 2) Concealed, "off" time-delay selector at 30 seconds and 5, 10, and 20 minutes.
 - g. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and help eliminate false "off" switching.
 - h. Operating Ambient Conditions: Suitable for operation in ambient temperatures ranging from **minus 40 to plus 130 deg F (minus 40 to plus 54 deg C)**, rated as "raintight" in accordance with UL 773A.

2.8 INDUSTRIAL CONTROL SWITCHES

A. Lighting Contactor :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[Allen-Bradley/Rockwell Automation]**
 - c. **[ASCO Power Technologies]**
 - d. **[Eaton]**
 - e. **[Leviton Manufacturing Co., Inc.]**
 - f. **[Square D; Schneider Electric USA]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Allen-Bradley/Rockwell Automation]**
 - c. **[ASCO Power Technologies]**
 - d. **[Eaton]**
 - e. **[Leviton Manufacturing Co., Inc.]**
 - f. **[Square D; Schneider Electric USA]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Industrial Control Switches: UL CCN NRNT, including UL 508.
5. Standard Features:
 - a. Electrically operated and **[mechanically][electrically]** held, combination-type lighting contactors with **[fusible switch][nonfused disconnect]**, complying with NEMA ICS 2.
 - b. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush driver (driver with 15 percent or less THD of normal load current).
 - c. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
 - d. Enclosure Rating: Comply with UL 50E.
 - e. Provide with control and pilot devices as **[indicated on the Drawings][scheduled]**, matching the enclosure rating specified for the enclosure.
 - f. Interface with DDC System for HVAC: Provide hardware interface to enable the DDC system for HVAC to monitor and control lighting contactors.
 - 1) Monitoring: On-off status, **<Insert monitoring point>**.
 - 2) Control: On-off operation, **<Insert control point>**.

2.9 EMERGENCY LIGHTING CONTROLS

- A. UL FTBR - Automatic Load Control Relay :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Bodine; Signify North America; Signify Holding]**
 - b. **[Chloride; Signify North America; Signify Holding]**
 - c. **[HLI Solutions; brand of GE Current, a Daintree Company]**
 - d. **[Intelligent Lighting Controls Inc.]**
 - e. **[Lithonia Lighting; Acuity Brands Lighting, Inc.]**
 - f. **[nLight; Acuity Brands Lighting, Inc.]**
 - g. **[WattStopper; Legrand North America, LLC]**
 - h. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Bodine; Signify North America; Signify Holding]**
 - b. **[Chloride; Signify North America; Signify Holding]**
 - c. **[HLI Solutions; brand of GE Current, a Daintree Company]**
 - d. **[Intelligent Lighting Controls Inc.]**
 - e. **[Lithonia Lighting; Acuity Brands Lighting, Inc.]**
 - f. **[nLight; Acuity Brands Lighting, Inc.]**
 - g. **[WattStopper; Legrand North America, LLC]**
 - h. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Emergency Lighting and Power Equipment: UL CCN FTBR, including UL 924.
 5. Standard Features:
 - a. N.C., electrically held relay.
 - b. Coil Rating: **[120][277]** V.
- B. UL WPWR - Branch Circuit Emergency Lighting Transfer Switch (BCE LTS) :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Bodine; Signify North America; Signify Holding]**
 - b. **[Chloride; Signify North America; Signify Holding]**
 - c. **[HLI Solutions; brand of GE Current, a Daintree Company]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Bodine; Signify North America; Signify Holding]**

- b. [Chloride; Signify North America; Signify Holding]
 - c. [HLI Solutions; brand of GE Current, a Daintree Company]
 - d. <Insert manufacturer's name>
- 3. Source Limitations: Obtain products from single manufacturer.
- 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Automatic Transfer Switches: UL CCN WPWR, including UL 1008.
- 5. Standard Features:
 - a. Automatically transfers emergency lighting load from normal branch circuit to emergency branch circuit in accordance with Article 700 of NFPA 70.
 - b. Rating: [120][277] V, not exceeding 20 A.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine lighting control devices before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.
- B. Examine walls and ceilings for suitable conditions where lighting control devices will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 SELECTION OF CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than 12 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than [18 AWG][22 AWG][24 AWG]. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than [14 AWG][16 AWG][18 AWG]. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 INSTALLATION OF LIGHTING CONTROL DEVICES

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:
 - 1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
 - 2. Electrical Maintenance: NFPA 70B.

3. Electrical Safety: NFPA 70E.
4. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
5. Communications Work: BICSI N1.
6. Life Safety and Means of Egress Work: NFPA 101.
7. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
8. Consult Architect for resolution of conflicting requirements.

C. Special Installation Techniques:

1. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.
2. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's instructions.
3. Installation of Industrial Control Switches: Mount electrically held lighting contactors with elastomeric isolator pads to eliminate structure-borne vibration unless contactors are installed in an enclosure with factory-installed vibration isolators.
4. Installation of Wiring:
 - a. Conduit: Minimum conduit size is **1/2 inch (13 mm)**.
 - b. Wiring within Enclosures: Separate power-limited and nonpower-limited conductors in accordance with conductor manufacturer's published instructions.
 - c. Size conductors in accordance with lighting control device manufacturer's published instructions unless otherwise indicated.
 - d. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, device, and outlet boxes; terminal cabinets; and equipment enclosures.

D. Interfaces with Other Work:

1. Identification: Provide labels for lighting control devices and associated electrical equipment.
 - a. Identify field-installed conductors, interconnecting wiring, and components.
 - b. Label each enclosure with engraved metal or laminated-plastic nameplate.
 - c. Identify controlled circuits in lighting contactors.
 - d. Identify circuits or luminaires controlled by photoelectric and occupancy sensors at each sensor.
 - e. Label time switches and contactors with a unique designation.

3.4 FIELD QUALITY CONTROL

A. Administrant for Electrical Power Tests and Inspections:

1. **[Owner][Tenant]** will engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
2. Engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].

B. Administrant for Lighting Tests and Inspections:

1. **[Owner][Tenant]** will engage qualified lighting testing and inspecting agency to administer and perform tests and inspections.



2. Engage qualified lighting testing and inspecting agency to administer and perform tests and inspections.
 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
 4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].
- C. Field tests must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.
- D. Tests and Inspections:
1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- E. Nonconforming Work:
1. Lighting control devices will be considered defective if they do not pass tests and inspections.
 2. Remove and replace defective units and retest.
- F. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.
- G. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.
1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.
- 3.5 ADJUSTING
- A. Occupancy Adjustments: When requested within **[12]<Insert number>** months from date of Substantial Completion, provide on-site assistance in adjusting lighting control devices to suit actual occupied conditions. Provide up to **[two]<Insert number>** visits to the Project site during other-than-normal occupancy hours for this purpose. Some of the Work may be required during hours of darkness.
1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.
 2. For daylighting controls, adjust set points and deadband controls to suit Owner's operations.
 3. Align high-bay occupancy sensors using manufacturer's laser aiming tool.
- 3.6 CLOSEOUT ACTIVITIES
- A. Demonstration:
1. **[With assistance from factory-authorized service representatives, demonstrate][Demonstrate]** to Owner's maintenance and clerical personnel[**and building occupants**] how to operate the following systems and equipment:
 - a. Lighting control devices.

B. Training:

1. **[With assistance from factory-authorized service representatives, train][Train]** Owner's maintenance personnel on the following topics:
 - a. How to adjust, operate, and maintain lighting control devices.

3.7 MAINTENANCE

A. Software and Firmware Service Agreement:

1. Technical Support: Beginning at Substantial Completion, verify that software and firmware service agreement includes software support for **[two]<Insert number>** years.
2. Upgrade Service: At Substantial Completion, update software and firmware to latest version. Install and program software upgrades that become available within **[two]<Insert number>** years from date of Substantial Completion. Verify upgrading software includes operating system and new or revised licenses for using software.
 - a. Upgrade Notice: Not less than **[30 days]<Insert duration>**; to allow Owner to schedule and access the system **[and to upgrade computer equipment if necessary]**.
3. Field Reports for Software and Firmware Upgrades: Prepare and submit report after each update, documenting upgrades installed.

END OF SECTION 26 09 23 00



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SECTION 26 09 23 00A - MODULAR DIMMING CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Modular dimming controls.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. **[Section 230923 "Direct Digital Control (DDC) System for HVAC"]<Insert Section number and name>** specifies monitoring and control devices referenced by this Section.
5. Section 260519 "Low-Voltage Electrical Power Conductors and Cables" specifies wiring referenced by this Section.
6. Section 260523 "Control-Voltage Electrical Power Cables" specifies Class 2 control cabling referenced by this Section.
7. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs referenced by this Section.
8. **[Section 260943.16 "Addressable Luminaire Lighting Controls"]****[and]****[Section 260943.23 "Relay-Based Lighting Controls"]****[and]****[Section 260923 "Lighting Control Devices"]** specify lighting control system components referenced by this Section.
9. Section 265000 "Lighting" specifies lighting equipment referenced by this Section.
10. Section 270528 "Pathways for Communications Systems" specifies additional requirements for raceway materials, routing, locations, and identification of communications equipment and cabling.

1.2 DEFINITIONS

- A. Fade Rate: The time it takes each zone to arrive at the next scene, dependent on the degree of change in lighting level.
- B. RFI: Radio-frequency interference.
- C. Scene: The lighting effect created by adjusting several zones of lighting to the desired intensity.
- D. SCR: Silicon-controlled rectifier.
- E. Zone: A luminaire or group of luminaires controlled simultaneously as a single entity. Also known as a "channel."

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
1. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing agency, certifying product's compliance with specified listing criteria.
 - a. If listed manufacturer differs from selling manufacturer, indicate relationship between entities on submittal. Clearly indicate which entity warrants product performance and fitness for purpose.
 - b. Listing criteria identified in approval letter must match specified listing criteria. UL label indicating approval of equipment's enclosure is not considered approval of equipment for intended application.
 - c. Product identification in approval letter must match product branding and model numbers in submittal. Approval letters for discontinued or superseded products are unacceptable for submitted product.
 2. Include manufacturer's sample extended warranty language.
- B. Shop Drawings: Prepare and submit the following:
1. Detail assemblies of standard components, custom assembled for specific application on Project. Indicate dimensions, weights, arrangement of components, and clearance and access requirements.
 - a. Include elevation views of front panels of control and indicating devices and control stations.
 - b. Include diagrams for power, signal, and control wiring.
 2. Address Drawing: Reflected ceiling plan and floor plans, showing connected luminaires, address for each luminaire, and luminaire groups. Base plans on construction plans, using the same legend, symbols, and schedules.
 3. Point List and Data Bus Load: Summary list of control devices, sensors, ballasts, and other loads. Include percentage of rated connected load and device addresses.
 4. Wire Termination Diagrams and Schedules: Coordinate nomenclature and presentation with Drawings and block diagram. Differentiate between manufacturer-installed and field-installed wiring.
 5. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices used. Describe characteristics of network and other data communication lines.
 6. Submit evidence that lighting controls are compatible with connected monitoring and control devices and systems.
 - a. Show interconnecting signal and control wiring, and interface devices that show compatibility of inputs and outputs.
 - b. For control interfaces and adapters, list network protocols and provide statements from manufacturers that input and output devices comply with interoperability requirements of the protocol.
- C. Samples for Initial Selection: For master- and remote-control stations, and cover plates with factory-applied color finishes and technical features.
- D. Samples for Verification: For master- and remote-control stations, and cover plates with factory-applied color finishes and technical features.

- E. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

- A. Manufacturer's published instructions.
- B. Field Reports:
 - 1. Manufacturer's field reports for field quality-control support.
 - 2. Manufacturer's field reports for system startup support.
 - 3. Field reports for software and firmware upgrades.

1.5 CLOSEOUT SUBMITTALS

- A. Warranty documentation.
- B. Maintenance service agreement.
- C. Software and firmware service agreement.

1.6 QUALIFICATIONS

- A. Electrical Power Testing (EPT) Technician I: Possessing active NICET EPT Level I certification. Able to work safely around electrical power equipment and cabling under supervision.
- B. Electrical Power Testing (EPT) Technician II: Possessing active NICET EPT Level II certification. Able to isolate and ground electrical power equipment, to connect test equipment, and to conduct and document standard tests of basic equipment.
- C. Electrical Power Testing (EPT) Technician III: Possessing active NICET EPT Level III certification. Able to manage switching procedures, to conduct tests of complex equipment, to analyze test and equipment data, to plan a job, and to lead a team. Has experience performing NFPA 70B, IEEE, and NETA electrical tests.
- D. Electrical Power Testing (EPT) Technician IV: Possessing active NICET EPT Level IV certification. Able to conduct tests of complex metering and relay systems; to evaluate tests, test equipment, test results, and power system performance; to recommend actions to maintain or improve system performance; and to lead multi-team projects.
- E. Electrical Power Testing and Inspecting Agency: Entities possessing active credentials from qualified electrical testing laboratory recognized by authorities having jurisdiction.
 - 1. On-site electrical testing supervisors must possess active NICET EPT Technician [III][IV] certification.
- F. Lighting Certified Professional: Design professional possessing active qualifications in accordance with Section 014000 "Quality Requirements" and the following:
 - 1. Expertise in lighting design.
 - 2. Lighting Certified (LC) Professional by the National Council on Qualifications for the Lighting Professions (NCQLP).



- G. Lighting Testing and Inspecting Agency: Entity possessing active qualifications specified in Section 014000 "Quality Requirements" with documented training and experience with testing and inspecting lighting installations in accordance with applicable IES standards.
- H. Communications Cable Installer: Entity possessing active qualifications specified in Section 014000 "Quality Requirements" and the following:
 - 1. Training and manufacturer certification to install, splice, and terminate communications cabling.
 - 2. Installation Supervisor: BICSI Technician (TECH) certification.
 - 3. Copper Installers: **[30 percent]<Insert quantity>** of employees possess BICSI Copper Installer 2 (INSTC) certification. Remaining employees possess BICSI Installer 1 (INST1) certification.
 - 4. Fiber Installers: **[30 percent]<Insert quantity>** of employees possess BICSI Optical Fiber Installer 2 (INSTF) certification. Remaining employees possess BICSI Installer 1 (INST1) certification.
- I. Communications Testing and Inspecting Agency: Entity possessing active credentials from qualified electrical testing laboratory recognized by authorities having jurisdiction.
 - 1. On-site communications testing supervisor must have **[BICSI Technician (TECH)]<Insert certification program>** certification and documented training, and be experienced with testing communications equipment in accordance with **[BICSI]<Insert code enforced by authorities having jurisdiction>** testing standards.

1.7 WARRANTY

- A. Special Installer Extended Warranty: Installer warrants that assembled and installed modular dimming controls perform in accordance with specified requirements and agrees to repair or replace components or products that fail to perform as specified within extended-warranty period. Warranty must convey to Owner upon acceptance of the Work.
 - 1. Extended-Warranty Period: **[Two][Three][Four]<Insert number>** years from date of Substantial Completion; full coverage for labor, materials, and equipment.
- B. Special Manufacturer Extended Warranty: Manufacturer warrants that modular dimming controls perform in accordance with specified requirements and agrees to repair or replace components or products that fail to perform as specified within extended-warranty period. Warranty must convey to Owner upon acceptance of the Work.
 - 1. Initial Extended-Warranty Period: **[Three][Four][Five]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for labor, materials, and equipment.
 - 2. Follow-On Extended-Warranty Period: **[Eight]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for materials only, free on board **[origin][destination]**, freight prepaid.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

B. General Characteristics:

1. Compatibility:
 - a. Dimming control components must be compatible with **[luminaires][luminaires and ballasts][luminaires, ballasts, and transformers]**.
 - b. Dimming control devices must be compatible with lighting control system components.
 2. Dimmers and Dimmer Modules:
 - a. Audible Noise and RFI Suppression: Solid-state dimmers must operate smoothly over their operating ranges without audible lamp or dimmer noise or RFI. Modules must include integral or external filters to suppress audible noise and RFI.
 - b. Dimmer or Dimmer-Module Rating: Not less than 125 percent of connected load unless otherwise indicated.
 3. Capacities: Unit must be rated for **[2400 W at 240 V(ac) and 2000 W at 120 V(ac)]<Insert value>** for up to **[100]<Insert number>** devices or zones.
 4. Surge Protection: Withstand supply power surges without impairment to performance.
 - a. Panels: 6000 V, 3000 A, complying with IEEE C62.41.1 and IEEE C62.41.2.
 - b. Other System Devices: 6000 V, 3000 A, complying with IEEE C62.41.1 and IEEE C62.41.2.
 5. Off Control Position: User-selected off position of any control point must disconnect the load from line supply.
- C. Seismic and Wind Performance: Installed assembly must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:
1. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events[**and unit must be fully operational after seismic events**]."
 2. Component Importance Factor (Ip): **[1.0][1.5]**.
 3. Component Amplification Factor (ap): **[1.0][2.5]<Insert value>**.
 4. Component Response Modification Factor (Rp): **[1.5][2.0][2.5][6.0]<Insert value>**.
 5. Component Overstrength Factor (Ωo): **[1.5][2.5]<Insert value>**.

2.2 MODULAR DIMMING CONTROLS

A. UL EOXT or EOYX - Wall-Box Multiscene Dimming Control :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Douglas Lighting Controls]**
 - b. **[Leviton Manufacturing Co., Inc.]**
 - c. **[Lutron Electronics Co., Inc]**
 - d. **[Philips; Signify North America; Signify Holding]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the

following:

- a. **[Douglas Lighting Controls]**
 - b. **[Leviton Manufacturing Co., Inc.]**
 - c. **[Lutron Electronics Co., Inc]**
 - d. **[Philips; Signify North America; Signify Holding]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Incandescent and Fluorescent Commercial Dimmers: UL CCN EOXT, including UL 508.
 - b. Incandescent, Fluorescent, or Extra-Low Voltage Dimming Controls: UL CCN EOYX, including UL 1472.
 5. Standard Features:
 - a. Factory-fabricated equipment providing manual dimming consisting of a wall-box-mounted master controller **[and indicated number of wall-box zone stations]**.
 - b. Controls and dimmers must be integrated for mounting in multigang wall box under a single wall plate.
 - c. Each zone must be adjustable to indicated number of scenes, which must reside in the memory of zone controller.
 - d. Dimmers:
 - 1) Each zone must be configurable to control the following loads:
 - a) Fluorescent lamps with **[electronic][magnetic]** ballasts.
 - b) LED lamps.
 - c) Incandescent lamps.
 - d) Control-voltage lamps, derived with **[magnetic][electronic]** transformers.
 - e) Non-dim, on-off switching only.
 - f) **<Insert special lighting equipment>**.
 - 2) Regulate voltages to maintain a constant light level, with no visible flicker, when the source voltage varies plus or minus 2 percent of RMS voltage.
 - e. Memory:
 - 1) Retain preset scenes and fade rates through momentary (up to 3 s) power interruptions.
 - 2) Retain preset scenes through power failures for at least **[seven]<Insert number>** days.
 - f. Master controller must include the following:
 - 1) Cover-mounted switches, including master off, all bright, and selectors for each scene.
 - 2) Cover-mounted LED indicator lights, one associated with each scene switch, and one for the master off switch.
 - 3) Concealed switches and indicators for specified function.
 - 4) A raise/lower switch for each zone for temporary adjustments of the zone, without altering scene values stored in memory.

- 5) Fade time indicated by digital display for current scene while fading.
- 6) Cover-mounted infrared receiver.
- g. Infrared Transmitters: Wireless remote control for recalling **[each][four]<Insert number>** of the presets. Operate up to **50 ft. (15 m)** within line of sight of the master controller.
6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- B. UL EOXT, EOYX, or DIVQ - Multipreset Modular Dimming Control :
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Douglas Lighting Controls]**
 - b. **[Leviton Manufacturing Co., Inc.]**
 - c. **[Lutron Electronics Co., Inc]**
 - d. **[Philips; Signify North America; Signify Holding]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Douglas Lighting Controls]**
 - b. **[Leviton Manufacturing Co., Inc.]**
 - c. **[Lutron Electronics Co., Inc]**
 - d. **[Philips; Signify North America; Signify Holding]**
 - e. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Incandescent and Fluorescent Commercial Dimmers: UL CCN EOXT, including UL 508.
 - b. Incandescent, Fluorescent, or Extra-Low Voltage Dimming Controls: UL CCN EOYX, including UL 1472.
 - c. Circuit Breakers: UL CCN DIVQ, including UL 489; and the following:
 - 1) Marked "SWD" if circuit breaker is switching fluorescent lighting loads.
 - 2) Marked "HID" if circuit breaker is switching high-intensity-discharge lighting loads.
 5. Standard Features:
 - a. Factory-fabricated equipment providing manual dimming consisting of the following:
 - 1) Master controller.
 - 2) Dimmer panels[, **and indicated number of zone stations**].
 - 3) Controls and dimmers must be integrated for mounting in a multigang wall box under a single wall plate.



- 4) Each zone must be adjustable to indicated number of scenes, which must reside in the memory of zone controller.
- b. Dimmers:
 - 1) Each zone must be configurable to control the following loads:
 - a) Fluorescent lamps with **[electronic][magnetic]** ballasts.
 - b) LED lamps.
 - c) Incandescent lamps.
 - d) Control-voltage incandescent lamps, derived with **[magnetic][electronic]** transformers.
 - e) Non-dim, on-off switching only.
 - f) Neon and cold-cathode lighting.
 - g) **<Insert special lighting equipment>**.
 - 2) Regulate voltages to maintain a constant light level, with no visible flicker, when the source voltage varies plus or minus 2 percent of RMS voltage.
- c. Memory: Retain preset scenes and fade settings through power failures by retaining physical settings of controls.
- d. Master controller must include the following:
 - 1) Wall-box style, single cover plate supplied by manufacturer.
 - 2) Cover-mounted switches, including master off, all bright, and selectors for each scene.
 - 3) Cover-mounted LED indicator lights, one associated with each scene switch, and one for the master off switch.
 - 4) Concealed switches and indicators for specified function.
 - 5) A raise/lower switch for each zone for temporary adjustments of the zone, without altering scene values stored in memory.
 - 6) Fade time indicated by digital display for current scene while fading.
 - 7) Cover-mounted infrared receiver.
- e. Remote-Control Stations:
 - 1) Numbered push buttons to select scenes.
 - 2) Off switch to turn master station off. **[Operating the off switch at any remote station must automatically turn on selected housekeeping lighting.]**
 - 3) On switch turns all scenes of master station to full bright.
 - 4) Control Wiring: NFPA 70, Class 2.
 - 5) Mounting: Single flush wall box with manufacturer's **[standard faceplate]<Insert special material and color for faceplate>**.
- f. Infrared Remote-Control Station: Same functions as for standard remote-control station except that functions are input by a hand-held infrared transmitter. Operate up to **50 ft. (15 m)** within line of sight of the master controller.
- g. Dimmer Panels: Modular, plug-in type.
 - 1) Integrated Short-Circuit Rating: **[10 kA at 120 V][, 14 kA at 277 V]**.
 - 2) Dimmers:
 - a) Dimming Circuit: Two SCR dimmers, in inverse parallel configuration.
 - b) Dimming Curve: Modified square law as specified in "The Lighting Handbook" from IES; control voltage is zero to 10 V(dc).

- c) Dimming Range: Zero to 100 percent, full output voltage not less than 98 percent of line voltage.
- d) Voltage Regulation: Dimmer must maintain a constant light level, with no visible flicker, when the source voltage varies plus or minus 2 percent of RMS voltage.

6. Accessories:

- a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
- b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

PART 3 - EXECUTION

3.1 SELECTION OF CONDUCTORS AND CABLES

- A. Wiring to Supply Side of Remote-Control Power Sources: Not smaller than 12 AWG.
- B. Class 2 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than **[18 AWG][22 AWG][24 AWG]**.

3.2 INSTALLATION OF MODULAR DIMMING CONTROLS

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:
 - 1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
 - 2. Electrical Safety: NFPA 70E.
 - 3. Commissioning of Electrical Systems: NECA NEIS 90.
 - 4. Communications Work: BICSI N1.
 - 5. Life Safety and Means of Egress Work: NFPA 101.
 - 6. Emergency and Standby Power Work: NFPA 110, NFPA 111, and NECA NEIS 416.
 - 7. Consult Architect for resolution of conflicting requirements.
- C. Special Installation Techniques:
 - 1. Wiring Method: Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables" and Section 260533.13 "Conduits for Electrical Systems."
 - 2. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power-limited and nonpower-limited conductors in accordance with conductor manufacturer's instructions.
 - 3. Size conductors in accordance with lighting control device manufacturer's instructions unless otherwise indicated.
 - 4. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, device, and outlet boxes; terminal cabinets; and equipment enclosures.
- D. Interfaces with Other Work:
 - 1. Identification: Provide labels for modular dimming controls and associated electrical equipment.



- a. Identify field-installed conductors, interconnecting wiring, and components.
- b. Label each enclosure with engraved metal or laminated-plastic nameplate.
- c. Provide warning signs and arc-flash hazard warning labels for electrical equipment.
- d. Label each dimmer module with a unique designation.
- e. Label each scene control button with approved scene description.

3.3 FIELD QUALITY CONTROL

A. Administrant for Electrical Power Tests and Inspections:

1. **[Owner][Tenant]** will engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
2. Engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].

B. Administrant for Field Tests and Inspections of Lighting Installations:

1. **[Owner][Tenant]** will engage qualified lighting testing and inspecting agency to administer and perform tests and inspections.
2. Engage qualified lighting testing and inspecting agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].

C. Administrant for Communications Tests and Inspections:

1. **[Owner][Tenant]** will engage qualified communications testing and inspecting agency to administer and perform tests and inspections.
2. Engage qualified communications testing and inspecting agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].

D. Acceptance Testing Preparation:

1. **<Insert requirements>**.

E. Field tests must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.

F. Tests and Inspections:

1. Continuity tests of circuits.
2. Operational Test: Set and operate controls to demonstrate their functions and capabilities in a methodical sequence that cues and reproduces actual operating functions.

- a. Include testing of modular dimming control equipment under conditions that simulate actual operational conditions. Record control settings, operations, cues, and functional observations.
3. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible agency and representative.
- G. Nonconforming Work:
 1. Dimming control components will be considered defective if they do not pass tests and inspections.
 2. Remove and replace defective units and retest.
- H. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports. Record defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.
- I. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.

3.4 SYSTEM STARTUP

- A. Perform startup service.
 1. Complete installation and startup checks in accordance with manufacturer's published instructions.
 2. **<Insert startup steps if any>**.
- B. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** system startup.
 1. Manufacturer's Field Reports for System Startup Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.

3.5 ADJUSTING

- A. Control Sensor Adjustments: Adjust control devices to suit actual occupied conditions.
 1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.
 2. For daylighting controls, adjust set points and deadband controls to suit Owner's operations.
 3. Align high-bay occupancy sensors using manufacturer's laser aiming tool.

3.6 CLOSEOUT ACTIVITIES

- A. Demonstration:
 1. **[With assistance from factory-authorized service representatives, demonstrate][Demonstrate]** to Owner's maintenance and clerical personnel **[and building occupants]** how to operate the following systems and equipment:
 - a. Lighting control devices.

2. **[Provide video recordings of demonstrations to Owner][Allow Owner to record demonstrations].**

B. Training:

1. **[With assistance from factory-authorized service representatives, train][Train]** Owner's maintenance personnel on the following topics:
 - a. How to adjust, operate, and maintain hardware and software specified in this Section.
Laptop computer must be used in training.]
2. **[Provide video recordings of training sessions to Owner][Allow Owner to record training sessions].**

3.7 PROTECTION

- A. After installation, protect modular dimming controls from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

3.8 MAINTENANCE

- A. Control Sensor Readjustments: When requested within **[12]<Insert number>** months from date of Substantial Completion, provide on-site assistance in readjusting system to suit actual occupied conditions. Provide up to **[two]<Insert number>** visits to the Project site during other-than-normal occupancy hours for this purpose.
- B. Maintenance Service Agreement: Beginning at Substantial Completion, verify that maintenance service agreement includes **[one year]<Insert duration>** period for full maintenance by **[skilled employees of modular dimming controls Installer][manufacturer's authorized service representative]**. Include annual preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper modular dimming controls operation. Verify that parts and supplies are manufacturer's authorized replacement parts and supplies.
- C. Software and Firmware Service Agreement:
 1. Technical Support: Beginning at Substantial Completion, verify that software and firmware service agreement includes software and firmware support for **[two years]<Insert duration>**.
 2. Upgrade Service: At Substantial Completion, update software and firmware to latest version. Install and program software and firmware upgrades that become available within **[two years]<Insert duration>** from date of Substantial Completion.
[Verify that upgrading software includes operating system and new or revised licenses for using software.]
 - a. Upgrade Notice: Not less than **[30 days]<Insert duration>**; to allow Owner to schedule and access the system **[and to upgrade computer equipment if necessary.]**
 3. Field Reports for Software and Firmware Upgrades: Prepare and submit report after each update, documenting upgrades installed.

END OF SECTION 26 09 23 00A



Task	Specification	Specification Description
26 09 23 00	02 84 16 00	Handling of Lighting Ballasts and Lamps Containing PCBs and Mercury
26 09 23 00	26 09 13 00	Electrical Power Monitoring
26 09 23 00	26 09 00 00	Addressable Luminaire Lighting Controls
26 09 23 00	26 09 00 00a	Relay-Based Lighting Controls
26 09 23 00	26 24 19 00	Motor-Control Centers



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SECTION 26 11 16 00 - SECONDARY UNIT SUBSTATIONS WITH SWITCHBOARD SECONDARY

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Secondary unit substation equipment.

B. Products Installed, but Not Furnished, under This Section:

1. **<Insert products identified in "Existing Products to be Modified" Article or "Existing Products to be Removed and Re-Installed" Article>.**

C. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. Section 078413 "Penetration Firestopping" specifies materials and methods for sealing penetrations of rated walls and partitions referenced by this Section.
5. Section 260513 "Medium-Voltage Cables" for requirements for terminating cables in incoming section of substation.
6. Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for requirements for connecting wires.
7. Section 260526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding referenced by this Section.
8. Section 260529 "Hangers and Supports for Electrical Systems" specifies hangers, supports, and concrete bases referenced by this Section.
9. Section 260548 "Vibration and Seismic Controls for Electrical Systems" specifies vibration isolation and seismic-[**and wind**]- control devices referenced by this Section.
10. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs referenced by this Section.
11. Section 260573 "Power System Studies" specifies short-circuit current studies, overcurrent protective device coordination studies, arc-flash hazard analysis, warning labels, and circuit-breaker trip ranges referenced by this Section.
12. Section 260913 "Electrical Power Monitoring" specifies remote monitoring of metering instruments and for remote control of circuit breakers and switches.
13. Section 264313 "Surge Protective Devices for Low-Voltage Electrical Power Circuits" specifies field-mounted surge-suppression devices referenced in this Section.

1.2 DEFINITIONS

- A. ICCB: Insulated-case circuit breaker.
- B. MCCB: Molded-case circuit breaker.

- C. PCB: Polychlorinated biphenyl.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, and furnished specialties and accessories.
2. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing agency, certifying product's compliance with specified listing criteria.
 - a. If listed manufacturer differs from selling manufacturer, indicate relationship between entities on submittal. Clearly indicate which entity warrants product performance and fitness for purpose.
 - b. Listing criteria identified in approval letter must match specified listing criteria. UL label indicating approval of equipment's enclosure is not considered approval of equipment for intended application.
 - c. Product identification in approval letter must match product branding and model numbers in submittal. Approval letters for discontinued or superseded products are unacceptable for submitted product.
3. Include manufacturer's sample extended warranty language.
4. Include product certificates for secondary unit substations, signed by manufacturer.

- B. Shop Drawings: Prepare and submit the following:

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: Power, signal, and control wiring.
3. Dimensioned plans and elevations showing major components and features.
 - a. Include a plan view and cross section of equipment base, showing clearances, manufacturer's recommended workspace that accounts for breaker service and removal, and locations of penetrations for grounding and conduits.
4. One-line diagram.
5. List of materials.
6. Nameplate legends.
7. The material, size and number of bus bars, and current rating for each bus, including mains and branches of phase, neutral, and ground buses.
8. Short-time and short-circuit current ratings of secondary unit substations and components.
9. Ratings of individual protective devices.
10. Design Data:
 - a. Time-Current Characteristic Curves: For overcurrent protective devices.
 - b. Primary Fuses: Submit recommendations and size calculations.
 - c. Utility company's metering provisions with indication of approval by utility company.

- C. Factory test reports.

- D. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

- A. Manufacturer's published instructions.
- B. Field Reports:
 - 1. Manufacturer's field reports for field quality-control support.
 - 2. Manufacturer's field reports for system startup support.
 - 3. Field reports for voltage monitoring and adjusting.
 - 4. Field reports for infrared scanning.

1.5 CLOSEOUT SUBMITTALS

- A. Warranty documentation.
- B. Maintenance service agreement.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Spare parts.
- B. Special tools.
- C. Consumable items.

1.7 REGULATORY AGENCY APPROVALS

- A. Submittals for secondary unit substations requiring approval by <Insert name of electrical utility> must be signed by qualified electrical professional engineer responsible for their preparation. **[Obtain approval by electrical utility prior to submitting for action by Architect][Submit for action by Architect prior to submitting for approval by electrical utility].**

1.8 QUALIFICATIONS

- A. Electrical Power Testing (EPT) Technician I: Possessing active NICET EPT Level I certification. Able to work safely around electrical power equipment and cabling under supervision.
- B. Electrical Power Testing (EPT) Technician II: Possessing active NICET EPT Level II certification. Able to isolate and ground electrical power equipment, to connect test equipment, and to conduct and document standard tests of basic equipment.
- C. Electrical Power Testing (EPT) Technician III: Possessing active NICET EPT Level III certification. Able to manage switching procedures, to conduct tests of complex equipment, to analyze test and equipment data, to plan a job, and to lead a team. Has experience performing NFPA 70B, IEEE, and NETA electrical tests.
- D. Electrical Power Testing (EPT) Technician IV: Possessing active NICET EPT Level IV certification. Able to conduct tests of complex metering and relay systems; to evaluate tests, test equipment, test results, and power system performance; to recommend actions to maintain or improve system performance; and to lead multi-team projects.



- E. Electrical Power Testing and Inspecting Agency: Entities possessing active credentials from qualified electrical testing laboratory recognized by authorities having jurisdiction.
 1. On-site electrical testing supervisors must possess active NICET EPT Technician [III][IV] certification.
 - F. Electrical Professional Engineer: Professional engineer possessing active qualifications specified in Section 014000 "Quality Requirements," with expertise in electrical engineering, including electrical power system modeling and analysis of electrical safety in accordance with NFPA 70E.
 - G. Medium-Voltage Cable Installer: Entity possessing active qualifications specified in Section 014000 "Quality Requirements" with training and manufacturer certification to install, splice, and terminate medium-voltage cable[**in accordance with electrical utility service provider's requirements**].
 1. Medium-voltage cable Installer must be approved by <**Insert name of electrical utility service provider**>.
 - H. Medium-Voltage Duct Installer: Entity possessing active qualifications specified in Section 014000 "Quality Requirements" with documented training and experience with installation of medium-voltage duct banks[**in accordance with electrical utility service provider's requirements**].
 1. Medium-voltage duct Installer must be approved by <**Insert name of electrical utility service provider**>.
 - I. Medium-Voltage Equipment Installer: Entity possessing active qualifications specified in Section 014000 "Quality Requirements" with documented training and experience with hazards and safety requirements associated with installation and operation of medium-voltage equipment[**in accordance with electrical utility service provider requirements**].
 1. Medium-voltage equipment Installer must be approved by <**Insert name of electrical utility service provider**>.
 - J. Electrical Power Monitoring Installers: Installer possessing active qualifications specified in Section 014000 "Quality Requirements," and able to present unexpired certified Installer credentials issued by manufacturer prior to starting installation.
 - K. Power Quality Specialist: Recognized experts possessing active NICET Electrical Power Testing (EPT) Technician IV certification and documented experience in power quality testing for installations similar in complexity to the Project.
- 1.9 DELIVERY, STORAGE, AND HANDLING
- A. Deliver in shipping splits in sizes that can be moved past obstructions in delivery path.
 - B. Coordinate delivery of secondary unit substations to allow movement into designated space.
 - C. Store secondary unit substation components[**protected from weather and**] so condensation will not form on or in units. Provide temporary heating in accordance with manufacturer's instructions.
 - D. Handle secondary unit substation components in accordance with manufacturer's instructions. Use factory-installed lifting provisions.

1.10 SERVICE CONDITIONS FOR ELECTRICAL EQUIPMENT

- A. Modeling, analysis, product selection, installation, and quality control for all electrical Work on the Project must comply with service condition requirements specified in Section 018116 "Facility Environmental Requirements" and Section 018123 "Facility Seismic and Wind Criteria."
- B. Usual Service Conditions: Unless unusual service conditions have been specified in "General Equipment Service Conditions," "Outdoor Equipment Service Conditions," and "Indoor Equipment Services Conditions" articles of Section 018116 "Facility Environmental Requirements," electrical service and distribution equipment must be suitable for operation under usual service conditions specified in applicable IEEE C37 series and IEEE C57 series standards.

1.11 WARRANTY FOR SECONDARY UNIT SUBSTATIONS

- A. Special Installer Extended Warranty: Installer warrants that assembled and installed secondary unit substation performs in accordance with specified requirements and agrees to repair or replace components or products that fail to perform as specified within extended-warranty period. Warranty must convey to Owner upon acceptance of the Work.
 - 1. Extended-Warranty Period: **[Two][Three][Four]<Insert number>** years from date of Substantial Completion; full coverage for labor, materials, and equipment.
- B. Special Manufacturer Extended Warranty: Manufacturer warrants that secondary unit substations performs in accordance with specified requirements and agrees to repair or replace components or products that fail to perform as specified within extended-warranty period. Warranty must convey to Owner upon acceptance of the Work.
 - 1. Initial Extended-Warranty Period: **[Three][Four][Five]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for labor, materials, and equipment.
 - 2. Follow-On Extended-Warranty Period: **[Eight]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for materials only, free on board **[origin][destination]**, freight prepaid.

PART 2 - PRODUCTS

2.1 EXISTING PRODUCTS TO BE MODIFIED

- A. Basis for Pricing: **<Insert name of manufacturer; model number or series for existing product>**.
- B. Description: **<Insert description of existing product, including special features, options, and finishes that may impact the Work>**.
- C. Accessories: **<Insert accessories included with existing product>**.

2.2 EXISTING PRODUCTS TO BE REMOVED AND RE-INSTALLED

- A. Basis for Pricing: **<Insert name of manufacturer; model number or series for existing product>**.
- B. Description: **<Insert description of existing product, including special features, options, and finishes that may impact the Work>**.



- C. Accessories: **<Insert accessories included with existing product>**.

2.3 PERFORMANCE REQUIREMENTS

- A. Description: Medium-voltage, primary incoming section; transformer section; and low-voltage secondary switchgear section; and including coordinated circuit breakers, fusible switches, and metering components.
- B. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- C. General Characteristics:
1. Referenced Standards: IEEE C2 and IEEE C37.121.
 2. Indoor Unit Arrangement: Single assembly.
 3. Outdoor Unit Arrangement: Single assembly.
 - a. Weatherproof, listed for installation outdoors, complying with IEEE C37.20.1.
 - b. Aisleless Construction: Full-height doors in front of basic weatherproof equipment.
 4. Connections between the primary device and transformer must be **[cable][bus]**, and between the transformer and secondary must be flexible bus braid unless noted otherwise.
 5. Indoor Enclosure: Steel.
 6. Outdoor Enclosure: Weatherproof, galvanized steel, listed for installation outdoors, complying with IEEE C37.20.1. Aisleless, full-height doors, with provisions for padlocking, in front of basic weatherproof equipment. Integral structural-steel base frame with factory-applied asphaltic undercoating.
 7. Each compartment must have the following features:
 - a. Structural design and anchorage adequate to resist loads imposed by **[125 mile/h (200 km/h)]<Insert wind speed>** wind.
 - b. Space heater operating at one-half or less of rated voltage, sized to prevent condensation, controlled by thermostats to maintain temperature of each section above expected dew point.
 - c. Louvers equipped with insect and rodent screens and filters, and arranged to permit air circulation while excluding rodents and exterior dust.
 - d. Weatherproof ground-fault circuit interrupter duplex receptacle.
 - e. Power for heaters and receptacles must be provided **[by control power transformer][as indicated]**.
 - f. Skid Mounted: Mount each shipping group on an integral base frame as a complete weatherproof unit.
 8. Enclosure Finish:
 - a. Outdoor Finish: Provide factory-applied finish in manufacturer's standard color, including under surfaces treated with corrosion-resistant undercoating.
 - b. Indoor Finish: Provide factory-applied finish in manufacturer's standard gray over a rust-inhibiting primer on treated metal surface.
 - c. Severe Environment Finish: Provide factory-applied corrosion-resistant finish in manufacturer's standard color that withstands **[120][480]** hours of exposure to the salt spray test specified in ASTM B117 without loss of paint or release of adhesion of the paint primer coat to the metal surface in excess of **1/16 inch (1.6 mm)** from the test mark. The

scribed test mark and test evaluation must be conducted in accordance with ASTM D1654, with a rating of not less than 7 arrived at in accordance with Table 1 (procedure A). Cut edges or otherwise damaged surfaces of hot-dip galvanized sheet steel or mill-galvanized sheet steel must be coated with a manufacturer's standard zinc-rich paint.

2.4 SECONDARY UNIT SUBSTATION EQUIPMENT

A. Source Quality Control:

1. Factory Tests:

- a. Owner will witness required factory tests. Notify Architect at least 14 days before date of tests and indicate their approximate duration.
- b. Testing Administrant: **[Owner will engage][Engage]** qualified electrical testing agency to evaluate secondary unit substation equipment.
- c. Factory Tests and Inspections: Perform the following tests and inspections on secondary unit substation equipment, by, or under supervision of, qualified electrical testing laboratory recognized by authorities having jurisdiction, in accordance with the following standards before delivering to site. Affix label with name and date of **[manufacturer's][qualified electrical testing laboratory's]** certification of system compliance.
 - 1) Conduct transformer tests in accordance with IEEE C57.12.90.
 - 2) Conduct primary switchgear tests in accordance with NEMA C37.51.
 - 3) Conduct routine tests of completely assembled switchboard.
 - 4) Resistance measurements of windings on rated voltage connection and on tap extreme connections.
 - 5) Ratios on rated voltage connection and on tap extreme connections.
 - 6) Polarity and phase relation on rated voltage connection.
 - 7) No-load loss at rated voltage on rated voltage connection.
 - 8) Exciting current at rated voltage on rated voltage connection.
 - 9) Impedance and load loss at rated current on rated voltage connection and on tap extreme connections.
 - 10) Applied potential.
 - 11) Induced potential.

2. Temperature Test: If transformer is supplied with auxiliary cooling equipment to provide more than one rating, test at lowest kVA Class ONAN or Class AA rating and highest kVA Class ONAF or Class AFA rating.

- a. Temperature test is not required if record of temperature test on essentially duplicate unit is available.
- b. Nonconforming Work:
 - 1) Equipment that does not pass tests and inspections will be considered defective.
- c. Factory Test Reports: Compile and submit factory test and inspection reports.

B. UL YEFV or DLAH or WVGN - Medium-Voltage Terminal Compartment Section :

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



- b. [Eaton]
 - c. [Siemens Industry, Inc., Energy Management Division]
 - d. [Square D; Schneider Electric USA]
 - e. <Insert manufacturer's name>
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [ABB, Electrification Business]
 - b. [Eaton]
 - c. [Siemens Industry, Inc., Energy Management Division]
 - d. [Square D; Schneider Electric USA]
 - e. <Insert manufacturer's name>
 - 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Unit Substation Over 600 V: UL CCN YEFV, including the following referenced standards:
 - 1) Articulated Unit Substations: IEEE C37.121.
 - 2) Integral Unit Substations: IEEE C37.20.2, IEEE C37.20.3, NEMA C37.55, and NEMA C37.57.
 - b. Metal-Clad Switchgear Over 1000 V: UL CCN DLAH, including IEEE C37.20.2 and NEMA C37.55.
 - c. Metal-Enclosed Arc-Resistant Switchgear Over 1000 V: UL CCN WVGN, including IEEE C37.20.3 and IEEE C37.20.7.
 - 4. Standard Features:
 - a. Primary Incoming Section: Terminal assembly with adequate space for incoming-cable terminations and surge arresters, complying with NEMA SG 4 and meeting thermal, mechanical, and dielectric requirements specified for the transformer section.
 - b. Ratings: Suitable for application in three-phase, 60 Hz, solidly grounded-neutral system.
 - c. System Voltage: [4.16 kV nominal; 4.76 kV maximum][7.2 kV nominal; 15 kV maximum][13.8 kV nominal; 15 kV maximum][34.5 kV nominal; 38 kV maximum]<Insert other voltage>.
 - d. Surge Arresters: Comply with IEEE C62.11, Distribution Class; metal-oxide-varistor type, connected in each phase of incoming circuit and ahead of disconnecting device.
- C. UL YEFV or DLAH or WVGN - Medium-Voltage Metal-Enclosed Switchgear Section :
- 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [ABB, Electrification Business]
 - b. [Eaton]
 - c. [Siemens Industry, Inc., Energy Management Division]
 - d. [Square D; Schneider Electric USA]
 - e. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Eaton]**
 - c. **[Siemens Industry, Inc., Energy Management Division]**
 - d. **[Square D; Schneider Electric USA]**
 - e. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Unit Substation Over 600 V: UL CCN YEFV, including the following referenced standards:
 - 1) Articulated Unit Substations: IEEE C37.121.
 - 2) Integral Unit Substations: IEEE C37.20.2, IEEE C37.20.3, NEMA C37.55, and NEMA C37.57.
 - b. Metal-Clad Switchgear Over 1000 V: UL CCN DLAH, including IEEE C37.20.2 and NEMA C37.55.
 - c. Metal-Enclosed Arc-Resistant Switchgear Over 1000 V: UL CCN WVGW, including IEEE C37.20.3 and IEEE C37.20.7.
4. Standard Features:
 - a. Metal-enclosed, air-interrupter switchgear, **[with][without]** fuses, complying with IEEE C37.20.3.
 - 1) Switchgear must be arc-resistant, complying with IEEE C37.20.7, **[Type 1A][Type 2A][Type 1C][Type 2C]**.
 - b. Ratings: Comply with IEEE C37.04; and suitable for application in three-phase, 60 Hz, solidly grounded-neutral system.
 - 1) System Voltage: **[4.16 kV nominal; 4.76 kV maximum][7.2 kV nominal; 15 kV maximum][13.8 kV nominal; 15 kV maximum][34.5 kV nominal; 38 kV maximum]<Insert other voltage>**.
 - 2) Design Level of Available-Source Fault Current: Integrated short-circuit rating consistent with value of fault current indicated.
 - 3) Main-Bus Rating: **[600][1200][2000]** A, continuous.
 - c. Interrupter Switches: Stationary, gang operated, and suitable for application at maximum short-circuit rating of integrated switchgear assembly.
 - 1) Rating: **[600][1200]** A continuous duty and load break.
 - 2) Two-Time Duty-Cycle Fault Closing: **[25 000][40 000]** A, asymmetrical.
 - 3) Switch Action: No external arc and no significant quantities of ionized gas released into the enclosure.
 - 4) Switch Construction: Supported entirely by interior framework of structure, with copper switchblades and stored-energy operating mechanism.
 - 5) Phase Barriers: Full length of switchblades and fuses for each pole; designed for easy removal; allow visual inspection of switch components if barrier is in place.
 - 6) Protective Shields: Cover live components and terminals.



- a) Fuse Mounts: Single-frame mounted and de-energized when switch is open.
 - 7) Mechanical Interlock: Prevent opening switch compartment door unless switchblades are open, and prevent closing switch if door is open. **[Interlock air-interrupter switch with transformer secondary main circuit breaker, preventing switch from being opened or closed unless secondary main circuit breaker is open.]**
 - 8) Window: Permits viewing switch-blade positions when door is closed.
 - 9) Accessory Set: Tools and miscellaneous items required for interrupter switchgear test, inspection, maintenance, and operation. Include fuse-handling tool as recommended by switchgear manufacturer.
 - d. Fuses: Sizes recommended by secondary unit substation manufacturer, considering fan cooling, temperature-rise specification, and cycle loading.
 - 1) Current-Limiting Fuses: Full-range, fast-replaceable, current-limiting type that will operate without explosive noise or expulsion of gas, vapor, or foreign matter from tube.
 - 2) Expulsion Fuses: Furnished in disconnect-type mountings and renewable with replacement fuse units. Gases emitted on interruption are controlled and silenced by chambers designed for that purpose.
 - 3) Indicator integral with each fuse to show when it has blown.
 - 4) Spares: Include three fuses in use and three spare fuses in storage clips in each switch.
 - e. Surge Arresters: Comply with IEEE C62.11, Distribution Class; metal-oxide-varistor type, with ratings as indicated, connected in each phase of incoming circuit and ahead of disconnecting device.
- D. UL YEFV or DLAH or WVG N - Medium-Voltage Instruments Section :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[Eaton]**
 - c. **[Siemens Industry, Inc., Energy Management Division]**
 - d. **[Square D; Schneider Electric USA]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Eaton]**
 - c. **[Siemens Industry, Inc., Energy Management Division]**
 - d. **[Square D; Schneider Electric USA]**
 - e. **<Insert manufacturer's name>**
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product

categories:

- a. Unit Substation Over 600 V: UL CCN YEFV, including the following referenced standards:
 - 1) Articulated Unit Substations: IEEE C37.121.
 - 2) Integral Unit Substations: IEEE C37.20.2, IEEE C37.20.3, NEMA C37.55, and NEMA C37.57.
 - b. Metal-Clad Switchgear Over 1000 V: UL CCN DLAH, including IEEE C37.20.2 and NEMA C37.55.
 - c. Metal-Enclosed Arc-Resistant Switchgear Over 1000 V: UL CCN WVGN, including IEEE C37.20.3 and IEEE C37.20.7.
4. Standard Features:
- a. Instrument Transformers: Comply with IEEE C57.13.
 - 1) Potential and Current Transformers: Burden and Accuracy Class suitable for connected meters.
 - b. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems.
 - 1) Inputs from sensors or 5 A current-transformer secondaries, and potential terminals rated to 600 V.
 - 2) Switch-selectable digital display with the following features:
 - a) Phase Currents, Each Phase: Plus or minus 1 percent.
 - b) Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
 - c) Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
 - d) Three-Phase Real Power: Plus or minus 2 percent.
 - e) Three-Phase Reactive Power: Plus or minus 2 percent.
 - f) Power Factor: Plus or minus 2 percent.
 - g) Frequency: Plus or minus 0.5 percent.
 - h) Integrated Demand, with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
 - i) Accumulated energy, in **MWh (MJ)**, plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.
 - 3) Communications module suitable for remote monitoring of meter quantities and functions. Interface communication and metering.
 - 4) Mounting: Display and control unit that is flush or semiflush mounted in instrument compartment door.
 - c. Analog Instruments: Rectangular, **4-1/2 inch (115 mm)** square, 1 percent accuracy, semiflush mounting, with antiparallax 250-degree scale and external zero adjustment.
 - 1) Voltmeters: Cover an expanded scale range of normal voltage plus 10 percent.
 - 2) Voltmeter Selector Switch: Rotary type with off position to provide readings of phase-to-phase[**and phase-to-neutral**] voltages.
 - 3) Ammeters: Cover an expanded scale range of bus rating plus 10 percent.
 - 4) Ammeter Selector Switch: Permits current reading in each phase and keeps current-transformer secondary circuits closed in off position.
 - 5) Locate meter and selector switch on circuit-breaker compartment door for indicated feeder circuits only.
 - 6) Watt-Hour Meters: Flush- or semiflush-mounting type, 5 A, 120 V, three phase, three



wire; with three elements, **[15 min]<Insert value>** indicating demand register, and provision for testing and adding pulse initiation.

- 7) Recording Demand Meter: Usable as totalizing relay or indicating and recording maximum demand meter with **[15 min]<Insert value>** interval.
 - a) Operation: Counts and records a succession of pulses entering two channels.
 - b) Housing: Drawout, back-connected case arranged for semiflush mounting.

E. UL YEFV or XPLH - Liquid-Filled Transformer Section :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[Siemens Industry, Inc., Energy Management Division]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Siemens Industry, Inc., Energy Management Division]**
 - c. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Unit Substation Over 600 V: UL CCN YEFV, including the following referenced standards:
 - 1) Articulated Unit Substations: IEEE C37.121.
 - 2) Integral Unit Substations: IEEE C37.20.2, IEEE C37.20.3, NEMA C37.55, and NEMA C37.57.
 - 3) Liquid-Immersed Transformers: IEEE C57.12.00.
 - b. Liquid-Filled Distribution Transformers Over 600 V: UL CCN XPLH, including IEEE C57.12.00 and IEEE C57.12.28.
4. Standard Features:
 - a. Insulating Liquid:
 - 1) Mineral oil complying with ASTM D3487, Type II, and tested in accordance with ASTM D117.
 - 2) Less flammable, edible-seed-oil based, and listed and labeled by a qualified electrical testing laboratory as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested in accordance with ASTM D92. Liquid must be biodegradable and nontoxic.
 - 3) Less flammable, dielectric, and listed and labeled by a qualified electrical testing laboratory as complying with NFPA 70 requirements for fire point of not less than

- 300 deg C when tested in accordance with ASTM D92. Liquid must be biodegradable and nontoxic.
- 4) Less flammable, silicone-based dielectric, and listed and labeled by a qualified electrical testing laboratory as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested in accordance with ASTM D92. Liquid must have low toxicity and be nonhazardous.
- b. Insulation Temperature Rise:
- 1) 55 deg C, based on an average ambient temperature of **86 deg F (30 deg C)** over 24 hours with a maximum ambient temperature of **104 deg F (40 deg C)**. Insulation system must be rated to continuously allow an additional 12-percent kVA output, at 65 deg C temperature rise, without decreasing rated transformer life.
 - 2) 65 deg C, based on an average ambient temperature of **86 deg F (30 deg C)** over 24 hours with a maximum ambient temperature of **104 deg F (40 deg C)**.
- c. BIL: **[60][75][95][110]** kV.
- d. Full-Capacity Voltage Taps: Four nominal 2.5 percent taps[, **two above and two**] below rated primary voltage; with externally operable tap changer for de-energized use and with position indicator and padlock hasp.
- e. Cooling System: **[Class ONAN, liquid cooled][Class ONAN/ONAF, liquid cooled, and with forced-air rating][Class ONAN/ONAF/ONAF, liquid cooled, and with provisions for future forced-air rating]**. Cooling systems must include auxiliary cooling equipment, automatic controls, and status indicating lights.
- f. Impedance: **<Insert number>** percent.
- g. Accessories: Grounding pads, lifting lugs, and provisions for jacking under base. Transformers must have a steel base and frame allowing use of pipe rollers in any direction, and an insulated, low-voltage, neutral bushing with removable ground strap.
Include the following additional accessories:
- 1) Liquid-level gage.
 - 2) Pressure-vacuum gage.
 - 3) Liquid temperature indicator.
 - 4) Drain and filter valves.
 - 5) Pressure-relief device.
- F. UL YEFV - Dry-Type Transformer Section :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Eaton]**
 - b. **[Square D; Schneider Electric USA]**
 - c. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Eaton]**
 - b. **[Square D; Schneider Electric USA]**
 - c. **<Insert manufacturer's name>**
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in

accordance with guide information and standards specified for the following UL product categories:

- a. Unit Substation Over 600 V: UL CCN YEFV, including the following referenced standards:
 - 1) Articulated Unit Substations: IEEE C37.121.
 - 2) Integral Unit Substations: IEEE C37.20.2, IEEE C37.20.3, NEMA C37.55, and NEMA C37.57.
 - 3) Dry-Type Transformers: UL 1562.
4. Standard Features:
 - a. Primary Incoming Section: Transformer cover-mounted bushings. The bushings must meet thermal, mechanical, and dielectric requirements as specified for the transformer section.
 - b. Style:
 - 1) **[Indoor, ventilated][Outdoor, ventilated][Totally enclosed, nonventilated]**, cast coil/encapsulated coil, with primary and secondary windings individually cast in epoxy; with insulation system rated at 185 deg C with an 80 deg C average winding temperature rise above a maximum ambient temperature of **104 deg F (40 deg C)**.
 - 2) **[Indoor, ventilated][Outdoor, ventilated][Totally enclosed, nonventilated]**, vacuum-pressure, impregnated type, and with insulation system rated at 220 deg C with an 80 deg C average winding temperature rise above a maximum ambient temperature of **104 deg F (40 deg C)**.
 - c. Cooling System:
 - 1) Class AA, air cooled, complying with IEEE C57.12.01.
 - 2) Class AFA, air cooled with forced-air rating, complying with IEEE C57.12.01.
 - a) Manual forced-air cooling system controls, including manual switch for fans, fan controller and associated power and control wiring, and power panel with current-limiting fuses.
 - b) Include mounting provision for fans.
 - 3) Class AA/FA, air cooled with provisions for future forced-air rating, complying with IEEE C57.12.01.
 - a) Automatic forced-air cooling system controls, including thermal sensors, fans, control wiring, temperature controller with test switch, power panel with current-limiting fuses, indicating lights, alarm, and alarm-silencing relay.
 - b) Include mounting provision for fans.
 - 4) Class AFA, forced-air cooling, complying with IEEE C57.12.01.
 - a) Automatic forced-air cooling system controls, including thermal sensors, fans, control wiring, temperature controller with test switch, power panel with current-limiting fuses, indicating lights, alarm, and alarm-silencing relay.
 - b) Include cooling fans.
 - d. Insulation Materials: IEEE C57.12.01, rated **[220]<Insert number>** deg C.
 - 1) Insulation Temperature Rise: **[80][115][150]** deg C, maximum rise above **104 deg F**

(40 deg C).

- e. BIL: **[60][75][95][110]** kV.
- f. Full-Capacity Voltage Taps: Four nominal 2.5 percent taps[, **two above and two**] below rated primary voltage.
- g. Impedance: **<Insert number>** percent.
- h. High-Temperature Alarm: Sensor at transformer with local audible and visual alarm and contacts for remote alarm.

G. UL WEVC - Secondary Distribution Section Switchboard :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[Eaton]**
 - c. **[Siemens Industry, Inc., Energy Management Division]**
 - d. **[Square D; Schneider Electric USA]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Eaton]**
 - c. **[Siemens Industry, Inc., Energy Management Division]**
 - d. **[Square D; Schneider Electric USA]**
 - e. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Dead-Front Switchboards: UL CCN WEVZ, including UL 891.
 - 1) Arc Resistance: Annex J of IEEE C37.20.7.
4. Standard Features:
 - a. The secondary distribution section must be drawout, **[fused][fused where indicated]**, low-voltage switchgear, complying with NEMA PB 2.
 - b. Switchboard Structure: Front and rear accessible.
 - 1) Match and align the **[front][front and rear]** of the switchgear.
 - 2) Comply with UL requirements for service entrance equipment.
 - c. Switchboard Bus:
 - 1) Use bus bars to connect compartments and vertical sections. Cable connections are not permitted.
 - 2) Main Phase Bus: Uniform capacity the entire length of section.
 - 3) Neutral Bus: **[50][100]** percent of phase-bus ampacity, except as indicated. Equip bus with pressure-connector terminations for outgoing circuit neutral conductors.



- 4) Include braces for neutral-bus extensions for busway feeders.
- 5) Vertical Section Bus: Extend to spaces for future circuit breakers.
- 5) Phase- and Neutral-Bus Material:
 - a) Hard-drawn copper of 98 percent minimum conductivity, with copper feeder circuit-breaker line connections.
 - b) Hard-drawn copper of 98 percent minimum conductivity or tin-plated, high-strength, electrical-grade aluminum alloy.
- 6) Ground Bus: Hard-drawn copper of 98 percent minimum conductivity, with pressure connector for feeder and branch-circuit ground conductors, minimum size **1/4-by-2 inch (6 by 50 mm)**.
- 7) Neutral bus equipped with pressure-connector terminations for outgoing circuit neutral conductors. Neutral-bus extensions for busway feeders are braced.
- 8) Neutral Disconnect Link: Bolted, uninsulated, **1/4-by-2 inch (6-by-50 mm)** copper bus, arranged to connect neutral bus to ground bus.
- d. Switchboard Arrangement:
 - 1) Main Disconnect Device(s): **[Power circuit breakers][Bolted pressure switches][ICCBs][MCCBs][Fusible switches]**.
 - 2) Feeder Protective Devices: **[Bolted pressure switches][ICCBs][MCCBs][Fusible switches]**.
- e. Power Circuit Breakers: **[Fixed][Drawout]** mounted, electrically operated air-circuit breakers, complying with UL 1066.
 - 1) With "close" and "open" push buttons and red and green lighted breaker position indicators. Charging time of the motor operator must not exceed 8 seconds. Operator power must be from a control power transformer internal to the switchboard.
 - 2) Solid-state monitoring and tripping system to provide system status monitoring, adjustable time-current protection, and shunt trip.
 - 3) Interchangeable current sensors and timing circuits for adjustable time-current protection settings and status signals.
 - 4) LED indicators or display, with manual reset, to show cause of automatic trip.
 - 5) Display panel to indicate that the status of the system circuitry is fully operational, or give fault location based on automatic diagnosis.
 - 6) Trip the circuit breaker when closing on a fault.
 - 7) Time-current adjustments to achieve protective-device coordination as follows:
 - a) Adjustable long-delay pickup and time.
 - b) Individual adjustments for short-delay pickup, time, and I-squared-t setting.
 - c) Adjustable instantaneous pickup.
 - d) Individually adjustable ground-fault pickup and time, with **[I-squared-t setting][ground alarm]**.
 - 8) One test kit to test each trip function.
 - 9) Battery backup for informational displays after automatic trip, with battery status indicator LED.
- f. Bolted Pressure Switches: Fixed-mounted, manually operated, **[electrically tripped],[fusible,]**bolted pressure contact switch. Comply with UL 977.

- 1) Stored energy deadfront mechanism, compressed and released by the operating handle; switching action must be independent of the speed of the operating handle.
 - 2) Indication whether the switch is open or closed, and provisions for padlocking the operating handle.
 - 3) With fuse clips and fuses for UL 248 Class L time-delay fuses.
 - 4) Electrically tripped switches must include:
 - a) Ground-fault protection, with adjustable time delay and test panel.
 - b) Single-phase protection, tripping the switch on loss of a source phase.
 - c) Blown fuse protection, tripping the switch on a blown fuse, with blown fuse indication.
- g. ICCBs: **[Fixed][Drawout]**-mounted, **[manually][electrically]** operated air-circuit breakers. Comply with UL 1066.
- 1) With "close" and "open" push buttons and red and green lighted breaker position indicators. Charging time of the motor operator must not exceed 8 seconds. Operator power must be from a control power transformer internal to the switchboard.
 - 2) Solid-state monitoring and tripping system to provide system status monitoring, adjustable time-current protection, and shunt trip.
 - 3) Interchangeable current sensors and timing circuits for adjustable time-current protection settings and status signals.
 - 4) LED indicators or display, with manual reset, to show cause of automatic trip.
 - 5) Display panel to indicate that the status of the system circuitry is fully operational, or give fault location based on automatic diagnosis.
 - 6) Trip the circuit breaker when closing on a fault.
 - 7) Time-current adjustments to achieve protective-device coordination as follows:
 - a) Adjustable long-delay pickup and time.
 - b) Individual adjustments for short-delay pickup, time, and I-squared-t setting.
 - c) Adjustable instantaneous pickup.
 - d) Individually adjustable ground-fault pickup and time, with **[I-squared-t setting][ground alarm]**.
 - 8) With built-in connector to test the breaker settings. Provide one test set.
 - 9) Battery backup for informational displays after automatic trip, with battery status indicator.
- h. MCCBs (to 2500 A): Fixed-mounted, manually operated air-circuit breakers. Comply with UL 489.
- 1) With quick-make, quick-break, over-center switching mechanism that is mechanically trip-free, and its position is shown by the position of the handle. With manual push-to-trip push button.
 - 2) Solid-state monitoring and tripping system to provide system status monitoring, adjustable time-current protection, and shunt trip.
 - 3) Interchangeable current sensors and timing circuits for adjustable time-current protection settings and status signals.
 - 4) With trip-setting dials or interchangeable plugs to establish the continuous trip of the circuit breaker. Plugs must not be interchangeable between frames, and the breaker may not be closed without the plug. With neutral ground-fault sensor.
 - 5) Time-current adjustments to achieve protective-device coordination as follows:
 - a) Adjustable long-time delay.
 - b) Adjustable short-time setting and delay to shape the time-current curve.

- c) Adjustable instantaneous setting.
 - d) Individually adjustable ground-fault setting and time delay.
- 6) With built-in connector to test the long-time delay, instantaneous, and ground-fault functions of the breaker. **[Provide one test set for testing installed circuit breakers with 225 A frame and higher.]**
- 7) With built-in digital ammeter display, showing load current and tripping cause.
- i. MCCBs (1600 to 2500 A): Fixed-mounted, manually operated air-circuit breakers. Comply with UL 489.
 - 1) With quick-make, quick-break, over-center switching mechanism that is mechanically trip-free, and its position is shown by the position of the handle. With manual push-to-trip push button.
 - 2) Solid-state monitoring and tripping system to provide system status monitoring, adjustable time-current protection, and shunt trip.
 - 3) Interchangeable current sensors and timing circuits for adjustable time-current protection settings and status signals.
 - 4) LED indicators or display, with manual reset, to show reasons of automatic trip.
 - 5) Display panel to indicate that the status of the system circuitry is fully operational, or give fault location based on automatic diagnosis.
 - 6) Trip the circuit breaker when closing on a fault.
 - 7) Time-current adjustments to achieve protective-device coordination as follows:
 - a) Adjustable long-delay pickup and time.
 - b) Individual adjustments for short-delay pickup, time, and I-squared-t setting.
 - c) Adjustable instantaneous pickup.
 - d) Individually adjustable ground-fault pickup and time, with **[I-squared-t setting][ground alarm]**.
 - 8) One test kit to test each trip function.
 - 9) Battery backup for informational displays after automatic trip, with battery status indicator.
- j. Fusible Switches: Fixed-mounted, manually operated, **[electrically tripped]**, fusible, quick-make, quick-break switch. Comply with UL 98.
 - 1) Indication whether the switch is open or closed, and provisions for padlocking the operating handle.
 - 2) With fuse clips and fuses.
 - 3) Electrically tripped switches must include:
 - a) Shunt trip.
 - b) Ground-fault protection, with adjustable time delay and test panel.
 - c) Single-phase protection, tripping the switch on loss of a source phase.
 - d) Blown fuse protection, tripping the switch on a blown fuse, with blown fuse indication.

H. UL YEFV or YEFR - Low-Voltage Instruments Section :

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

Secondary Unit Substations with Switchboard

Secondary

- a. **[ABB, Electrification Business]**
 - b. **[Eaton]**
 - c. **[Siemens Industry, Inc., Energy Management Division]**
 - d. **[Square D; Schneider Electric USA]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Eaton]**
 - c. **[Siemens Industry, Inc., Energy Management Division]**
 - d. **[Square D; Schneider Electric USA]**
 - e. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Unit Substation Over 600 V: UL CCN YEFV, including the following referenced standards:
 - 1) Articulated Unit Substations: IEEE C37.121.
 - 2) Integral Unit Substations: IEEE C37.20.2, IEEE C37.20.3, NEMA C37.55, and NEMA C37.57.
 - b. Unit Substation Rated 600 V or Less: UL CCN YEFR, including UL 1062.
4. Standard Features:
 - a. Instrument Transformers: Comply with IEEE C57.13.
 - 1) Potential Transformers: Secondary voltage rating of 120 V and NEMA C 12.11 Accuracy Class of 0.3 with burdens of W, X, and Y.
 - 2) Current Transformers: Burden and Accuracy Class suitable for connected relays, meters, and instruments.
 - b. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems.
 - 1) Inputs from sensors or 5 A current-transformer secondaries, and potential terminals rated to 600 V.
 - 2) Switch-selectable digital display with the following features:
 - a) Phase Currents, Each Phase: Plus or minus 1 percent.
 - b) Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
 - c) Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
 - d) Three-Phase Real Power: Plus or minus 2 percent.
 - e) Three-Phase Reactive Power: Plus or minus 2 percent.
 - f) Power Factor: Plus or minus 2 percent.
 - g) Frequency: Plus or minus 0.5 percent.
 - h) Integrated Demand, with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
 - i) Accumulated energy, in **MWh (MJ)**, plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.



- 3) Communications module suitable for remote monitoring of meter quantities and functions. Interface communication and metering.
 - 4) Mounting: Display and control unit that is flush or semiflush mounted in instrument compartment door.
- c. Analog Instruments: Rectangular, **4-1/2 inch (115 mm)** square, 1 percent accuracy, semiflush mounting, with antiparallax 250-degree scale and external zero adjustment.
- 1) Voltmeters: Cover an expanded scale range of normal voltage plus 10 percent.
 - 2) Voltmeter Selector Switch: Rotary type with "off" position to provide readings of phase-to-phase[**and phase-to-neutral**] voltages.
 - 3) Ammeters: Cover an expanded scale range of bus rating plus 10 percent.
 - 4) Ammeter Selector Switch: Permits current reading in each phase and keeps current-transformer secondary circuits closed in "off" position.
 - 5) Locate meter and selector switch on circuit-breaker compartment door for indicated feeder circuits only.
 - 6) Watt-Hour Meters: Flush- or semiflush-mounting type, 5 A, 120 V, three phase, three wire; with three elements, 15-minute indicating demand register, and provision for testing and adding pulse initiation.
 - 7) Recording Demand Meter: Usable as totalizing relay or indicating and recording maximum demand meter with 15-minute interval.
 - a) Operation: Counts and records a succession of pulses entering two channels.
 - b) Housing: Drawout, back-connected case arranged for semiflush mounting.
- d. Relays: Comply with IEEE C37.90, types and settings as indicated; with test blocks and plugs.
- e. Surge Suppression: Factory installed as an integral part of the low-voltage switchgear, complying with UL 1449 SPD, Type 1, with the following features and accessories:
- 1) Integral disconnect switch.
 - 2) Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
 - 3) Indicator light display for protection status.
 - 4) Form-C contacts rated at 5 A and 250 V(ac), one N.O. and one N.C., for remote monitoring of protection status.[**Contacts must reverse on failure of surge diversion module or on opening of current-limiting device. Coordinate with building power monitoring and control system.**]
 - 5) Surge counter.
- f. Control Power Supply: Control power transformer supplying 120 V control circuits through secondary disconnect devices.
- g. Control Wiring: Factory installed, complete with bundling, lacing, and protection; and complying with the following:
- 1) Flexible conductors for 8 AWG and smaller, for conductors across hinges and for conductors for interconnections between shipping units.
 - 2) Conductors sized in accordance with NFPA 70 for duty required.

2.5 MAINTENANCE MATERIAL ITEMS

- A. Spare Parts: Furnish to Owner spare parts, for repairing unit substation equipment, that are packaged with protective covering for storage on-site and identified with labels describing contents.[**Include the**

Secondary Unit Substations with Switchboard

Secondary

following:]

1. Spare Fuses: **[Six]<Insert number>** of each type and rating of fuse and fusible device used, except for medium-voltage fuses. Include spares for the following:
 - a. Primary disconnect fuses.
 - b. Potential transformer fuses.
 - c. Control power fuses.
 - d. Fuses and fusible devices for fused circuit breakers.
 - e. Fuses for secondary fusible devices.
 2. Spare Indicating Lights: Six of each type installed.
 3. Spare Mounting Gaskets: **[One]<Insert number>** set(s) for bushings, handholes, and the gasket between relief cover and flange of pressure-relief device.
- B. Special Tools: Furnish to Owner proprietary equipment, keys, and software required to operate, maintain, repair, adjust, or implement future changes to secondary unit substation equipment, that are packaged with protective covering for storage on-site and identified with labels describing contents.**[Include the following:]**
1. Racking handle, to manually move circuit breaker between "connected" and "disconnected" positions.
 2. Portable test set for testing functions of circuit-breaker, solid-state trip devices without removal from switchboard.
 3. Relay and meter test plugs suitable for testing switchgear meters and switchgear class relays.
 4. Circuit-Breaker Removal Apparatus: Portable, floor-supported, roller-base, elevating carriage arranged for moving circuit breakers in and out of compartments.
 5. Spare-Fuse Cabinet: Identified and compartmented steel box or cabinet with lockable door.
 6. Storage for Manual: Include rack or holder, near operating instructions, for copy of maintenance manual.
- C. Consumable Items: Furnish to Owner extra consumable items for storage on-site, identified with labels describing contents.**[Include the following:]**
1. Touchup Paint: **[Three]<Insert number>** half-pint containers of paint matching enclosure's exterior finish.
 2. Primary Switch Contact Lubricant: **[One]<Insert number>** container(s).

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and space conditions for compliance with requirements for secondary unit substations and other conditions affecting performance of the Work.
- B. Examine roughing-in of conduits and grounding systems to verify the following:
 1. Wiring entries comply with layout requirements.
 2. Entries are within conduit-entry tolerances specified by manufacturer, and no feeders will have to cross section barriers to reach load or line lugs.
- C. Examine walls, floors, roofs, and concrete bases for suitable conditions for secondary unit substation installation.

- D. Verify that ground connections are in place. Maximum ground resistance must be 5 Ω at secondary unit substation location.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF SECONDARY UNIT SUBSTATION EQUIPMENT

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:
 - 1. Electrical Construction: ICC IBC, ICC IFB, NFPA 1, NFPA 70, and NECA NEIS 1.
 - 2. Electrical Maintenance: NFPA 70B.
 - 3. Electrical Safety: NFPA 70E.
 - 4. Temporary Electric Power Work: NECA NEIS 200.
 - 5. Commissioning of Electrical Systems: NECA NEIS 90.
 - 6. Hot Work: NFPA 51B.
 - 7. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
 - 8. Life Safety and Means of Egress Work: NFPA 101.
 - 9. Emergency and Standby Power Work: NFPA 110, NFPA 111, and NECA NEIS 416.
 - 10. Work in Confined Spaces: NFPA 350.
 - 11. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
 - 12. Evaluation of Unlabeled Electrical Equipment: NFPA 791.
 - 13. Installation of Switchboards: NECA NEIS 400.
 - 14. Installation of Liquid-Filled Transformers: NECA NEIS 410.
 - 15. Installation of Medium-Voltage Switchgear: NECA NEIS 430.
 - 16. AC Outdoor High-Voltage Circuit Breakers: NEMA SG 11.
 - 17. Consult Architect for resolution of conflicting requirements.
- C. Special Installation Techniques:
 - 1. Install secondary unit substations on cast-in-place concrete equipment base(s).
 - 2. Comply with requirements for vibration isolation and seismic control devices.
- D. Interfaces with Other Work:
 - 1. Identification: Provide labels for secondary unit substation equipment and associated electrical equipment.
 - a. Identify field-installed conductors, interconnecting wiring, and components.
 - b. Label each enclosure with engraved metal or laminated-plastic nameplate.
 - c. Provide warning signs and arc-flash hazard warning labels for electrical equipment.
 - d. Install the number of signs required to be readable from each accessible side, but space the signs a maximum of **30 ft (9 m)** apart.
 - e. Operating Instructions: Place printed operating instructions for secondary unit substations, including key interlocking, control sequences, elementary single-line diagram, and emergency procedures with the maintenance materials.
 - 2. Grounding and Bonding:
 - a. At Interior Locations: For grounding to grounding electrodes, use bare copper cable not

smaller than 4/0 AWG. Bond surge arrester and neutrals directly to the transformer enclosure and then to the grounding electrode system with bare copper conductors. Keep leads as short as practicable with no kinks or sharp bends. Make joints in grounding conductors and loops by exothermic weld or compression connector.

- b. At Exterior Locations:
- c. For counterpoise, use tinned bare copper cable not smaller than 4/0 AWG, buried not less than **30 inch (765 mm)** below grade interconnecting the grounding electrodes. Bond surge arrester and neutrals directly to the transformer enclosure and then to the grounding electrode system with bare copper conductors, sized as shown. Keep lead lengths as short as practicable with no kinks or sharp bends.
 - 1) Fence and equipment connections must not be smaller than 4 AWG. Ground fence at each gate post and corner post and at intervals not exceeding **10 ft (3050 mm)**. Bond each gate section to the fence post using **1/8 by 1 inch (3 by 25 mm) [tinned]** flexible braided copper strap and clamps.
 - 2) Make joints in grounding conductors and loops by exothermic weld or compression connector.

3.3 FIELD QUALITY CONTROL

A. Administrant for Electrical Power Tests and Inspections:

- 1. **[Owner][Tenant]** will engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
- 2. Engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
- 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
- 4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].

B. Acceptance Testing Preparation:

- 1. **<Insert requirements>**.

C. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.

D. Tests and Inspections:

- 1. Comply with the provisions of NFPA 70B Ch. 11, "Testing and Test Methods."
- 2. Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.
- 3. After installing secondary unit substation but before primary is energized, verify that grounding system at the substation is tested at the specified value or less.
- 4. After installing secondary unit substation and after electrical circuitry has been energized, test for compliance with requirements.
- 5. Visual and Mechanical Inspection:
 - a. Verify equipment nameplate data complies with the Contract Documents.
 - b. Inspect bolted electrical connections for high resistance using one of the following two methods:

- 1) Use a low-resistance ohmmeter to compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar

- 2) bolted connections by more than 50 percent of the lowest value.
- 2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.

E. Switchgear Field Tests:

1. Visual and Mechanical Inspection:

- a. Inspect physical and mechanical condition.
- b. Inspect anchorage, alignment, grounding, and required area clearances.
- c. Verify the unit is clean and shipping bracing, loose parts, and documentation shipped inside cubicles have been removed.
- d. Verify that fuse and circuit-breaker sizes and types correspond to the Drawings and coordination study as well as the address of the circuit breaker that is used to identify it in microprocessor-communication software.
- e. Verify that current and voltage-transformer ratios correspond to the Drawings.
- f. Confirm correct operation and sequencing of electrical and mechanical interlock systems.
 - 1) Attempt closure on locked-open devices. Attempt to open locked-closed devices.
 - 2) Make key exchange with devices operated in off-normal positions.
- g. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
- h. Inspect insulators for evidence of physical damage or contaminated surfaces.
- i. Verify correct barrier and shutter installation and operation.
- j. Exercise active components.
- k. Inspect mechanical indicating devices for correct operation.
- l. Verify that filters are in place and vents are clear.
- m. Inspect control power transformers as follows:
 - 1) Inspect for physical damage, cracked insulation, broken leads, connection tightness, defective wiring, and overall general condition.
 - 2) Verify that primary- and secondary-use or circuit-breaker ratings match the Drawings and comply with manufacturer's published instructions.
 - 3) Verify correct functioning of drawout disconnecting and grounding contacts and interlocks.

2. Electrical Tests:

- a. Perform dc voltage insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground, for one minute. If the temperature of the bus is other than plus or minus 20 deg C, adjust the resulting resistance as provided in NETA ATS Table 100.11.
 - 1) Insulation-resistance values of bus insulation must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's published instructions or NETA ATS, Table 100.1.
 - 2) Do not proceed to the dielectric-withstand-voltage tests until insulation-resistance levels are raised above minimum values.

- b. Perform a dielectric-withstand-voltage test on each bus section, each phase-to-ground with phases not under test grounded, in accordance with manufacturer's published data. If manufacturer has no recommendation for this test, it must be conducted in accordance with NETA ATS, Table 100.2. Apply the test voltage for one minute.
 - 1) If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric-withstand-voltage test, the test specimen is considered to have passed the test.
- c. Voltage Transformers:
 - 1) Perform secondary wiring integrity test. Verify correct potential at devices.
 - 2) Verify secondary voltages by energizing the primary winding with system voltage.
- d. Perform current-injection tests on the entire current circuit in each section of switchgear.
 - 1) Perform current tests by secondary injection with magnitudes such that a minimum current of 1.0 A flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.
 - 2) Perform current tests by primary injection with magnitudes such that a minimum of 1.0 A flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.
- e. Verify operation of space heaters.
- f. Perform phasing checks on double-ended or dual-source switchgear to ensure correct bus phasing from each source.

F. Medium-Voltage Surge Arrester Field Tests:

- 1. Visual and Mechanical Inspection:
 - a. Inspect physical and mechanical condition.
 - b. Inspect anchorage, alignment, grounding, and clearances.
 - c. Verify the arresters are clean.
 - d. Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.
 - e. Verify that the stroke counter is correctly mounted and electrically connected if applicable. Record the stroke counter reading.
- 2. Electrical Test:
 - a. Perform an insulation-resistance test on each arrester, phase terminal-to-ground. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Replace units that fail to meet recommended minimum insulation resistance listed in the table.
 - b. Perform a watts-loss test. Evaluate watts-loss values by comparison with similar units and test equipment manufacturer's published data.

G. Instrument Transformer Field Tests:

- 1. Visual and Mechanical Inspection:
 - a. Inspect physical and mechanical condition.
 - b. Verify correct connection of transformers with system requirements.
 - c. Verify that adequate clearances exist between primary and secondary circuit wiring.
 - d. Verify the unit is clean.

- e. Verify that required grounding and shorting connections provide contact.
- f. Verify correct operation of transformer withdrawal mechanism and grounding operation.
- g. Verify correct primary- and secondary-fuse sizes for voltage transformers.
- h. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

2. Electrical Tests of Current Transformers:

- a. Perform insulation-resistance test of each current transformer and its secondary wiring with respect to ground at 1000 V(dc) for one minute. For units with solid-state components that cannot tolerate the applied voltage, comply with manufacturer's published instructions. Insulation-resistance values of instrument transformers must not be less than values shown in NETA ATS, Table 100.5.
- b. Perform a polarity test of each current transformer in accordance with IEEE C57.13.1. Polarity results must agree with transformer markings.
- c. Perform a ratio-verification test using the voltage or current method in accordance with IEEE C57.13.1. Ratio errors must comply with IEEE C57.13.
- d. Perform an excitation test on transformers used for relaying applications in accordance with IEEE C57.13.1. Excitation results must match the curve supplied by the manufacturer or must comply with IEEE C57.13.1.
- e. Measure current circuit burdens at transformer terminals in accordance with IEEE C57.13.1. The measured burdens must match the instrument transformer Accuracy Class rating.
- f. Perform insulation-resistance tests on the primary winding with the secondary grounded. Test voltages must comply with NETA ATS, Table 100.5. The insulation-resistance value must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5.
- g. Perform dielectric-withstand-voltage tests on the primary winding with the secondary grounded. Test voltages must comply with NETA ATS, Table 100.9. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application, the primary winding is considered to have passed the test.
- h. Perform power-factor or dissipation-factor tests in accordance with test equipment manufacturer's published data. Power-factor or dissipation-factor values must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with test equipment manufacturer's published data.
- i. Verify that current-transformer secondary circuits are grounded and have only one grounding point in accordance with IEEE C57.13.3.

3. Electrical Tests of Voltage and Potential Transformers:

- a. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply the test voltage for one minute in accordance with NETA ATS, Table 100.5. For units with solid-state components that cannot tolerate the applied voltage, follow manufacturer's published instructions. Insulation-resistance values of instrument transformers must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5.
- b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Test voltages must be applied for one minute in accordance with NETA ATS, Table 100.5. Insulation-resistance values of the transformers must not be less than values shown in NETA ATS, Table 100.5.
- c. Perform a polarity test on each transformer to verify the polarity marks or H(1)- X(1) relationship. Polarity results must agree with transformer markings.
- d. Perform a turns-ratio test on tap positions. Ratio errors must not exceed the tolerances specified in IEEE C57.13.

- e. Measure voltage circuit burdens at transformer terminals. Measured burdens must be compared to instrument transformer ratings. The measured burdens must match the instrument transformer Accuracy Class rating.
- f. Perform a dielectric-withstand-voltage test on the primary windings with the secondary windings connected to ground. The dielectric voltage must comply with NETA ATS, Table 100.9. The test voltage must be applied for one minute. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric-withstand-voltage test, the primary windings are considered to have passed the test.
- g. Perform power-factor or dissipation-factor tests in accordance with test equipment manufacturer's published data. Power-factor or dissipation-factor values must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with test equipment manufacturer's published data.
- h. Verify that voltage-transformer secondary circuits are grounded and have only one grounding point in accordance with IEEE C57.13.3.

H. Microprocessor-Based Protective Relay Field Tests:

1. Visual and Mechanical Inspection:

- a. Record model number, style number, serial number, firmware revision, software revision, and rated control voltage.
- b. Verify operation of light-emitting diodes, display, and targets.
- c. Record passwords for each access level.
- d. Clean the front panel and remove foreign material from the case.
- e. Check tightness of connections.
- f. Verify that the frame is grounded in accordance with manufacturer's instructions.
- g. Set the relay in accordance with results in Section 260573 "Power System Studies."
- h. Download settings from the relays. Print a copy of the settings for the report and compare the settings to those specified in the coordination study.

2. Electrical Tests:

- a. Perform insulation-resistance tests from each circuit to the grounded frame in accordance with manufacturer's published data.
- b. Apply voltage or current to analog inputs, and verify correct registration of the relay meter functions.
- c. Functional Operation: Check functional operation of each element used in the protection scheme.

I. Liquid-Filled Transformer Section Field Tests:

1. Visual and Mechanical Inspection:

- a. Inspect physical and mechanical condition.
- b. Inspect impact recorder prior to unloading.
- c. Test dew point of tank gases if applicable.
- d. Inspect anchorage, alignment, and grounding.
- e. Verify the presence of PCB content labeling.
- f. Verify removal of shipping bracing after placement.
- g. Verify the bushings are clean.
- h. Verify that alarm, control, and trip settings on temperature and level indicators are set and operate within manufacturer's recommended settings.
- i. Verify that cooling fans and pumps operate correctly and have appropriate overcurrent protection.
- j. Verify that liquid level in tanks and bushings is within manufacturer's published tolerances.



- k. Perform specific inspections and mechanical tests recommended by the manufacturer.
- l. Verify presence of transformer surge arresters and that their ratings are as specified.
- m. Verify that as-left tap connections are as specified.
- n. Verify the presence of surge arresters and that their ratings are as specified.

2. Electrical Tests:

- a. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index; the value of the index must not be less than 1.0.
- b. Perform power-factor or dissipation-factor tests on windings in accordance with test equipment manufacturer's published data. Maximum winding insulation power-factor/dissipation-factor values must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.3.
- c. Measure core insulation resistance at 500 V(dc) if the core is insulated and the core ground strap is removable. Core insulation-resistance values must not be less than 1 MΩ at 500 V(dc).
- d. Perform a power-factor or dissipation-factor tip-up test on windings greater than 2.5 kV.
- e. Perform turns-ratio tests at tap positions. Turns-ratio test results must not deviate by more than one-half percent from either the adjacent coils or the calculated ratio. If the test fails, replace the transformer.
- f. Perform an excitation-current test on each phase. The typical excitation-current test data pattern for a three-legged core transformer is two similar current readings and one lower current reading. Investigate and correct if the test shows a different pattern.
- g. Measure the resistance of each winding at each tap connection, and record temperature-corrected winding-resistance values in the Operations and Maintenance Manual.
- h. Perform an applied-voltage test on high- and low-voltage windings-to-ground. Comply with IEEE C57.12.91, Sections 10.2 and 10.9.
- i. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.
- j. Remove a sample of insulating liquid in accordance with ASTM D923. Insulating liquid values must comply with NETA ATS, Table 100.4. Sample must be tested for the following:
 - 1) Dielectric Breakdown Voltage: ASTM D877 or ASTM D1816.
 - 2) Acid Neutralization Number: ASTM D974.
 - 3) Specific Gravity: ASTM D1298.
 - 4) Interfacial Tension: ASTM D971.
 - 5) Color: ASTM D1500.
 - 6) Visual Condition: ASTM D1524.
 - 7) Water in Insulating Liquids: ASTM D1533.
 - 8) Power Factor or Dissipation Factor: ASTM D924.
- k. Remove a sample of insulating liquid in accordance with ASTM D923 and perform dissolved-gas analysis in accordance with IEEE C57.104 or ASTM D3612.

J. Small Dry-Type Transformer Section Field Tests:

1. Visual and Mechanical Inspection:

- a. Inspect physical and mechanical condition.
- b. Inspect anchorage, alignment, and grounding.
- c. Verify that resilient mounts are free and that shipping brackets have been removed.
- d. Verify the unit is clean.

- e. Perform specific inspections and mechanical tests recommended by the manufacturer.
- f. Verify that as-left tap connections are as specified.
- g. Verify the presence of surge arresters and that their ratings are as specified.

2. Electrical Tests:

- a. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index; the value of the index must not be less than 1.0.
- b. Perform turns-ratio tests at tap positions. The test results must not deviate by more than one-half percent from either the adjacent coils or the calculated ratio. If the test fails, replace the transformer.
- c. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

K. Large Dry-Type Transformer Section Field Tests:

1. Visual and Mechanical Inspection:

- a. Inspect physical and mechanical condition.
- b. Inspect anchorage, alignment, and grounding.
- c. Verify that resilient mounts are free and that shipping brackets have been removed.
- d. Verify the unit is clean.
- e. Verify that alarm, control, and trip settings on temperature and level indicators are set and operate within manufacturer's recommended settings.
- f. Verify that cooling fans operate and that fan motors have correct overcurrent protection.
- g. Perform specific inspections and mechanical tests recommended by the manufacturer.
- h. Verify that as-left tap connections are as specified.
- i. Verify the presence of surge arresters and that their ratings are as specified.

2. Electrical Tests:

- a. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index; the value of the index must not be less than 1.0.
- b. Perform power-factor or dissipation-factor tests on windings in accordance with the test equipment manufacturer's published data. Investigate and correct power-factor values that exceed:
 - 1) 2.0 percent for power transformers.
 - 2) 5.0 percent for distribution transformers.
 - 3) Measure core insulation resistance at 500 V dc if the core is insulated and the core ground strap is removable. Core insulation-resistance values must not be less than 1 M Ω at 500 V(dc).
- c. Perform a power-factor or dissipation-factor tip-up test on windings greater than 2.5 kV. Tip-up test result exceeding 1.0 percent must be investigated.
- d. Perform turns-ratio tests at tap positions. The test results must not deviate by more than one-half percent from either the adjacent coils or the calculated ratio. If the test fails, replace the transformer.
- e. Perform an excitation-current test on each phase. The typical excitation-current test data pattern for a three-legged core transformer is two similar current readings and one lower current reading. Investigate and correct if the test shows a different pattern.
- f. Measure the resistance of each winding at each tap connection.

- g. Perform an applied-voltage test on high- and low-voltage windings-to-ground. See IEEE C57.12.91, Sections 10.2 and 10.9. The AC dielectric-withstand-voltage test result must not exceed 75 percent of factory test voltage for one-minute duration. The dc dielectric-withstand-voltage test result must not exceed 100 percent of the AC RMS test voltage specified in IEEE C57.12.91, Section 10.2, for one-minute duration. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric-withstand-voltage test, the test specimen is considered to have passed the test.
- h. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

L. Low-Voltage Power Circuit-Breaker Field Tests:

1. Visual and Mechanical Inspection:

- a. Inspect physical and mechanical condition.
- b. Inspect anchorage, alignment, and grounding.
- c. Verify that maintenance devices are available for servicing and operating the breaker.
- d. Verify the unit is clean.
- e. Verify that the arc chutes are intact.
- f. Inspect moving and stationary contacts for condition and alignment.
- g. Verify that primary and secondary contact wipe and other dimensions vital to satisfactory operation of the breaker are correct.
- h. Perform mechanical operator and contact alignment tests on both the breaker and its operating mechanism in accordance with manufacturer's published data.
- i. Verify cell fit and element alignment.
- j. Verify racking mechanism operation.
- k. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
- l. Perform adjustments for final protective-device settings in accordance with coordination study provided by end user.
- m. Record as-found and as-left operation counter readings.

2. Electrical Tests:

- a. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Insulation-resistance values must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Values of insulation resistance less than this table or manufacturer's published instructions must be investigated.
- b. Measure contact resistance across each power contact of the circuit breaker. Drop values for $\mu\Omega$ or mV(dc) must not exceed the high levels of the normal range as indicated in the manufacturer's published data. If manufacturer's published data is not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
- c. Determine long-time pickup and delay by primary current injection. Long-time pickup values must be as specified, and the trip characteristic must not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors. If manufacturer's curves are not available, trip times must not exceed the value shown in NETA ATS, Table 100.7.
- d. Determine short-time pickup and delay by primary current injection. Short-time pickup values must be as specified, and the trip characteristic must not exceed manufacturer's

- published time-current tolerance band.
- e. Determine ground-fault pickup and delay by primary current injection. Ground-fault pickup values must be as specified, and the trip characteristic must not exceed manufacturer's published time-current tolerance band.
- f. Determine instantaneous pickup value by primary current injection. Instantaneous pickup values must be as specified and within manufacturer's published tolerances. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.8.
- g. Test functions of the trip unit by means of secondary injection. Pickup values and trip characteristic must be as specified and within manufacturer's published tolerances.
- h. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data. Minimum pickup voltage of the shunt trip and close coils must conform to the manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.20.
- i. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.
- j. Verify correct operation of auxiliary features, such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free operation, antipump function, and trip unit battery condition. Reset trip logs and indicators. Auxiliary features must operate in accordance with manufacturer's published data.
- k. Verify operation of charging mechanism. The charging mechanism must operate in accordance with manufacturer's published data.

M. Insulated-Case/Molded-Case Air-Circuit-Breaker Field Tests:

1. Visual and Mechanical Inspection:

- a. Inspect physical and mechanical condition.
- b. Inspect anchorage and alignment.
- c. Verify the unit is clean.
- d. Operate the circuit breaker to ensure smooth operation.
- e. Inspect operating mechanism, contacts, and arc chutes in unsealed units.
- f. Perform adjustments for final protective-device settings in accordance with the coordination study. Set the protective devices in accordance with coordination study report.

2. Electrical Tests:

- a. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Insulation-resistance values must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Values of insulation resistance less than this table or manufacturer's published instructions must be investigated.
- b. Perform a contact/pole-resistance test. Drop values for $\mu\Omega$ or mV(dc) must not exceed the high levels of the normal range as indicated in the manufacturer's published data. If manufacturer's published data is not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
- c. Determine long-time pickup and delay by primary current injection. Ground-fault pickup values must be as specified, and the trip characteristic must not exceed manufacturer's published time-current tolerance band, including adjustment factors.
- d. Determine short-time pickup and delay by primary current injection. Short-time pickup values must be as specified, and the trip characteristic must not exceed manufacturer's published time-current tolerance band.
- e. Determine ground-fault pickup and time delay by primary current injection. Ground-fault pickup values must be as specified, and the trip characteristic must not exceed manufacturer's published time-current tolerance band.

- f. Determine instantaneous pickup by primary current injection. Instantaneous pickup values must be as specified and within manufacturer's published tolerances. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.8.
- g. Test functions of the trip unit by means of secondary injection. Pickup values and trip characteristic must be as specified and within manufacturer's published tolerances.
- h. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data. Minimum pickup voltage of the shunt trip and close coils must conform to the manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.20.
- i. Verify correct operation of auxiliary features, such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free operation, anti-pump function, and trip unit battery condition. Reset trip logs and indicators. Auxiliary features must operate in accordance with manufacturer's published data.
- j. Verify operation of charging mechanism. The charging mechanism must operate in accordance with manufacturer's published data.

N. Low-Voltage Ground-Fault Protection System Field Tests:

1. Visual and Mechanical Inspection:

- a. Inspect the components for damage and errors in polarity or conductor routing.
 - 1) Verify that ground connection is made on the source side of the neutral disconnect link and on the source side of ground-fault sensor.
 - 2) Verify that the neutral sensors are connected with correct polarity on both primary and secondary.
 - 3) Verify that phase conductors and the neutral pass through the sensor in the same direction for zero sequence systems.
 - 4) Verify that grounding conductors do not pass through zero sequence sensors.
 - 5) Verify that grounded conductor is solidly grounded.
- b. Verify the unit is clean.
- c. Operate the circuit breaker to ensure smooth operation.
- d. Verify correct operation of functions of the self-test panel if provided.
- e. Verify that the control power transformer has adequate capacity for the system.
- f. Set pickup and time-delay settings. Record appropriate operation and test sequences in accordance with Section 230.95 "Ground-Fault Protection of Equipment" of NFPA 70.

2. Electrical Tests:

- a. Measure the system neutral-to-ground insulation resistance with the neutral disconnect link temporarily removed. Replace the neutral disconnect link after testing. System neutral-to-ground insulation resistance must be a minimum of 1 MΩ. Correct wiring until the minimum is achieved.
- b. Perform ground-fault protective-device pickup tests using primary injection. Results of pickup test must be greater than 90 percent of the ground-fault protective-device pickup setting and less than 1200 A or 125 percent of the pickup setting, whichever is smaller. Adjust or replace the device until these parameters are achieved.
- c. For summation-type systems utilizing phase and neutral current transformers, verify correct polarities by applying current to each phase-neutral current-transformer pair. This test also applies to MCCBs utilizing an external neutral current transformer. The ground-fault protective device must operate when current direction is the same relative to polarity marks in the two current transformers. The ground-fault protective device must not operate when current direction is opposite relative to polarity marks in the two current transformers.

- d. Measure time delay of the ground-fault protective device at a value equal to or greater than 150 percent of the pickup value. Relay timing must be in accordance with manufacturer's published data but must be no longer than one second at 3000 A in accordance with Section 230.95 "Ground-Fault Protection of Equipment" of NFPA 70.
- e. Verify reduced control voltage tripping capability is 55 percent for AC systems and 80 percent for DC systems. Replace the ground-fault system if the reduced control voltage tripping requirement is not achieved, and retest.
- f. Verify blocking capability of zone interlock systems. Results of zone-blocking tests must be in accordance with manufacturer's published data and design specifications.

O. Metering Device Field Tests:

1. Visual and Mechanical Inspection:

- a. Inspect physical and mechanical condition.
- b. Inspect cover gasket, cover glass, condition of spiral spring, disk clearance, contacts, and case shorting contacts, as applicable.
- c. Verify the unit is clean.
- d. Verify freedom of movement, end play, and alignment of rotating disk(s).

2. Electrical Tests:

- a. Verify accuracy of meters at cardinal points. Meter accuracy must be in accordance with manufacturer's published data.
- b. Calibrate meters in accordance with manufacturer's published data. Calibration results must be within manufacturer's published tolerances.
- c. Verify instrument multipliers. Instrument multipliers must be in accordance with system design specifications.
- d. Verify that current-transformer and voltage-transformer secondary circuits are intact. Test results must confirm the integrity of the secondary circuits of current and voltage transformers.

P. Nonconforming Work:

- 1. Equipment and devices will be considered defective if they do not pass tests and inspections.
- 2. Remove and replace defective units and retest.

Q. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports. Record as-left set points of adjustable devices.

R. Manufacturer Services: Engage factory-authorized service representative to [support][supervise] field tests and inspections.

- 1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.

3.4 SYSTEM STARTUP

A. Perform startup service.

- 1. Complete installation and startup checks in accordance with manufacturer's published instructions.
- 2. <Insert startup steps if any>.

- B. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** system startup.
 - 1. Manufacturer's Field Reports for System Startup Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.

3.5 CLEANING

- A. After completing equipment installation and before energizing, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish. Vacuum interiors of secondary unit substation sections.

3.6 CLOSEOUT ACTIVITIES

- A. Training:
 - 1. **[With assistance from factory-authorized service representatives, train][Train]** Owner's maintenance personnel on the following topics:
 - a. How to adjust, operate, and maintain secondary unit substation equipment.
 - 2. **[Provide video recordings of training sessions to Owner][Allow Owner to record training sessions].**

3.7 PROTECTION

- A. After installation, protect secondary unit substation equipment from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

3.8 MAINTENANCE

- A. Voltage Monitoring and Adjusting: After Substantial Completion, if requested by Owner, but not more than six months after Final Acceptance, perform the following voltage monitoring:
 - 1. During a period of normal load cycles as evaluated by Owner, perform seven days of three-phase voltage recording at the outgoing section of each secondary unit substation. Use voltmeters with calibration traceable to the National Institute of Science and Technology standards and with a chart speed of not less than **1 inch (25 mm)** per hour. Voltage unbalance greater than 1 percent between phases, or deviation of phase voltage from the nominal value by more than plus or minus 5 percent during the test period, is unacceptable.
 - 2. Corrective Action: If test results are unacceptable, perform the following corrective action, as appropriate:
 - a. Adjust transformer taps.
 - b. Rebalance loads.
 - c. Prepare written request for voltage adjustment by electric utility.

3. Retests: Repeat monitoring, after corrective action has been performed, until satisfactory results are obtained.
 4. Field Reports for Voltage Monitoring and Adjusting:
 - a. Prepare a written report covering monitoring performed and corrective action taken.
 - b. For each relay and adjustable circuit breaker, tag the device with adjusting technician's initials and the date of the adjustment. Record the settings and file with test records specified in "Field Quality Control" Article.
- B. Infrared Scanning of Secondary Unit Substation Equipment: Perform the survey during periods of maximum possible loading. Remove covers prior to the inspection. Take visible light photographs at same locations and orientations as infrared scans for documentation to ensure follow-on scans match same conditions for valid comparison.
1. After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared inspection of the electrical power connections of the unit substation.
 2. Follow-On Infrared Scanning: Perform an additional follow-up infrared scan of each switchgear 11 months after date of Substantial Completion.
 3. Instrument: Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1 deg C at 30 deg C. Provide documentation of device calibration.
 4. Field Reports for Infrared Scanning: Prepare a certified report that identifies the testing technician and equipment used, and lists the results as follows:
 - a. Description of equipment to be tested.
 - b. Discrepancies.
 - c. Temperature difference between the area of concern and the reference area.
 - d. Probable cause of temperature difference.
 - e. Areas inspected. Identify inaccessible and unobservable areas and equipment.
 - f. Identify load conditions at time of inspection.
 - g. Provide photographs and thermograms of the deficient area.
 5. Act on inspection results in accordance with the recommendations of NETA ATS, Table 100.18. Correct possible and probable deficiencies as soon as Owner's operations permit. Retest until deficiencies are corrected.
- C. Maintenance Service Agreement: Beginning at Substantial Completion, verify that maintenance service agreement includes **[one year]<Insert duration>** period for full maintenance by **[skilled employees of secondary unit substation equipment Installer][manufacturer's authorized service representative]**. Include annual preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper secondary unit substation equipment operation. Verify that parts and supplies are manufacturer's authorized replacement parts and supplies.

END OF SECTION 26 11 16 00



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**SECTION 26 11 16 00A - SECONDARY UNIT SUBSTATIONS WITH MOTOR CONTROL CENTER
SECONDARY**

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Secondary unit substation equipment.

B. Products Installed, but Not Furnished, under This Section:

1. **<Insert products identified in "Existing Products to be Modified" Article or "Existing Products to be Removed and Re-Installed" Article>.**

C. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. **[Section 013100 "Project Management and Coordination"]<Insert Section number and title>** for preinstallation conference procedures.
5. Section 078413 "Penetration Firestopping" specifies materials and methods for sealing penetrations of rated walls and partitions referenced by this Section.
6. Section 260513 "Medium-Voltage Cables" for requirements for terminating cables in incoming section of substation.
7. Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for requirements for connecting wires.
8. Section 260526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding referenced by this Section.
9. Section 260529 "Hangers and Supports for Electrical Systems" specifies hangers, supports, and concrete bases referenced by this Section.
10. Section 260548 "Vibration and Seismic Controls for Electrical Systems" specifies vibration isolation and seismic[**and wind**] control devices referenced by this Section.
11. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs referenced by this Section.
12. Section 260573 "Power System Studies" specifies short-circuit current studies, overcurrent protective device coordination studies, arc-flash hazard analysis, warning labels, and circuit-breaker trip ranges referenced by this Section.
13. Section 260913 "Electrical Power Monitoring" specifies remote monitoring of metering instruments and for remote control of circuit breakers and switches.
14. Section 264313 "Surge Protective Devices for Low-Voltage Electrical Power Circuits" specifies field-mounted surge-suppression devices referenced in this Section.

1.2 DEFINITIONS

- A. Combination Motor Controller: A combination motor-control unit that includes externally operable circuit-disconnecting means, branch-circuit overcurrent protection, and a motor controller with associated auxiliary devices when used.
- B. CPT: Control power transformer.
- C. ICCB: Insulated-case circuit breaker.
- D. MCCB: Molded-case circuit breaker.
- E. MCP: Motor-circuit protector.
- F. PCB: Polychlorinated biphenyl.
- G. SCR: Silicon controlled rectifier.
- H. SPD: Surge protection device.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at **[Project site]<Insert location>**.
- B. Preinstallation Coordination Meeting(s): For unit substation. Conduct meeting(s) **[as videoconference][or][at Project site]<Insert location> before <Insert construction activity>**.
 - 1. Attendees: Installers, fabricators, representatives of manufacturers, and administrators for field tests and inspections. Notify Architect[, **Construction Manager**][, and **Owner's Commissioning Authority**] of scheduled meeting dates.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, operating characteristics, and furnished specialties and accessories.
 - 2. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing agency, certifying product's compliance with specified listing criteria.
 - a. If listed manufacturer differs from selling manufacturer, indicate relationship between entities on submittal. Clearly indicate which entity warrants product performance and fitness for purpose.
 - b. Listing criteria identified in approval letter must match specified listing criteria. UL label indicating approval of equipment's enclosure is not considered approval of equipment for intended application.
 - c. Product identification in approval letter must match product branding and model numbers in submittal. Approval letters for discontinued or superseded products are unacceptable for submitted product.
 - 3. Include manufacturer's sample extended warranty language.
 - 4. Include product certificates for secondary unit substations, signed by manufacturer.

- B. Shop Drawings: Prepare and submit the following:
1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of field connections.
 2. Wiring Diagrams: Power, signal, and control wiring.
 3. Dimensioned plans and elevations showing major components and features.
 - a. Include plan view and cross section of equipment base, showing clearances, manufacturer's published instructions for minimum workspace clearances that account for breaker service and removal, and locations of penetrations for grounding and conduits.
 4. One-line diagram.
 5. List of materials.
 6. Nameplate legends.
 7. Material, size and number of bus bars, and current rating for buses, including mains and branches of phase, neutral, and ground buses.
 8. Short-time and short-circuit current ratings of secondary unit substations and components.
 9. Ratings of individual protective devices.
 10. For motor-control secondary section, submit manufacturer's standard drawings complying with requirements of UL 845.
 - a. Manufacturer's production drawings as defined in UL 845.
 - b. Schematic and Connection Wiring Diagrams: For power, signal, and control wiring for installed controllers.
 - c. Nameplate legends.
 - d. Vertical and horizontal bus capacities.
 - e. Features, characteristics, ratings, and factory settings of installed units.
 - f. **<Insert required information>**.
 11. Design Data:
 - a. Time-Current Characteristic Curves: For overcurrent protective devices.
 - b. Primary Fuses: Submit recommendations and size calculations.
 - c. Utility company's metering provisions with indication of approval by utility company.
- C. Factory test reports.
- D. Field quality-control reports.

1.5 INFORMATIONAL SUBMITTALS

- A. For motor-control secondary section, submit the following:
1. Manufacturer's approval drawings as defined in UL 845.
 2. Manufacturer's custom drawings as defined in UL 845.
 3. Manufacturer's production drawings as defined in UL 845.
- B. Manufacturer's published instructions.
- C. Field Reports:
1. Manufacturer's field reports for field quality-control support.
 2. Manufacturer's field reports for system startup support.



3. Field reports for voltage monitoring and adjusting.
4. Field reports for infrared scanning.

1.6 CLOSEOUT SUBMITTALS

- A. Warranty documentation.
- B. Maintenance service agreement.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Spare parts.
- B. Special tools.
- C. Consumable items.

1.8 REGULATORY AGENCY APPROVALS

- A. Submittals for secondary unit substations requiring approval by **<Insert name of electrical utility>** must be signed by qualified electrical professional engineer responsible for their preparation. **[Obtain approval by electrical utility prior to submitting for action by Architect][Submit for action by Architect prior to submitting for approval by electrical utility].**

1.9 QUALIFICATIONS

- A. Electrical Power Testing (EPT) Technician I: Possessing active NICET EPT Level I certification. Able to work safely around electrical power equipment and cabling under supervision.
- B. Electrical Power Testing (EPT) Technician II: Possessing active NICET EPT Level II certification. Able to isolate and ground electrical power equipment, to connect test equipment, and to conduct and document standard tests of basic equipment.
- C. Electrical Power Testing (EPT) Technician III: Possessing active NICET EPT Level III certification. Able to manage switching procedures, to conduct tests of complex equipment, to analyze test and equipment data, to plan a job, and to lead a team. Has experience performing NFPA 70B, IEEE, and NETA electrical tests.
- D. Electrical Power Testing (EPT) Technician IV: Possessing active NICET EPT Level IV certification. Able to conduct tests of complex metering and relay systems; to evaluate tests, test equipment, test results, and power system performance; to recommend actions to maintain or improve system performance; and to lead multi-team projects.
- E. Electrical Power Testing and Inspecting Agency: Entities possessing active credentials from qualified electrical testing laboratory recognized by authorities having jurisdiction.
 1. On-site electrical testing supervisors must possess active NICET EPT Technician [III][IV] certification.

- F. Electrical Professional Engineer: Professional engineer possessing active qualifications specified in Section 014000 "Quality Requirements," with expertise in electrical engineering, including electrical power system modeling and analysis of electrical safety in accordance with NFPA 70E.
- G. Medium-Voltage Cable Installer: Entity possessing active qualifications specified in Section 014000 "Quality Requirements" with training and manufacturer certification to install, splice, and terminate medium-voltage cable[**in accordance with electrical utility service provider's requirements**].
 - 1. Medium-voltage cable Installer must be approved by **<Insert name of electrical utility service provider>**.
- H. Medium-Voltage Duct Installer: Entity possessing active qualifications specified in Section 014000 "Quality Requirements" with documented training and experience with installation of medium-voltage duct banks[**in accordance with electrical utility service provider's requirements**].
 - 1. Medium-voltage duct Installer must be approved by **<Insert name of electrical utility service provider>**.
- I. Medium-Voltage Equipment Installer: Entity possessing active qualifications specified in Section 014000 "Quality Requirements" with documented training and experience with hazards and safety requirements associated with installation and operation of medium-voltage equipment[**in accordance with electrical utility service provider requirements**].
 - 1. Medium-voltage equipment Installer must be approved by **<Insert name of electrical utility service provider>**.
- J. Electrical Power Monitoring Installers: Installer possessing active qualifications specified in Section 014000 "Quality Requirements," and able to present unexpired certified Installer credentials issued by manufacturer prior to starting installation.
- K. Power Quality Specialist: Recognized experts possessing active NICET Electrical Power Testing (EPT) Technician IV certification and documented experience in power quality testing for installations similar in complexity to the Project.

1.10 DELIVERY, STORAGE, AND HANDLING

- A. Deliver in shipping splits in sizes that can be moved past obstructions in delivery path.
- B. Coordinate delivery of secondary unit substations to allow movement into designated space.
- C. Store secondary unit substation components[**protected from weather and**] so condensation will not form on or in units. Provide temporary heating in accordance with manufacturer's written instructions.
- D. Handle secondary unit substation components in accordance with manufacturer's written instructions. Use factory-installed lifting provisions.
 - 1. Handle MCCs in accordance with NEMA ICS 2.3 and NECA NEIS 402.

1.11 SERVICE CONDITIONS FOR ELECTRICAL EQUIPMENT

- A. Modeling, analysis, product selection, installation, and quality control for all electrical Work on the Project must comply with service condition requirements specified in Section 018116 "Facility



Environmental Requirements" and Section 018123 "Facility Seismic and Wind Criteria."

- B. Usual Service Conditions: Unless unusual service conditions have been specified in "General Equipment Service Conditions," "Outdoor Equipment Service Conditions," and "Indoor Equipment Services Conditions" articles of Section 018116 "Facility Environmental Requirements," electrical service and distribution equipment must be suitable for operation under usual service conditions specified in applicable IEEE C37 series and IEEE C57 series standards.

1.12 WARRANTY FOR SECONDARY UNIT SUBSTATIONS

- A. Special Installer Extended Warranty: Installer warrants that assembled and installed secondary unit substation performs in accordance with specified requirements and agrees to repair or replace components or products that fail to perform as specified within extended-warranty period. Warranty must convey to Owner upon acceptance of the Work.
 - 1. Extended-Warranty Period: **[Two][Three][Four]<Insert number>** years from date of Substantial Completion; full coverage for labor, materials, and equipment.
- B. Special Manufacturer Extended Warranty: Manufacturer warrants that secondary unit substation performs in accordance with specified requirements and agrees to repair or replace components or products that fail to perform as specified within extended-warranty period. Warranty must convey to Owner upon acceptance of the Work.
 - 1. Initial Extended-Warranty Period: **[Three][Four][Five]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for labor, materials, and equipment.
 - 2. Follow-On Extended-Warranty Period: **[Eight]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for materials only, free on board **[origin][destination]**, freight prepaid.

PART 2 - PRODUCTS

2.1 EXISTING PRODUCTS TO BE MODIFIED

- A. Basis for Pricing: **<Insert name of manufacturer and model number or series for existing product>**.
- B. Description: **<Insert description of existing product, including special features, options, and finishes that may impact Work>**.
- C. Accessories: **<Insert accessories included with existing product>**.

2.2 EXISTING PRODUCTS TO BE REMOVED AND RE-INSTALLED

- A. Basis for Pricing: **<Insert name of manufacturer and model number or series for existing product>**.
- B. Description: **<Insert description of existing product, including special features, options, and finishes that may impact Work>**.
- C. Accessories: **<Insert accessories included with existing product>**.

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Secondary

2.3 PERFORMANCE REQUIREMENTS

- A. Description: Medium-voltage, primary incoming section; transformer section; and low-voltage MCC section; and including coordinated circuit breakers, fusible switches, and metering components.
- B. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- C. General Characteristics:
 1. Referenced Standards: IEEE C2 and IEEE C37.121.
 2. Indoor Unit Arrangement: Single assembly, with secondary section MCC complying with **[UL 50E, Type 1][UL 50E, Type 1 (gasketed)][UL 50E, Type 12]** construction.
 3. Outdoor Unit Arrangement: Single assembly.
 - a. Weatherproof, listed for installation outdoors, with primary and transformer sections complying with IEEE C37.20.1, and MCC section complying with UL 50E, Type 3R.
 - b. Aisleless Construction: Full-height doors in front of basic weatherproof equipment.
 4. Connections between primary device and transformer must be **[cable][bus]**, and between transformer and secondary must be flexible bus braid unless noted otherwise.
 5. Indoor Enclosure: Steel.
 6. Outdoor Enclosure: Weatherproof, galvanized steel, listed for installation outdoors, complying with IEEE C37.20.1. Aisleless, full-height doors, with provisions for padlocking, in front of basic weatherproof equipment. Integral structural-steel base frame with factory-applied asphaltic undercoating.
 - a. Compartments must have the following features:
 - 1) Structural design and anchorage adequate to resist loads imposed by **[125 mph (200 km/h)]<Insert wind speed>** wind.
 - 2) Space heater operating at one-half or less of rated voltage, sized to prevent condensation, controlled by thermostats to maintain temperature of section above expected dew point.
 - 3) Louvers equipped with insect and rodent screens and filters, and arranged to permit air circulation while excluding rodents and exterior dust.
 - 4) Weatherproof ground-fault circuit interrupter (GFCI) duplex receptacle.
 - 5) Power for heaters and receptacles must be provided **[by control power transformer][as indicated on the Drawings]**.
 - 6) Skid Mounted: Mount shipping group on integral base frame as complete weatherproof unit.
 7. Unit Substation Enclosures Finish:
 - a. Factory-applied finish in manufacturer's standard color, including under surfaces treated with corrosion-resistant undercoating.
 - b. Factory-applied finish in manufacturer's standard gray over rust-inhibiting primer on treated metal surface.
 - c. Factory-applied corrosion-resistant finish in manufacturer's standard color that withstands **[120 h][480 h]** of exposure to salt spray test specified in ASTM B117 without loss of paint or release of adhesion of paint primer coat to metal surface in excess of **1/16 inch (1.6 mm)** from test mark. Scribed test mark and test evaluation must be in accordance with ASTM D1654, with rating of not less than 7, in accordance with Table 1 (procedure A). Cut edges or otherwise damaged surfaces of hot-dip galvanized sheet steel or mill-galvanized

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sheet steel must be coated with manufacturer's standard zinc-rich paint.

2.4 SECONDARY UNIT SUBSTATION EQUIPMENT

A. Source Quality Control:

1. Factory Tests:

- a. Owner will witness required factory tests. Notify Architect at least 14 days before date of tests and indicate their approximate duration.
- b. Testing Administrant: **[Owner will engage][Engage]** qualified electrical testing agency to evaluate secondary unit substation equipment.
- c. Factory Tests and Inspections: Perform the following tests and inspections on secondary unit substation equipment, by, or under supervision of, qualified electrical testing laboratory recognized by authorities having jurisdiction, in accordance with the following standards before delivering to site. Affix label with name and date of **[manufacturer's][qualified electrical testing laboratory's]** certification of system compliance.

- 1) Conduct transformer tests in accordance with IEEE C57.12.90.
- 2) Conduct primary switchgear tests in accordance with NEMA C37.51.
- 3) Conduct routine tests of completely assembled MCC, including the following:
 - a) Dielectric Tests: Comply with NEMA ICS 1.
 - b) Verify correct operation of circuit breaker, **[motor circuit protector,]** magnetic contactor, and control devices, accessories and indicating lamps. Verification checks must be made at rated voltage with power supplies to main buses.
 - c) Verify correct operation of magnetic contactors with power at 90 percent of rated voltage.
- 4) Resistance measurements of windings on rated voltage connection and on tap extreme connections.
- 5) Ratios on rated voltage connection and on tap extreme connections.
- 6) Polarity and phase relation on rated voltage connection.
- 7) No-load loss at rated voltage on rated voltage connection.
- 8) Exciting current at rated voltage on rated voltage connection.
- 9) Impedance and load loss at rated current on rated voltage connection and on tap extreme connections.
- 10) Applied potential.
- 11) Induced potential.

2. Temperature Test: If transformer is supplied with auxiliary cooling equipment to provide more than one rating, test at lowest kVA Class ONAN or Class AA rating and highest kVA Class ONAF or Class AFA rating.
 - a. Temperature test is not required if record of temperature test on essentially duplicate unit is available.
 - b. Nonconforming Work:
 - 1) Equipment that does not pass tests and inspections will be considered defective.
 - c. Factory Test Reports: Compile and submit factory test and inspection reports.

B. UL YEFV or DLAH or WVG N - Medium-Voltage Terminal Compartment Section :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[Eaton]**
 - c. **[Siemens Industry, Inc., Energy Management Division]**
 - d. **[Square D; Schneider Electric USA]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Eaton]**
 - c. **[Siemens Industry, Inc., Energy Management Division]**
 - d. **[Square D; Schneider Electric USA]**
 - e. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Unit Substation over 600 V: UL CCN YEFV, including the following referenced standards:
 - 1) Articulated Unit Substations: IEEE C37.121.
 - 2) Integral Unit Substations: IEEE C37.20.2, IEEE C37.20.3, NEMA C37.55, and NEMA C37.57.
 - b. Metal-Clad Switchgear over 1000 V: UL CCN DLAH, including IEEE C37.20.2 and NEMA C37.55.
 - c. Metal-Enclosed Arc-Resistant Switchgear over 1000 V: UL CCN WVG N, including IEEE C37.20.3 and IEEE C37.20.7.
4. Standard Features:
 - a. Primary Incoming Section: Terminal assembly with adequate space for incoming-cable terminations and surge arresters, complying with NEMA SG 4 and meeting thermal, mechanical, and dielectric requirements specified for transformer section.
 - b. Ratings: Suitable for application in three-phase, 60 Hz, solidly grounded-neutral system.
 - c. System Voltage: **[4.16 kV nominal; 4.76 kV maximum][7.2 kV nominal; 15 kV maximum][13.8 kV nominal; 15 kV maximum][34.5 kV nominal; 38 kV maximum]<Insert other voltage>**.
 - d. Surge Arresters: Comply with IEEE C62.11, Distribution Class; metal-oxide-varistor type, connected in each phase of incoming circuit and ahead of disconnecting device.

C. UL YEFV or DLAH or WVG N - Medium-Voltage Metal-Enclosed Switchgear Section :

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

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following]:

- a. **[ABB, Electrification Business]**
 - b. **[Eaton]**
 - c. **[Siemens Industry, Inc., Energy Management Division]**
 - d. **[Square D; Schneider Electric USA]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Eaton]**
 - c. **[Siemens Industry, Inc., Energy Management Division]**
 - d. **[Square D; Schneider Electric USA]**
 - e. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Unit Substation over 600 V: UL CCN YEFV, including the following referenced standards:
 - 1) Articulated Unit Substations: IEEE C37.121.
 - 2) Integral Unit Substations: IEEE C37.20.2, IEEE C37.20.3, NEMA C37.55, and NEMA C37.57.
 - b. Metal-Clad Switchgear over 1000 V: UL CCN DLAH, including IEEE C37.20.2 and NEMA C37.55.
 - c. Metal-Enclosed Arc-Resistant Switchgear over 1000 V: UL CCN WVGN, including IEEE C37.20.3 and IEEE C37.20.7.
4. Standard Features:
 - a. Metal-enclosed, air-interrupter switchgear, **[with][without]** fuses, complying with IEEE C37.20.3.
 - 1) Switchgear must be arc-resistant, complying with IEEE C37.20.7, **[Type 1A][Type 2A][Type 1C][Type 2C]**.
 - b. Ratings: Comply with IEEE C37.04; and suitable for application in three-phase, 60 Hz, solidly grounded-neutral system.
 - 1) System Voltage: **[4.16 kV nominal; 4.76 kV maximum][7.2 kV nominal; 15 kV maximum][13.8 kV nominal; 15 kV maximum][34.5 kV nominal; 38 kV maximum]<Insert other voltage>**.
 - 2) Design Level of Available-Source Fault Current: Integrated short-circuit rating consistent with value of fault current indicated.
 - 3) Main-Bus Rating: **[600 A][1200 A][2000 A]**, continuous.
 - c. Interrupter Switches: Stationary, gang operated, and suitable for application at maximum short-circuit rating of integrated switchgear assembly.

- 1) Rating: **[600 A][1200 A]** continuous duty and load break.
 - 2) Two-Time Duty-Cycle Fault Closing: **[25 000 A(asym)][40 000 A(asym)]**.
 - 3) Switch Action: No external arc and no significant quantities of ionized gas released into enclosure.
 - 4) Switch Construction: Supported entirely by interior framework of structure, with copper switchblades and stored-energy operating mechanism.
 - 5) Phase Barriers: Full length of switchblades and fuses for each pole; designed for easy removal; allow visual inspection of switch components if barrier is in place.
 - 6) Protective Shields: Cover live components and terminals.
 - a) Fuse Mounts: Single-frame mounted and de-energized when switch is open.
 - 7) Mechanical Interlock: Prevent opening switch compartment door unless switchblades are open, and prevent closing switch if door is open. **[Interlock air-interrupter switch with transformer secondary main circuit breaker, preventing switch from being opened or closed unless secondary main circuit breaker is open.]**
 - 8) Window: Permits viewing switch-blade positions when door is closed.
 - 9) Accessory Set: Tools and miscellaneous items required for interrupter switchgear test, inspection, maintenance, and operation. Include fuse-handling tool as recommended by switchgear manufacturer.
- d. Fuses: Sizes recommended by secondary unit substation manufacturer, considering fan cooling, temperature-rise specification, and cycle loading.
- 1) Current-Limiting Fuses: Full-range, fast-replaceable, current-limiting type that will operate without explosive noise or expulsion of gas, vapor, or foreign matter from tube.
 - 2) Expulsion Fuses: Furnished in disconnect-type mountings and renewable with replacement fuse units. Gases emitted on interruption are controlled and silenced by chambers designed for that purpose.
 - 3) Indicator integral with fuse to show when it has blown.
 - 4) Spares: Include three fuses in use and three spare fuses in storage clips in switch.
- e. Surge Arresters: Comply with IEEE C62.11, Distribution Class; metal-oxide-varistor type, with ratings as indicated, connected in each phase of incoming circuit and ahead of disconnecting device.

D. UL YEFV or DLAH or WVG N - Medium-Voltage Instruments Section :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[Eaton]**
 - c. **[Siemens Industry, Inc., Energy Management Division]**
 - d. **[Square D; Schneider Electric USA]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[ABB, Electrification Business]**
 - b. **[Eaton]**
 - c. **[Siemens Industry, Inc., Energy Management Division]**
 - d. **[Square D; Schneider Electric USA]**
 - e. **<Insert manufacturer's name>**

3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Unit Substation over 600 V: UL CCN YEFV, including the following referenced standards:
 - 1) Articulated Unit Substations: IEEE C37.121.
 - 2) Integral Unit Substations: IEEE C37.20.2, IEEE C37.20.3, NEMA C37.55, and NEMA C37.57.
 - b. Metal-Clad Switchgear over 1000 V: UL CCN DLAH, including IEEE C37.20.2 and NEMA C37.55.
 - c. Metal-Enclosed Arc-Resistant Switchgear over 1000 V: UL CCN WVGN, including IEEE C37.20.3 and IEEE C37.20.7.

4. Standard Features:
 - a. Instrument Transformers: Comply with IEEE C57.13.
 - 1) Potential and Current Transformers: Burden and Accuracy Class suitable for connected meters.
 - b. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems.
 - 1) Inputs from sensors or 5 A current-transformer secondaries, and potential terminals rated to 600 V.
 - 2) Switch-selectable digital display with the following features:
 - a) Phase Currents, Each Phase: Plus or minus 1 percent.
 - b) Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
 - c) Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
 - d) Three-Phase Real Power: Plus or minus 2 percent.
 - e) Three-Phase Reactive Power: Plus or minus 2 percent.
 - f) Power Factor: Plus or minus 2 percent.
 - g) Frequency: Plus or minus 0.5 percent.
 - h) Integrated Demand: Demand interval selectable from 5 to 60 min; plus or minus 2 percent.
 - i) Accumulated Energy in MWh (MJ): Plus or minus 2 percent; stored values unaffected by power outages for up to 72 h.
 - 3) Communications module suitable for remote monitoring of meter quantities and functions. Interface communication and metering.
 - 4) Mounting: Display and control unit that is flush or semiflush mounted in instrument compartment door.
 - c. Analog Instruments: Rectangular, **4-1/2 inch (115 mm)** square, 1 percent accuracy, semiflush mounting, with antiparallax 250-degree scale and external zero adjustment.

- 1) Voltmeters: Cover expanded scale range of normal voltage plus 10 percent.
 - 2) Voltmeter Selector Switch: Rotary type with off position to provide readings of phase-to-phase[**and phase-to-neutral**] voltages.
 - 3) Ammeters: Cover expanded scale range of bus rating plus 10 percent.
 - 4) Ammeter Selector Switch: Permits current reading in each phase and keeps current-transformer secondary circuits closed in off position.
 - 5) Locate meter and selector switch on circuit-breaker compartment door for indicated feeder circuits only.
 - 6) Watt-Hour Meters: Flush- or semiflush-mounting type, 5 A, 120 V, three phase, three wire; with three elements, **[15 min]<Insert duration>** indicating demand register, and provision for testing and adding pulse initiation.
 - 7) Recording Demand Meter: Usable as totalizing relay or indicating and recording maximum demand meter with **[15 min]<Insert duration>** interval.
- d. Operation: Counts and records succession of pulses entering two channels.
 - e. Housing: Drawout, back-connected case arranged for semiflush mounting.

E. UL YEFV or XPLH - Liquid-Filled Transformer Section :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[Siemens Industry, Inc., Energy Management Division]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Siemens Industry, Inc., Energy Management Division]**
 - c. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Unit Substation over 600 V: UL CCN YEFV, including the following referenced standards:
 - 1) Articulated Unit Substations: IEEE C37.121.
 - 2) Integral Unit Substations: IEEE C37.20.2, IEEE C37.20.3, NEMA C37.55, and NEMA C37.57.
 - 3) Liquid-Immersed Transformers: IEEE C57.12.00.
 - b. Liquid-Filled Distribution Transformers over 600 V: UL CCN XPLH, including IEEE C57.12.00 and IEEE C57.12.28.
4. Standard Features:
 - a. Insulating Liquid:
 - 1) Mineral oil complying with ASTM D3487, Type II, and tested in accordance with

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- ASTM D117.
- 2) Less flammable, edible-seed-oil based, listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, for fire point of not less than 300 deg C when tested in accordance with ASTM D92. Liquid must be biodegradable and nontoxic.
 - 3) Less flammable, dielectric, listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, for fire point of not less than 300 deg C when tested in accordance with ASTM D92. Liquid must be biodegradable and nontoxic.
 - 4) Less flammable, silicone-based dielectric, listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, for fire point of not less than 300 deg C when tested in accordance with ASTM D92. Liquid must have low toxicity and be nonhazardous.

b. Insulation Temperature Rise:

- 1) 55 deg C, based on average ambient temperature of 30 deg C over 24 h with maximum ambient temperature of 40 deg C. Insulation system must be rated to continuously allow additional 12 percent kVA output, at 65 deg C temperature rise, without decreasing rated transformer life.
- 2) 65 deg C, based on average ambient temperature of 30 deg C over 24 h with maximum ambient temperature of 40 deg C.

c. BIL: **[60 kV][75 kV][95 kV][110 kV]**.

d. Full-Capacity Voltage Taps:

- 1) Four nominal 2.5 percent taps, two above and two below rated primary voltage, with externally operable tap changer for de-energized use and with position indicator and padlock hasp.
- 2) Four nominal 2.5 percent taps below rated primary voltage, with externally operable tap changer for de-energized use and with position indicator and padlock hasp.

e. Cooling System: **[Class ONAN, liquid cooled][Class ONAN/ONAF, liquid cooled, and with forced-air rating][Class ONAN/ONAF/ONAF, liquid cooled, and with provisions for future forced-air rating]**. Cooling systems must include auxiliary cooling equipment, automatic controls, and status indicating lights.

f. Impedance: **<Insert number>** percent.

g. Accessories: Grounding pads, lifting lugs, and provisions for jacking under base. Transformers must have steel base and frame allowing use of pipe rollers in any direction, and insulated, low-voltage, neutral bushing with removable ground strap. **[Include the following additional accessories:]**

- 1) Liquid-level gauge.
- 2) Pressure-vacuum gauge.
- 3) Liquid temperature indicator.
- 4) Drain and filter valves.
- 5) Pressure-relief device.

F. UL YEFV - Dry-Type Transformer Section :

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

- a. **[Eaton]**
 - b. **[Square D; Schneider Electric USA]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Eaton]**
 - b. **[Square D; Schneider Electric USA]**
 - c. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Unit Substation over 600 V: UL CCN YEFV, including the following referenced standards:
 - 1) Articulated Unit Substations: IEEE C37.121.
 - 2) Integral Unit Substations: IEEE C37.20.2, IEEE C37.20.3, NEMA C37.55, and NEMA C37.57.
 - 3) Dry-Type Transformers: UL 1562.
4. Standard Features:
 - a. Primary Incoming Section: Transformer cover-mounted bushings. Bushings must meet thermal, mechanical, and dielectric requirements as specified for transformer section.
 - b. Style:
 - 1) **[Indoor, ventilated][Outdoor, ventilated][Totally enclosed, nonventilated]**, cast coil/encapsulated coil, with primary and secondary windings individually cast in epoxy; with insulation system rated at 185 deg C with 80 deg C average winding temperature rise above maximum ambient temperature of 40 deg C.
 - 2) **[Indoor, ventilated][Outdoor, ventilated][Totally enclosed, nonventilated]**, vacuum-pressure, impregnated type, and with insulation system rated at 220 deg C with 80 deg C average winding temperature rise above maximum ambient temperature of 40 deg C.
 - c. Cooling System:
 - 1) Class AA: air cooled, complying with IEEE C57.12.01.
 - 2) Class AFA: air cooled with forced-air rating, complying with IEEE C57.12.01.
 - a) Manual forced-air cooling system controls, including manual switch for fans, fan controller and associated power and control wiring, and power panel with current-limiting fuses.
 - b) Include **[mounting provisions for]** cooling fans.
 - 3) Class AA/FA: air cooled with provisions for future forced-air rating, complying with IEEE C57.12.01.
 - a) Automatic forced-air cooling system controls, including thermal sensors, fans, control wiring, temperature controller with test switch, power panel with current-limiting fuses, indicating lights, alarm, and alarm-silencing relay.
 - b) Include mounting provisions for fans.

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- d. Insulation Materials: IEEE C57.12.01, rated **[220 deg C]**<Insert deg C>.
 - 1) Insulation Temperature Rise: **[80 deg C][115 deg C][150 deg C]** maximum rise above 40 deg C.
 - e. BIL: **[60 kV][75 kV][95 kV][110 kV]**.
 - f. Full-Capacity Voltage Taps:
 - 1) Four nominal 2.5 percent taps, two above and two below rated primary voltage.
 - 2) Four nominal 2.5 percent taps below rated primary voltage.
 - g. Impedance: <Insert number> percent.
5. High-Temperature Alarm: Sensor at transformer with local audible and visual alarm and contacts for remote alarm.

G. UL NJAV - Secondary Distribution Section MCC :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[Eaton]**
 - c. **[Siemens Industry, Inc., Energy Management Division]**
 - d. **[Square D; Schneider Electric USA]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Eaton]**
 - c. **[Siemens Industry, Inc., Energy Management Division]**
 - d. **[Square D; Schneider Electric USA]**
 - e. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Motor Control Center: UL CCN NJAV, including UL 845.
4. Standard Features:
 - a. MCC: Combination motor controllers, complying with NEMA ICS 18.
 - 1) Wiring:
 - a) NEMA ICS 18, **[Class I][Class I-S], [Type A][Type B, for starters larger than Size 3][Type B-D, for starter Size 3 and smaller][Type B-T, for starter**

- Size 3 and smaller][Type C].
 - b) NEMA ICS 18, [Class II][Class II-S], [Type B, for starters larger than Size 3][Type B-D, for starter Size 3 and smaller][Type B-T, for starter Size 3 and smaller][Type C].
 - 2) Short-Circuit Current Rating for Each Unit: [Combination series rated][Fully rated]; [22 kA][42 kA][65 kA][100 kA]<Insert kA>.
 - 3) Short-Circuit Current Rating of MCC: [Combination series rated][Fully rated] with its main overcurrent device; [22 kA][42 kA][65 kA][100 kA]<Insert kA>.
- b. MCC Structure: Front and rear accessible.
- 1) Match and align front[and rear] of MCC.
 - 2) Comply with UL requirements for service entrance equipment.
- c. MCC Bus:
- 1) Use bus bars to connect compartments and vertical sections. Cable connections are prohibited.
 - 2) Main Phase Bus: Uniform capacity entire length of section.
 - 3) Neutral Bus: [50][100] percent of phase-bus ampacity, except as indicated on the Drawings. Equip bus with pressure-connector terminations for outgoing circuit neutral conductors.
 - 4) Vertical Section Bus: Extend to spaces for future controllers.
 - 5) Phase- and Neutral-Bus Material:
 - a) Hard-drawn copper of 98 percent minimum conductivity, with copper feeder circuit-breaker line connections.
 - b) Hard-drawn copper of 98 percent minimum conductivity or tin-plated, high-strength, electrical-grade aluminum alloy.
 - 6) Ground Bus: Hard-drawn copper of 98 percent minimum conductivity, with pressure connector for ground conductors, minimum size 1/4 by 2 inch (6 by 50 mm).
 - 7) Neutral Disconnect Link: Bolted, uninsulated, 1/4 by 2 inch (6 by 50 mm) copper bus, arranged to connect neutral bus to ground bus.
- d. Power Circuit Breaker: [Fixed][Drawout] mounted, electrically operated air-circuit breaker. Comply with UL 1066.
- 1) With "close" and "open" push-buttons and red and green lighted breaker position indicators. Charging time of motor operator must not exceed 8 s. Operator power must be from supply internal to MCC.
 - 2) Solid-state monitoring and tripping system to provide system status monitoring, adjustable time-current protection, and shunt trip.
 - 3) Interchangeable current sensors and timing circuits for adjustable time-current protection settings and status signals.
 - 4) LED indicators or display, with manual reset, to show cause of automatic trip.
 - 5) Display panel to indicate that status of system circuitry is fully operational, or give fault location based on automatic diagnosis.
 - 6) Trip circuit breaker when closing on fault.
 - 7) Time-current adjustments to achieve protective-device coordination as follows:
 - a) Adjustable long-delay pickup and time.
 - b) Individual adjustments for short-delay pickup, time, and I-squared-t setting.
 - c) Adjustable instantaneous pickup.

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- d) Individually adjustable ground-fault pickup and time, with **[I-squared-t setting][ground alarm]**.
 - 8) One test kit to test trip function.
 - 9) Battery backup for informational displays after automatic trip, with battery status indicator LED.
- e. Bolted Pressure Switch: Fixed mounted, manually operated, **[electrically tripped,][fusible,]** bolted pressure contact switch. Comply with UL 977.
 - 1) Stored energy deadfront mechanism, compressed and released by operating handle; switching action must be independent of speed of operating handle.
 - 2) Indication whether switch is open or closed, and provisions for padlocking operating handle.
 - 3) With fuse clips and fuses for UL 248 Class L time-delay fuses.
 - 4) Electrically tripped switches must include:
 - a) Ground-fault protection, with adjustable time delay and test panel.
 - b) Single-phase protection, tripping switch on loss of source phase.
 - c) Blown fuse protection, tripping switch on blown fuse, with blown fuse indication.
 - d) Operator power must be from supply internal to MCC.
- f. Insulated Case Circuit Breaker: **[Fixed][Drawout]** mounted, **[manually][electrically]** operated air-circuit breaker. Comply with UL 1066.
 - 1) With "close" and "open" push-buttons and red and green lighted breaker position indicators. Charging time of motor operator must not exceed 8 s. Operator power must be from supply internal to MCC.
 - 2) Solid-state monitoring and tripping system to provide system status monitoring, adjustable time-current protection, and shunt trip.
 - 3) Interchangeable current sensors and timing circuits for adjustable time-current protection settings and status signals.
 - 4) LED indicators or display, with manual reset, to show cause of automatic trip.
 - 5) Display panel to indicate that status of system circuitry is fully operational, or give fault location based on automatic diagnosis.
 - 6) Trip circuit breaker when closing on fault.
 - 7) Time-current adjustments to achieve protective-device coordination as follows:
 - a) Adjustable long-delay pickup and time.
 - b) Individual adjustments for short-delay pickup, time, and I-squared-t setting.
 - c) Adjustable instantaneous pickup.
 - d) Individually adjustable ground-fault pickup and time, with **[I-squared-t setting][ground alarm]**.
 - 8) With built-in connector to test breaker settings. Provide one test set.
 - 9) Battery backup for informational displays after automatic trip, with battery status indicator.
- g. MCCB (to 2500 A): Fixed mounted, manually operated air-circuit breaker. Comply with UL 489.
 - 1) With quick-make, quick-break, over-center switching mechanism that is mechanically trip-free, and its position is shown by position of handle. With manual

- push-to-trip push-button.
- 2) Solid-state monitoring and tripping system to provide system status monitoring, adjustable time-current protection, and shunt trip.
- 3) Interchangeable current sensors and timing circuits for adjustable time-current protection settings and status signals.
- 4) With trip-setting dials or interchangeable plugs to establish continuous trip of circuit breaker. Plugs must not be interchangeable between frames, and breaker may not be closed without plug. With neutral ground-fault sensor.
- 5) Time-current adjustments to achieve protective-device coordination as follows:
 - a) Adjustable long-time delay.
 - b) Adjustable short-time setting and delay to shape time-current curve.
 - c) Adjustable instantaneous setting.
 - d) Individually adjustable ground-fault setting and time delay.
- 6) With built-in connector to test long-time delay, instantaneous, and ground-fault functions of breaker. **[Provide one test set for testing installed circuit breakers 225 A frame and higher.]**
- 7) With built-in digital ammeter display, showing load current and tripping cause.
- h. MCCB (1600 to 2500 A): Fixed mounted, manually operated air-circuit breaker. Comply with UL 489.
 - 1) With quick-make, quick-break, over-center switching mechanism that is mechanically trip-free, and its position is shown by position of handle. With manual push-to-trip push-button.
 - 2) Solid-state monitoring and tripping system to provide system status monitoring, adjustable time-current protection, and shunt trip.
 - 3) Interchangeable current sensors and timing circuits for adjustable time-current protection settings and status signals.
 - 4) LED indicators or display, with manual reset, to show reasons of automatic trip.
 - 5) Display panel to indicate that status of system circuitry is fully operational, or give fault location based on automatic diagnosis.
 - 6) Trip circuit breaker when closing on fault.
 - 7) Time-current adjustments to achieve protective-device coordination as follows:
 - a) Adjustable long-delay pickup and time.
 - b) Individual adjustments for short-delay pickup, time, and I-squared-t setting.
 - c) Adjustable instantaneous pickup.
 - d) Individually adjustable ground-fault pickup and time, with **[I-squared-t setting][ground alarm]**.
 - 8) One test kit to test trip function.
 - 9) Battery backup for informational displays after automatic trip, with battery status indicator.
- i. Fusible Switch: Fixed-mounted, manually operated, **[electrically tripped,]** quick-make, quick-break switch. Comply with UL 98.
 - 1) Indication whether switch is open or closed, and provisions for padlocking operating handle.
 - 2) With fuse clips and fuses.
 - 3) Electrically tripped switches must include:
 - a) Shunt trip.



- b) Ground-fault protection, with adjustable time delay and test panel.
 - c) Single-phase protection, tripping switch on loss of source phase.
 - d) Blown fuse protection, tripping switch on blown fuse, with blown fuse indication.
 - e) Operator power must be from supply internal to MCC.
- j. Full-Voltage Magnetic Controllers: Electrically held, full voltage, NEMA ICS 2, general purpose, Class A.
 - 1) Configurations: **[Nonreversing][and][reversing]<Insert configuration>**.
- k. Reduced-Voltage Magnetic Controllers: Electrically held, NEMA ICS 2, general purpose, Class A; closed transition; adjustable time delay on transition.
 - 1) Configurations: Reduced voltage, electrically held.
 - a) Wye-Delta Controller: Four contactors, with three-phase starting resistor/reactor bank.
 - b) Part-Winding Controller: Separate START and RUN contactors, field selectable for one-half or two-thirds winding start mode, with either six- or nine-lead motors; with separate overload relays for starting and running sequences.
 - c) Autotransformer Reduced-Voltage Controller: Medium-duty service, with integral overtemperature protection; taps for starting at 50, 65, and 80 percent of line voltage; one RUN and two START contactors.
- l. Reduced-Voltage, Solid-State Controllers: Comply with UL 508.
 - 1) Description: Integrated unit with power SCRs, heat sink, microprocessor logic board, door-mounted digital display and keypad, bypass contactor, and overload relays.
 - 2) Application: Suitable for use with NEMA MG 1 Design B, polyphase induction motors.
 - 3) Configuration: **[Standard duty][Severe duty]; [nonreversible][reversible]**.
 - 4) Starting Mode: **[Voltage ramping][Current limit][Torque control][Torque control with voltage boost]; field selectable**.
 - 5) Stopping Mode: **[Coast to stop][Adjustable torque deceleration][Adjustable braking]; field selectable**.
 - 6) Surge Suppression: Factory installed as integral part of controller, SPD complying with UL 1449 as Type 2, or SPD complying with UL 1449, Type 4, suitable for use in Type 2 application.
 - 7) Bypass Contactor: Operates automatically to bypass SCRs when motor has reached rated speed and full voltage is applied to motor. Solid-state controller protective features must remain active when bypass relay is in bypass mode.
 - a) Manufacturer's standard product.
 - b) NEMA ICS 2, general-purpose, Class A contactor, rated to start load across the line.
 - 8) Bypass Contactor Coils: Pressure-encapsulated type; manufacturer's standard operating voltage, matching control power or line voltage, depending on contactor size and line-voltage rating. **[Provide coil with SPD.]**
 - 9) Adjustable acceleration-rate control using voltage or current ramp, and adjustable starting torque control with up to **[400]<Insert number>** percent current limitation for 20 s.

- 10) SCR Bridge: At least two SCRs per phase, for stable and smooth acceleration **[with][without]** external feedback from motor or driven equipment.
- 11) Keypad: Front accessible; for programming controller parameters, functions, and features; must be manufacturer's standard and include not less than the following functions:
 - a) Adjusting motor full-load amperes, as percentage of controller's rating.
 - b) Adjusting current limitation on starting, as percentage of motor full-load current rating.
 - c) Adjusting linear acceleration and deceleration ramps, in seconds.
 - d) Setting initial torque, as percentage of nominal motor torque.
 - e) Adjusting torque limit, as percentage of nominal motor torque.
 - f) Adjusting maximum start time, in seconds.
 - g) Adjusting voltage boost, as percentage of nominal supply voltage.
 - h) Selecting stopping mode and adjusting parameters.
 - i) Selecting motor thermal-overload protection class between 5 and 30.
 - j) Activating and deactivating protection modes.
 - k) Selecting or activating communications modes.
 - l) **<Insert function>**.
- 12) Digital display, front accessible; for showing motor, controller, and fault status; must be manufacturer's standard and include not less than the following:
 - a) Controller Condition: Ready, starting, running, stopping.
 - b) Motor Condition: Amperes, voltage, power factor, power, and thermal state.
 - c) Fault Conditions: Controller thermal fault, motor overload alarm and trip, motor underload, overcurrent, shorted SCRs, line or phase loss, phase reversal, and line frequency over or under normal.
 - d) **<Insert items>**.
- 13) Controller Diagnostics and Protection:
 - a) Microprocessor-based thermal protection system for monitoring SCR and motor thermal characteristics, and providing controller overtemperature and motor overload alarm and trip; settings selectable via keypad.
 - b) Protection from line-side reverse phasing; line-side and motor-side phase loss; motor jam, stall, and underload conditions; and line frequency over or under normal.
 - c) Input isolation contactor that opens when controller diagnostics detect faulted solid-state component, or when motor is stopped.
 - d) Shunt trip that opens disconnecting means when controller diagnostics detect faulted solid-state component.
 - e) **<Insert items>**.
- 14) Remote Output Features:
 - a) All outputs prewired to terminal blocks.
 - b) Form C status contacts that change state when controller is running.
 - c) Form C alarm contacts that change state when fault condition occurs.
 - d) **<Insert items>**.
- 15) Optional Features:
 - a) Analog output for field-selectable assignment of motor operating characteristics; **[Zero to 10 V(dc)][4 to 20 mA(dc)]**.



- b) **[Two]<Insert number>** additional field-assignable Form C contacts for alarm outputs.
 - c) Full-voltage/BYPASS selector switch. Power contacts must be totally enclosed, double break, and made of silver-cadmium oxide; and assembled to allow inspection and replacement without disturbing line or load wiring.
- m. Multispeed Magnetic Controllers: Electrically held, full voltage, NEMA ICS 2, general purpose, Class A.
 - 1) Nonreversing Configuration: **[Consequent pole][Two winding]**.
 - a) Two speed, with compelling relays to ensure that motor will start only at low speed.
 - b) Accelerating timer relays, for properly timed acceleration through speeds lower than that selected.
 - c) Decelerating timer relays, for automatically timed deceleration through each speed.
 - 2) Reversing Configuration: **[Consequent pole][Two winding]**.
 - a) Two speed, with compelling relay to ensure that motor will start only at low speed.
 - b) Compelling relays must ensure that motor starts only at low speed.
 - c) Accelerating timer relays, for properly timed acceleration through speeds lower than that selected.
 - d) Decelerating timer relays, for automatically timed deceleration through each speed.
 - e) Antiplugging timer relays, for time delay when transferring from FORWARD to REVERSE and back.
- n. Controller Disconnect and OCPD:
 - 1) Fusible Disconnecting Means:
 - a) NEMA KS 1, heavy-duty, horsepower-rated fusible switch, with clips or bolt pads to accommodate **[Class J][Class L]<Insert class>** fuses.
 - b) Lockable Handle: For three padlocks and interlocks with cover in closed position.
 - c) Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.
 - 2) MCP Disconnecting Means:
 - a) UL 489, with interrupting capacity complying with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
 - b) Lockable Handle: For three padlocks and interlocks with cover in closed position.
 - c) Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
 - d) **[N.C.][N.O.]** alarm contact that operates only when MCP has tripped.
 - e) Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.
 - 3) MCCB Disconnecting Means:

- a) UL 489, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
 - b) Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 - c) Lockable Handle: For three padlocks and interlocks with cover in closed position.
 - d) Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.
 - e) **[N.C.][N.O.]** alarm contact that operates only when MCCB has tripped.
- 4) Molded-Case Switch Disconnecting Means:
- a) UL 489, with in-line fuse block for Class J or Class L power fuses (depending on ampere rating), providing interrupting capacity to comply with available fault currents; MCCB with fixed, high-set instantaneous trip only.
 - b) Lockable Handle: For three padlocks and interlocks with cover in closed position.
 - c) Auxiliary contacts "a" and "b" arranged to activate with molded-case switch handle.
 - d) **[N.C.][N.O.]** alarm contact that operates only when molded-case switch has tripped.
- o. Overload Relays:
- 1) Melting-Alloy Overload Relays:
- a) Inverse-time-current characteristic.
 - b) **[Class 10][Class 20][Class 30]** tripping characteristic.
 - c) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
- 2) Bimetallic Overload Relays:
- a) Inverse-time-current characteristic.
 - b) **[Class 10][Class 20][Class 30]** tripping characteristic.
 - c) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 - d) Ambient compensated.
 - e) Automatic resetting.
- 3) Solid-State Overload Relays:
- a) Switch or dial selectable for motor-running overload protection.
 - b) Sensors in each phase.
 - c) **[Class 10][Class 20][Class 10/20 selectable]** tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
 - d) Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
 - e) Analog communication module.
- 4) **[N.C.][N.O.]** isolated overload alarm contact.
- 5) External overload reset push-button.
- p. Control Power:



- 1) Control Circuits: **[24 V(ac)][120 V(ac)]<Insert voltage>**; obtained from **[integral CPT, with primary and secondary fuses]<Insert source of control power>**, with **[CPT][control power source]** of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
 - 2) CPT Spare Capacity: **[50 VA][100 VA][200 VA]<Insert VA>**.
- q. Control Wiring: Factory installed, complete with bundling, lacing, and protection; and complying with the following:
- 1) Flexible conductors for 8 AWG and smaller, for conductors across hinges and for conductors for interconnections between shipping units.
 - 2) Conductors sized in accordance with NFPA 70 for duty required.
- r. ICCB Feeder Tap Units: **[Fixed][Drawout]**-mounted, **[manually][electrically]** operated air-circuit breakers. Comply with UL 1066.
- 1) With "close" and "open" push-buttons and red and green lighted breaker position indicators. Charging time of motor operator must not exceed 8 s. Operator power must be from control power transformer internal to switchboard.
 - 2) Solid-state monitoring and tripping system must provide system status monitoring, adjustable time-current protection, and shunt trip.
 - 3) Interchangeable current sensors and timing circuits for adjustable time-current protection settings and status signals.
 - 4) LED indicators or display, with manual reset, to show cause of automatic trip.
 - 5) Display panel to indicate that status of system circuitry is fully operational, or give fault location based on automatic diagnosis.
 - 6) Trip circuit breaker when closing on fault.
 - 7) Time-current adjustments to achieve protective-device coordination as follows:
 - a) Adjustable long-delay pickup and time.
 - b) Individual adjustments for short-delay pickup, time, and I-squared-t setting.
 - c) Adjustable instantaneous pickup.
 - d) Individually adjustable ground-fault pickup and time, with **[I-squared-t setting][ground alarm]**.
 - 8) Built-in connector tests breaker settings. Provide one test set.
 - 9) Battery backup for informational displays after automatic trip, with battery status indicator.
- s. MCCB Feeder Tap Units (to 2500 A): Fixed-mounted, manually operated air-circuit breakers, complying with UL 489.
- 1) Include quick-make, quick-break, over-center switching mechanism that is mechanically trip-free, and its position is shown by position of handle. Include manual push-to-trip push-button.
 - 2) Solid-state monitoring and tripping system to provide system status monitoring, adjustable time-current protection, and shunt trip.
 - 3) Interchangeable current sensors and timing circuits for adjustable time-current protection settings and status signals.
 - 4) Include trip-setting dials or interchangeable plugs to establish continuous trip of circuit breaker. Plugs must not be interchangeable between frames, and circuit breaker may not be closed without plug. With neutral ground-fault sensor.
 - 5) Time-current adjustments to achieve protective-device coordination as follows:

- a) Adjustable long-time delay.
 - b) Adjustable short-time setting and delay to shape time-current curve.
 - c) Adjustable instantaneous setting.
 - d) Individually adjustable ground-fault setting and time delay.
- 6) With built-in connector to test long-time delay, instantaneous, and ground-fault functions of breaker. **[Provide one test set for testing installed circuit breakers 225 A frame and higher.]**
- 7) With built-in digital ammeter and digital display, showing tripping cause.
- t. MCCB Feeder Tap Units (1600 to 2500 A): Fixed-mounted, manually operated air-circuit breakers, complying with UL 489.
 - 1) With quick-make, quick-break, over-center switching mechanism that is mechanically trip-free, and its position is shown by position of handle. With manual push-to-trip push-button.
 - 2) Solid-state monitoring and tripping system to provide system status monitoring, adjustable time-current protection, and shunt trip.
 - 3) Interchangeable current sensors and timing circuits for adjustable time-current protection settings and status signals.
 - 4) LED indicators or display, with manual reset, to show reasons of automatic trip.
 - 5) Display panel indicates that status of system circuitry is fully operational or gives fault location based on automatic diagnosis.
 - 6) Trip circuit breaker when closing on fault.
 - 7) Time-current adjustments to achieve protective-device coordination as follows:
 - a) Adjustable long-delay pickup and time.
 - b) Individual adjustments for short-delay pickup, time, and I-squared-t setting.
 - c) Adjustable instantaneous pickup.
 - d) Individually adjustable ground-fault pickup and time, with **[I-squared-t setting][ground alarm]**.
 - 8) One test kit to test trip function.
 - 9) Battery backup for informational displays after automatic trip, with battery status indicator.
- u. Fusible Switch Feeder Tap Units: Fixed-mounted, manually operated, **[electrically tripped]**, fusible, quick-make, quick-break switch. Comply with UL 98.
 - 1) Indication whether switch is open or closed, and provisions for padlocking operating handle.
 - 2) Include fuse clips and fuses.
 - 3) Electrically tripped switches must include:
 - a) Shunt trip.
 - b) Ground-fault protection, with adjustable time delay and test panel.
 - c) Single-phase protection, tripping switch on loss of source phase.
 - d) Blown fuse protection, tripping switch on blown fuse, with blown fuse indication.
- v. Compartments: Modular; individual **[lift-off]** doors with concealed hinges and quick-captive screw fasteners. Interlocks on units require disconnecting means in off position before door can be opened or closed, except by operating permissive release device.
- w. Interchangeability: Compartments constructed to allow for removal of units without opening adjacent doors, disconnecting adjacent compartments, or disturbing operation of other

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units in MCC. Same-size compartments permit interchangeability and ready rearrangement of units, such as replacing three single units with unit requiring three spaces, without cutting or welding.

- x. Wiring Spaces:
 - 1) Vertical wireways in vertical section for vertical wiring to unit compartments; supports to hold wiring in place.
 - 2) Horizontal wireways in **[bottom][and][top]** of vertical section for horizontal wiring between vertical sections; supports to hold wiring in place.
- y. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.
 - 1) Push-Buttons, Pilot Lights, and Selector Switches: **[Heavy][Standard]-duty[, oiltight]** type.
 - a) Push-Buttons: **[Covered][Lockable][Recessed][Shielded][Shrouded][Unguarded]** types; **[maintained][momentary]** contact unless otherwise indicated.
 - b) Pilot Lights: **[Incandescent][LED][Neon][Resistor][Transformer]** types; **<Insert color(s)>; push to test**.
 - c) Selector Switches: **[Rotary]<Insert description>** type.
 - 2) Elapsed-Time Meters: Heavy duty with digital readout in hours[; **nonresettable**][; **resettable**].
- z. Meters: Panel type, **2 1/2 inch (64 mm)** minimum size with 90- or 120-degree scale and plus or minus 2 percent accuracy, with selector switches having off position.
- aa. **[N.C.][N.O.][Reversible N.C./N.O.]** contactor auxiliary contact(s).
- bb. Control Relays: Auxiliary and adjustable **[pneumatic][solid-state]** time-delay relays.
- cc. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections and adjustable undervoltage, overvoltage, and time-delay settings.
- dd. Space heaters, with N.C. auxiliary contacts, to mitigate condensation in enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.
- ee. Sun shields, installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.
- ff. Cover gaskets, for UL 50E, Type 1 enclosures.
- gg. Terminals, for connecting power-factor correction capacitors to **[line][load]** side of overload relays.
- hh. Spare control-wiring terminal blocks[; **unwired**][; **wired**].
- ii. **<Insert auxiliary device>**.

H. UL YEFV or YEFR - Low-Voltage Instruments Section :

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[Eaton]**
 - c. **[Siemens Industry, Inc., Energy Management Division]**

- d. **[Square D; Schneider Electric USA]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Eaton]**
 - c. **[Siemens Industry, Inc., Energy Management Division]**
 - d. **[Square D; Schneider Electric USA]**
 - e. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Unit Substation over 600 V: UL CCN YEFV, including the following referenced standards:
 - 1) Articulated Unit Substations: IEEE C37.121.
 - 2) Integral Unit Substations: IEEE C37.20.2, IEEE C37.20.3, NEMA C37.55, and NEMA C37.57.
 - b. Unit Substation Rated 600 V or Less: UL CCN YEFR, including UL 1062.
4. Standard Features:
 - a. Instrument Transformers: Comply with IEEE C57.13.
 - 1) Potential Transformers: Secondary voltage rating of 120 V and NEMA C12.11 Accuracy Class 0.3 with burdens of W, X, and Y.
 - 2) Current Transformers: Burden and Accuracy Class suitable for connected relays, meters, and instruments.
 - b. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems.
 - 1) Inputs from sensors or 5 A current-transformer secondaries, and potential terminals rated to 600 V.
 - 2) Switch-selectable digital display with the following features:
 - a) Phase Currents, Each Phase: Plus or minus 1 percent.
 - b) Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
 - c) Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
 - d) Three-Phase Real Power: Plus or minus 2 percent.
 - e) Three-Phase Reactive Power: Plus or minus 2 percent.
 - f) Power Factor: Plus or minus 2 percent.
 - g) Frequency: Plus or minus 0.5 percent.
 - h) Integrated Demand, with Demand Interval: Selectable from 5 to 60 min, plus or minus 2 percent.
 - i) Accumulated energy, in **MWh (MJ)**, plus or minus 2 percent; stored values unaffected by power outages for up to 72 h.
 - 3) Communications module suitable for remote monitoring of meter quantities and functions. Interface communication and metering.

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- 4) Mounting: Display and control unit that is flush or semiflush mounted in instrument compartment door.
- c. Analog Instruments: Rectangular, **4-1/2 inch (115 mm)** square, 1 percent accuracy, semiflush mounting, with antiparallax 250-degree scale and external zero adjustment.
 - 1) Voltmeters: Cover expanded scale range of normal voltage plus 10 percent.
 - 2) Voltmeter Selector Switch: Rotary type with "off" position to provide readings of phase-to-phase[**and phase-to-neutral**] voltages.
 - 3) Ammeters: Cover expanded scale range of bus rating plus 10 percent.
 - 4) Ammeter Selector Switch: Permits current reading in each phase and keeps current-transformer secondary circuits closed in "off" position.
 - 5) Locate meter and selector switch on circuit-breaker compartment door for indicated feeder circuits only.
 - 6) Watt-Hour Meters: Flush- or semiflush-mounting type, 5 A, 120 V, three phase, three wire; with three elements, 15 min indicating demand register, and provision for testing and adding pulse initiation.
 - 7) Recording Demand Meter: Usable as totalizing relay or indicating and recording maximum demand meter with 15 min interval.
 - a) Operation: Counts and records succession of pulses entering two channels.
 - b) Housing: Drawout, back-connected case arranged for semiflush mounting.
- d. Surge Suppression: Factory installed as integral part of low-voltage switchgear, complying with UL 1449 SPD, Type 1, with the following features and accessories:
 - 1) Integral disconnect switch.
 - 2) Internal thermal protection that disconnects SPD before damaging internal suppressor components.
 - 3) Indicator light display for protection status.
 - 4) Form-C contacts rated at 5 A and 250 V(ac), one N.O. and one N.C., for remote monitoring of protection status.[**Contacts must reverse on failure of surge diversion module or on opening of current-limiting device. Coordinate with building power monitoring and control system.**]
 - 5) Surge counter.

2.5 MAINTENANCE MATERIAL ITEMS

- A. Spare Parts: Furnish to Owner spare parts, for repairing unit substation equipment, that are packaged with protective covering for storage on-site and identified with labels describing contents.[**Include the following:**]
 1. Spare Fuses: [**Six**]**<Insert number>** of each type and rating of fuse and fusible device used, except for medium-voltage fuses. Include spares for the following:
 - a. Primary disconnect fuses.
 - b. Potential transformer fuses.
 - c. Control power fuses.
 - d. Fuses for secondary fusible devices.
- B. Special Tools: Furnish to Owner proprietary equipment, keys, and software required to operate, maintain, repair, adjust, or implement future changes to secondary unit substation equipment, that are packaged with protective covering for storage on-site and identified with labels describing contents.[

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Include the following:]

1. Racking handle, to manually move circuit breaker between "connected" and "disconnected" positions.
 2. Spare-Fuse Cabinet: Identified and compartmented steel box or cabinet with lockable door.
 3. Storage for Manual: Include rack or holder, near operating instructions, for copy of maintenance manual.
- C. Consumable Items: Furnish to Owner extra consumable items for storage on-site, identified with labels describing contents. **[Include the following:]**
1. Touchup Paint: **[Three]<Insert number>** half-pint containers of paint matching enclosure's exterior finish.
 2. Primary Switch Contact Lubricant: **[One]<Insert number>** container(s).

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and space conditions for compliance with requirements for secondary unit substations and other conditions affecting performance of the Work.
- B. Examine roughing-in of conduits and grounding systems to verify the following:
 1. Wiring entries comply with layout requirements.
 2. Entries are within conduit-entry tolerances specified by manufacturer, and no feeders will have to cross section barriers to reach load or line lugs.
- C. Examine walls, floors, roofs, and concrete bases for suitable conditions for secondary unit substation installation.
- D. Verify that ground connections are in place. Maximum ground resistance must be 5 Ω at secondary unit substation location.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF SECONDARY UNIT SUBSTATION EQUIPMENT

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:
 1. Electrical Construction: ICC IBC, ICC IFB, NFPA 1, NFPA 70, and NECA NEIS 1.
 2. Electrical Maintenance: NFPA 70B.
 3. Electrical Safety: NFPA 70E.
 4. Temporary Electric Power Work: NECA NEIS 200.
 5. Commissioning of Electrical Systems: NECA NEIS 90.
 6. Hot Work: NFPA 51B.
 7. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
 8. Life Safety and Means of Egress Work: NFPA 101.

9. Emergency and Standby Power Work: NFPA 110, NFPA 111, and NECA NEIS 416.
10. Work in Confined Spaces: NFPA 350.
11. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
12. Evaluation of Unlabeled Electrical Equipment: NFPA 791.
13. Installation of Liquid-Filled Transformers: NECA NEIS 410.
14. Installation of Medium-Voltage Switchgear: NECA NEIS 430.
15. Installation of Motor Control Centers: NEMA ICS 2.3.
16. AC Outdoor High-Voltage Circuit Breakers: NEMA SG 11.
17. Consult Architect for resolution of conflicting requirements.

C. Special Installation Techniques:

1. Install secondary unit substations on cast-in-place concrete equipment base(s).
2. Comply with requirements for vibration isolation and seismic control devices.

D. Interfaces with Other Work:

1. Identification: Provide labels for secondary unit substation equipment and associated electrical equipment.
 - a. Identify field-installed conductors, interconnecting wiring, and components.
 - b. Label each enclosure with engraved metal or laminated-plastic nameplate.
 - c. Provide warning signs and arc-flash hazard warning labels for electrical equipment.
 - d. Install number of signs required to be readable from accessible side, but space signs maximum of **30 ft (9 m)** apart.
 - e. Operating Instructions: Place printed operating instructions for secondary unit substations, including key interlocking, control sequences, elementary single-line diagram, and emergency procedures with maintenance materials.
2. Grounding and Bonding:
 - a. At Interior Locations: For grounding to grounding electrodes, use bare copper cable not smaller than 4/0 AWG. Bond surge arrester and neutrals directly to transformer enclosure and then to grounding electrode system with bare copper conductors. Keep leads as short as practicable with no kinks or sharp bends. Make joints in grounding conductors and loops by exothermic weld or compression connector.
 - b. At Exterior Locations:
 - 1) For counterpoise use tinned bare copper cable not smaller than 4/0 AWG, buried not less than **24 inch (610 mm)** below grade interconnecting grounding electrodes. Bond surge arrester and neutrals directly to transformer enclosure and then to grounding electrode system with bare copper conductors, sized as shown. Keep lead lengths as short as practicable with no kinks or sharp bends.
 - 2) Fence and equipment connections must not be smaller than 4 AWG. Ground fence at gate post and corner post and at intervals not exceeding **10 ft (3 m)**. Bond gate section to fence post using **1/8 by 1 inch (3 by 25 mm) [tinned]** flexible braided copper strap and clamps.
 - 3) Make joints in grounding conductors and loops by exothermic weld or compression connector.

3.3 FIELD QUALITY CONTROL

A. Administrant for Electrical Power Tests and Inspections:

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1. [Owner][Tenant] will engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
 2. Engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
 4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].
- B. Acceptance Testing Preparation:
1. <Insert requirements>.
- C. Field tests and inspections must be witnessed by [Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>.
- D. Tests and Inspections:
1. Comply with provisions of "Testing and Test Methods" Chapter in NFPA 70B.
 2. Perform visual and mechanical inspections and electrical tests. Certify compliance with test parameters.
 3. After installing secondary unit substation but before primary is energized, verify that grounding system measurement at substation does not exceed specified value.
 4. After installing secondary unit substation and after electrical circuitry has been energized, test for compliance with requirements.
 5. Visual and Mechanical Inspection:
 - a. Verify equipment nameplate data complies with Contract Documents.
 - b. Inspect bolted electrical connections for high resistance using one of the following two methods:
 - 1) Use low-resistance ohmmeter to compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of lowest value.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels must be in accordance with manufacturer's published data. In absence of manufacturer's published data, use NETA ATS, Table 100.12.
- E. Switchgear and MCC Field Tests:
1. Visual and Mechanical Inspection:
 - a. Inspect physical and mechanical condition.
 - b. Inspect anchorage, alignment, grounding, and required area clearances.
 - c. Verify unit is clean and shipping bracing, loose parts, and documentation shipped inside cubicles have been removed.
 - d. Verify that fuse and circuit-breaker sizes and types correspond to Drawings and coordination study as well as address of circuit breaker that is used to identify it in microprocessor-communication software.
 - e. Verify that current and voltage-transformer ratios correspond to Drawings.
 - f. Confirm correct operation and sequencing of electrical and mechanical interlock systems.
 - 1) Attempt closure on locked-open devices. Attempt to open locked-closed devices.

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- 2) Make key exchange with devices operated in off-normal positions.
 - g. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
 - h. Inspect insulators for evidence of physical damage or contaminated surfaces.
 - i. Verify correct barrier and shutter installation and operation.
 - j. Exercise active components.
 - k. Inspect mechanical indicating devices for correct operation.
 - l. Verify that filters are in place and vents are clear.
 - m. Inspect control power transformers as follows:
 - 1) Inspect for physical damage, cracked insulation, broken leads, connection tightness, defective wiring, and overall general condition.
 - 2) Verify that primary- and secondary-fuse or circuit-breaker ratings match Drawings and comply with manufacturer's published instructions.
 - 3) Verify correct functioning of drawout disconnecting and grounding contacts and interlocks.
2. Electrical Tests:
- a. Perform DC voltage insulation-resistance tests on bus section, phase-to-phase and phase-to-ground, for 1 min. If temperature of bus is other than plus or minus 20 deg C, adjust resulting resistance as provided in NETA ATS, Table 100.11.
 - 1) Insulation-resistance values of bus insulation must be in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's published recommendations or NETA ATS, Table 100.1.
 - 2) Do not proceed to dielectric withstand-voltage tests until insulation-resistance levels are raised above minimum values.
 - b. Perform dielectric withstand-voltage test on bus section, phase-to-ground with phases not under test grounded, in accordance with manufacturer's published data. If manufacturer has no published recommendation for this test, it must be conducted to in accordance with NETA ATS, Table 100.2. Apply test voltage for 1 min.
 - 1) If no evidence of distress or insulation failure is observed by end of total time of voltage application during dielectric withstand-voltage test, test specimen is considered to have passed test.
 - c. Voltage Transformers:
 - 1) Perform secondary wiring integrity test. Verify correct potential at devices.
 - 2) Verify secondary voltages by energizing primary winding with system voltage.
 - d. Perform current-injection tests on entire current circuit in section of switchgear.
 - 1) Perform current tests by secondary injection with magnitudes such that minimum current of 1.0 A flows in secondary circuit. Verify correct magnitude of current at device in circuit.
 - 2) Perform current tests by primary injection with magnitudes such that minimum of 1.0 A flows in secondary circuit. Verify correct magnitude of current at device in circuit.
 - e. Verify operation of space heaters.

- f. Perform phasing checks on double-ended or dual-source switchgear to ensure correct bus phasing from every source.

F. Medium-Voltage Surge Arrester Field Tests:

1. Visual and Mechanical Inspection:

- a. Inspect physical and mechanical condition.
- b. Inspect anchorage, alignment, grounding, and clearances.
- c. Verify that arresters are clean.
- d. Verify that ground lead on device is individually attached to ground bus or ground electrode.
- e. Verify that stroke counter is correctly mounted and electrically connected if applicable. Record stroke counter reading.

2. Electrical Test:

- a. Perform insulation-resistance test on arrester, phase terminal-to-ground. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Replace units that fail to meet recommended minimum insulation resistance listed in table.
- b. Perform watts loss test. Evaluate watts loss values by comparison with similar units and test equipment manufacturer's published data.

G. Instrument Transformer Field Tests:

1. Visual and Mechanical Inspection:

- a. Inspect physical and mechanical condition.
- b. Verify correct connection of transformers with system requirements.
- c. Verify that adequate clearances exist between primary and secondary circuit wiring.
- d. Verify that unit is clean.
- e. Verify that required grounding and shorting connections provide contact.
- f. Verify correct operation of transformer withdrawal mechanism and grounding operation.
- g. Verify correct primary- and secondary-fuse sizes for voltage transformers.
- h. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

2. Electrical Tests of Current Transformers:

- a. Perform insulation-resistance test of current transformer and its secondary wiring with respect to ground at 1000 V(dc) for 1 min. For units with solid-state components that cannot tolerate applied voltage, comply with manufacturer's published instructions. Insulation-resistance values of instrument transformers must not be less than values shown in NETA ATS, Table 100.5.
- b. Perform polarity test of current transformer in accordance with IEEE C57.13.1. Polarity results must agree with transformer markings.
- c. Perform ratio-verification test using voltage or current method in accordance with IEEE C57.13.1. Ratio errors must comply with IEEE C57.13.
- d. Perform excitation test on transformers used for relaying applications in accordance with IEEE C57.13.1. Excitation results must match curve supplied by manufacturer or must comply with IEEE C57.13.1.
- e. Measure current circuit burdens at transformer terminals in accordance with IEEE C57.13.1. Measured burdens must match instrument transformer Accuracy Class rating.
- f. Perform insulation-resistance tests on primary winding with secondary grounded. Test

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- voltages must comply with NETA ATS, Table 100.5. Insulation-resistance value must be in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.5.
- g. Perform dielectric withstand-voltage tests on primary winding with secondary grounded. Test voltages must comply with NETA ATS, Table 100.9. If no evidence of distress or insulation failure is observed by end of total time of voltage application, primary winding is considered to have passed test.
 - h. Perform power-factor or dissipation-factor tests in accordance with test equipment manufacturer's published data. Power-factor or dissipation-factor values must be in accordance with substation equipment manufacturer's published data. In absence of substation equipment manufacturer's published data, comply with test equipment manufacturer's published data.
 - i. Verify that current-transformer secondary circuits are grounded and have only one grounding point in accordance with IEEE C57.13.3.
3. Electrical Tests of Voltage and Potential Transformers:
- a. Perform insulation-resistance tests winding-to-winding and winding-to-ground. Apply test voltage for 1 min in accordance with NETA ATS, Table 100.5. For units with solid-state components that cannot tolerate applied voltage, follow manufacturer's published instructions. Insulation-resistance values of instrument transformers must be in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.5.
 - b. Perform insulation-resistance tests winding-to-winding and winding-to-ground. Test voltages must be applied for 1 min in accordance with NETA ATS, Table 100.5. Insulation-resistance values of transformers must not be less than values shown in NETA ATS, Table 100.5.
 - c. Perform polarity test on transformer to verify polarity marks or H(1) to X(1) relationship. Polarity results must agree with transformer markings.
 - d. Perform turns-ratio test on tap positions. Ratio errors must not exceed tolerances specified in IEEE C57.13.
 - e. Measure voltage circuit burdens at transformer terminals. Measured burdens must be compared to instrument transformer ratings. Measured burdens must match instrument transformer Accuracy Class rating.
 - f. Perform dielectric withstand-voltage test on primary windings with secondary windings connected to ground. Dielectric voltage must comply with NETA ATS, Table 100.9. Test voltage must be applied for 1 min. If no evidence of distress or insulation failure is observed by end of total time of voltage application during dielectric withstand-voltage test, primary windings are considered to have passed test.
 - g. Perform power-factor or dissipation-factor tests in accordance with test equipment manufacturer's published data. Power-factor or dissipation-factor values must be in accordance with substation equipment manufacturer's published data. In absence of substation equipment manufacturer's published data, comply with test equipment manufacturer's published data.
 - h. Verify that voltage-transformer secondary circuits are grounded and have only one grounding point in accordance with IEEE C57.13.3.
- H. Liquid-Filled Transformer Section Field Tests:
1. Visual and Mechanical Inspection:
 - a. Inspect physical and mechanical condition.
 - b. Inspect impact recorder prior to unloading.
 - c. Test dew point of tank gases if applicable.

- d. Inspect anchorage, alignment, and grounding.
- e. Verify presence of PCB content labeling.
- f. Verify removal of shipping bracing after placement.
- g. Verify that bushings are clean.
- h. Verify that alarm, control, and trip settings on temperature and level indicators are set and operate within manufacturer's recommended settings.
- i. Verify that cooling fans and pumps operate correctly and have appropriate overcurrent protection.
- j. Verify that liquid level in tanks and bushings is within manufacturer's published tolerances.
- k. Perform specific inspections and mechanical tests recommended by manufacturer.
- l. Verify presence of transformer surge arresters and that their ratings are as specified.
- m. Verify that as-left tap connections are as specified.
- n. Verify presence of surge arresters and that their ratings are as specified.

2. Electrical Tests:

- a. Perform insulation-resistance tests winding-to-winding and winding-to-ground. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index; value of index must not be less than 1.0.
- b. Perform power-factor or dissipation-factor tests on windings in accordance with test equipment manufacturer's published data. Maximum winding insulation power-factor/dissipation-factor values must be in accordance with substation equipment manufacturer's published data. In absence of substation equipment manufacturer's published data, comply with NETA ATS, Table 100.3.
- c. Measure core insulation resistance at 500 V(dc) if core is insulated and core ground strap is removable. Core insulation-resistance values must not be less than 1 M Ω at 500 V(dc).
- d. Perform power-factor or dissipation-factor tip-up test on windings greater than 2.5 kV.
- e. Perform turns-ratio tests at tap positions. Turns-ratio test results must not deviate by more than one-half percent from either adjacent coils or calculated ratio. If test fails, replace transformer.
- f. Perform excitation-current test on each phase. Typical excitation-current test data pattern for three-legged core transformer is two similar current readings and one lower current reading. Investigate and correct if test shows different pattern.
- g. Measure resistance of winding at tap connection, and record temperature-corrected winding-resistance values in Operations and Maintenance Manual.
- h. Perform applied-voltage test on high- and low-voltage windings-to-ground. Comply with IEEE C57.12.91, Sections 10.2 and 10.9.
- i. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.
- j. Remove sample of insulating liquid in accordance with ASTM D923. Insulating liquid values must comply with NETA ATS, Table 100.4. Sample must be tested for the following:
 - 1) Dielectric Breakdown Voltage: ASTM D877 or ASTM D1816.
 - 2) Acid Neutralization Number: ASTM D974.
 - 3) Specific Gravity: ASTM D1298.
 - 4) Interfacial Tension: ASTM D971.
 - 5) Color: ASTM D1500.
 - 6) Visual Condition: ASTM D1524.
 - 7) Water in Insulating Liquids: ASTM D1533.
 - 8) Power Factor or Dissipation Factor: ASTM D924.
- k. Remove sample of insulating liquid in accordance with ASTM D923 and perform dissolved-gas analysis in accordance with IEEE C57.104 or ASTM D3612.

I. Small Dry-Type Transformer Section Field Tests:**1. Visual and Mechanical Inspection:**

- a. Inspect physical and mechanical condition.
- b. Inspect anchorage, alignment, and grounding.
- c. Verify that resilient mounts are free and that shipping brackets have been removed.
- d. Verify that unit is clean.
- e. Perform specific inspections and mechanical tests recommended by manufacturer.
- f. Verify that as-left tap connections are as specified.
- g. Verify presence of surge arresters and that their ratings are as specified.

2. Electrical Tests:

- a. Perform insulation-resistance tests winding-to-winding and winding-to-ground. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index; value of index must not be less than 1.0.
- b. Perform turns-ratio tests at tap positions. Test results must not deviate by more than one-half percent from either adjacent coils or calculated ratio. If test fails, replace transformer.
- c. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

J. Large Dry-Type Transformer Section Field Tests:**1. Visual and Mechanical Inspection:**

- a. Inspect physical and mechanical condition.
- b. Inspect anchorage, alignment, and grounding.
- c. Verify that resilient mounts are free and that shipping brackets have been removed.
- d. Verify that unit is clean.
- e. Verify that alarm, control, and trip settings on temperature and level indicators are set and operate within manufacturer's recommended settings.
- f. Verify that cooling fans operate and that fan motors have correct overcurrent protection.
- g. Perform specific inspections and mechanical tests recommended by manufacturer.
- h. Verify that as-left tap connections are as specified.
- i. Verify presence of surge arresters and that their ratings are as specified.

2. Electrical Tests:

- a. Perform insulation-resistance tests winding-to-winding and winding-to-ground. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index; value of index must not be less than 1.0.
- b. Perform power-factor or dissipation-factor tests on windings in accordance with test equipment manufacturer's published data. Investigate and correct power-factor values that exceed:
 - 1) 2 percent for power transformers.
 - 2) 5 percent for distribution transformers.
- c. Measure core insulation resistance at 500 V(dc) if core is insulated and core ground strap is removable. Core insulation-resistance values must not be less than 1 M Ω at 500 V(dc).
- d. Perform power-factor or dissipation-factor tip-up test on windings greater than 2.5 kV. Tip-

- up test result exceeding 1 percent must be investigated.
- e. Perform turns-ratio tests at tap positions. Test results must not deviate by more than one-half percent from either adjacent coils or calculated ratio. If test fails, replace transformer.
 - f. Perform excitation-current test on each phase. Typical excitation-current test data pattern for three-legged core transformer is two similar current readings and one lower current reading. Investigate and correct if test shows different pattern.
 - g. Measure resistance of winding at tap connection.
 - h. Perform applied-voltage test on high- and low-voltage windings-to-ground. See IEEE C57.12.91, Sections 10.2 and 10.9. AC dielectric-withstand-voltage test result must not exceed 75 percent of factory test voltage for 1 min duration. DC dielectric-withstand-voltage test result must not exceed 100 percent of AC RMS test voltage specified in IEEE 57.12.91, Section 10.2, for 1 min duration. If no evidence of distress or insulation failure is observed by end of total time of voltage application during dielectric-withstand-voltage test, test specimen is considered to have passed test.
 - i. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

K. Low-Voltage Motor Controller Field Tests:

1. Visual and Mechanical Inspection:

- a. Inspect anchorage, alignment, grounding, and clearances.
- b. Verify that unit is clean.
- c. Inspect contactors:
 - 1) Verify mechanical operation.
 - 2) Verify contact gap, wipe, alignment, and pressure are in accordance with manufacturer's published data.
- d. Motor-Running Protection:
 - 1) Verify that overload element rating is correct for its application.
 - 2) If motor-running protection is provided by fuses, verify correct fuse rating.
- e. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

2. Electrical Tests:

- a. **[For contactor and circuit breaker, perform][Perform]**insulation-resistance tests for 1 min on each pole, phase-to-phase and phase-to ground with switch closed, and across each open pole. Insulation-resistance values must comply with manufacturer's published data or NETA ATS, Table 100.1. In absence of manufacturer's published data, comply with Table 100.5. Investigate and correct values of insulation resistance less than this table or manufacturer's published instructions.
- b. Test circuit breakers as follows:
 - 1) Operate circuit breaker to ensure smooth operation.
 - 2) Perform contact/pole-resistance test. Drop values for $\mu\Omega$ or mV(dc) must not exceed high levels of normal range as indicated in manufacturer's published data. If manufacturer's published data is not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of lowest value.
- c. Perform operational tests by initiating control devices. Control devices must perform in accordance with system design requirements.

Secondary Unit Substations with Motor Control Center

L. Low-Voltage Power Circuit-Breaker Field Tests:

1. Visual and Mechanical Inspection:

- a. Inspect physical and mechanical condition.
- b. Inspect anchorage, alignment, and grounding.
- c. Verify that maintenance devices are available for servicing and operating breaker.
- d. Verify that unit is clean.
- e. Verify that arc chutes are intact.
- f. Inspect moving and stationary contacts for condition and alignment.
- g. Verify that primary and secondary contact wipe and other dimensions vital to satisfactory operation of breaker are correct.
- h. Perform mechanical operator and contact alignment tests on both breaker and its operating mechanism in accordance with manufacturer's published data.
- i. Verify cell fit and element alignment.
- j. Verify racking mechanism operation.
- k. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
- l. Perform adjustments for final protective-device settings in accordance with coordination study provided by end user.
- m. Record as-found and as-left operation counter readings.

2. Electrical Tests:

- a. Perform insulation-resistance tests for 1 min on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Insulation-resistance values must be in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Values of insulation resistance less than this table or manufacturer's published recommendations must be investigated.
- b. Measure contact resistance across power contact of circuit breaker. Drop values for $\mu\Omega$ or mV(dc) must not exceed high levels of normal range as indicated in manufacturer's published data. If manufacturer's published data is not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of lowest value.
- c. Determine long-time pickup and delay by primary current injection. Long-time pickup values must be as specified, and trip characteristic must not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors. If manufacturer's curves are not available, trip times must not exceed value shown in NETA ATS, Table 100.7.
- d. Determine short-time pickup and delay by primary current injection. Short-time pickup values must be as specified, and trip characteristic must not exceed manufacturer's published time-current tolerance band.
- e. Determine ground-fault pickup and delay by primary current injection. Ground-fault pickup values must be as specified, and trip characteristic must not exceed manufacturer's published time-current tolerance band.
- f. Determine instantaneous pickup value by primary current injection. Instantaneous pickup values must be as specified and within manufacturer's published tolerances. In absence of manufacturer's published data, comply with NETA ATS, Table 100.8.
- g. Test functions of trip unit by means of secondary injection. Pickup values and trip characteristic must be as specified and within manufacturer's published tolerances.
- h. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data. Minimum pickup voltage of shunt trip and close coils must conform to manufacturer's published data. In absence of manufacturer's published data,

- comply with NETA ATS, Table 100.20.
- i. Measure fuse resistance. Investigate fuse-resistance values that deviate from others by more than 15 percent.
- j. Verify correct operation of auxiliary features, such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free operation, antipump function, and trip unit battery condition. Reset trip logs and indicators. Auxiliary features must operate in accordance with manufacturer's published data.
- k. Verify operation of charging mechanism. Charging mechanism must operate in accordance with manufacturer's published data.

M. Insulated-Case/Molded-Case Air-Circuit-Breaker Field Tests:

1. Visual and Mechanical Inspection:

- a. Inspect physical and mechanical condition.
- b. Inspect anchorage and alignment.
- c. Verify that unit is clean.
- d. Operate circuit breaker to ensure smooth operation.
- e. Inspect operating mechanism, contacts, and arc chutes in unsealed units.
- f. Perform adjustments for final protective-device settings in accordance with coordination study. Set protective devices in accordance with coordination study report.

2. Electrical Tests:

- a. Perform insulation-resistance tests for 1 min on each pole, phase-to-phase and phase-to-ground with circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Insulation-resistance values must be in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Values of insulation resistance less than this table or manufacturer's published recommendations must be investigated.
- b. Perform contact/pole-resistance test. Drop values for $\mu\Omega$ or mV(dc) must not exceed high levels of normal range as indicated in manufacturer's published data. If manufacturer's published data is not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of lowest value.
- c. Determine long-time pickup and delay by primary current injection. Ground-fault pickup values must be as specified, and trip characteristic must not exceed manufacturer's published time-current tolerance band, including adjustment factors.
- d. Determine short-time pickup and delay by primary current injection. Short-time pickup values must be as specified, and trip characteristic must not exceed manufacturer's published time-current tolerance band.
- e. Determine ground-fault pickup and time delay by primary current injection. Ground-fault pickup values must be as specified, and trip characteristic must not exceed manufacturer's published time-current tolerance band.
- f. Determine instantaneous pickup by primary current injection. Instantaneous pickup values must be as specified and within manufacturer's published tolerances. In absence of manufacturer's published data, comply with NETA ATS, Table 100.8.
- g. Test functions of trip unit by means of secondary injection. Pickup values and trip characteristic must be as specified and within manufacturer's published tolerances.
- h. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data. Minimum pickup voltage of shunt trip and close coils must conform to manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.20.
- i. Verify correct operation of auxiliary features, such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free operation, anti-pump function, and

trip unit battery condition. Reset trip logs and indicators. Auxiliary features must operate in accordance with manufacturer's published data.

- j. Verify operation of charging mechanism. Charging mechanism must operate in accordance with manufacturer's published data.

N. Low-Voltage Ground-Fault Protection System Field Tests:

1. Visual and Mechanical Inspection:

- a. Inspect components for damage and errors in polarity or conductor routing.
 - 1) Verify that ground connection is made on source side of neutral disconnect link and on source side of ground-fault sensor.
 - 2) Verify that neutral sensors are connected with correct polarity on both primary and secondary.
 - 3) Verify that phase conductors and neutral pass through sensor in same direction for zero sequence systems.
 - 4) Verify that grounding conductors do not pass through zero sequence sensors.
 - 5) Verify that grounded conductor is solidly grounded.
- b. Verify that unit is clean.
- c. Operate circuit breaker to ensure smooth operation.
- d. Verify correct operation of functions of self-test panel if provided.
- e. Verify that control power transformer has adequate capacity for system.
- f. Set pickup and time-delay settings. Record appropriate operation and test sequences in accordance with Section 230.95 "Ground-Fault Protection Equipment" of NFPA 70.

2. Electrical Tests:

- a. Measure system neutral-to-ground insulation resistance with neutral disconnect link temporarily removed. Replace neutral disconnect link after testing. System neutral-to-ground insulation resistance must be minimum of 1 MΩ. Correct wiring until minimum is achieved.
- b. Perform ground-fault protective-device pickup tests using primary injection. Results of pickup test must be greater than 90 percent of ground-fault protective-device pickup setting and less than 1200 A or 125 percent of pickup setting, whichever is smaller. Adjust or replace device until these parameters are achieved.
- c. For summation-type systems utilizing phase and neutral current transformers, verify correct polarities by applying current to phase-neutral current-transformer pair. This test also applies to MCCBs utilizing external neutral current transformer. Ground-fault protective device must operate when current direction is same relative to polarity marks in two current transformers. Ground-fault protective device must not operate when current direction is opposite relative to polarity marks in two current transformers.
- d. Measure time delay of ground-fault protective device at value equal to or greater than 150 percent of pickup value. Relay timing must be in accordance with manufacturer's published data but must be no longer than 1 s at 3000 A in accordance with Section 230.95 "Ground-Fault Protection Equipment" of NFPA 70.
- e. Verify that reduced control voltage tripping capability is 55 percent for AC systems and 80 percent for DC systems. Replace ground-fault system if reduced control voltage tripping requirement is not achieved, and retest.
- f. Verify blocking capability of zone interlock systems. Results of zone-blocking tests must be in accordance with manufacturer's published data and design specifications.

O. Metering Device Field Tests:

Secondary Unit Substations with Motor Control Center

Secondary

1. Visual and Mechanical Inspection:
 - a. Inspect physical and mechanical condition.
 - b. Inspect cover gasket, cover glass, condition of spiral spring, disk clearance, contacts, and case shorting contacts, as applicable.
 - c. Verify that unit is clean.
 - d. Verify freedom of movement, end play, and alignment of rotating disk(s).
2. Electrical Tests:
 - a. Verify accuracy of meters at cardinal points. Meter accuracy must be in accordance with manufacturer's published data.
 - b. Calibrate meters in accordance with manufacturer's published data. Calibration results must be within manufacturer's published tolerances.
 - c. Verify instrument multipliers. Instrument multipliers must be in accordance with system design specifications.
 - d. Verify that current-transformer and voltage-transformer secondary circuits are intact. Test results must confirm integrity of secondary circuits of current and voltage transformers.

P. Nonconforming Work:

1. Equipment and devices will be considered defective if they do not pass tests and inspections.
2. Remove and replace defective units and retest.

Q. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports. Record as-left set points of adjustable devices.

R. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.

1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.

3.4 SYSTEM STARTUP

A. Perform startup service.

1. Complete installation and startup checks in accordance with manufacturer's published instructions.
2. **<Insert startup steps if any>.**

B. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** system startup.

1. Manufacturer's Field Reports for System Startup Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.

3.5 CLEANING

A. After completing equipment installation and before energizing, inspect unit components. Remove paint

splatters and other spots, dirt, and debris. Repair damaged finish to match original finish. Vacuum interiors of secondary unit substation sections.

3.6 CLOSEOUT ACTIVITIES

A. Training:

1. **[With assistance from factory-authorized service representatives, train][Train]** Owner's maintenance personnel on the following topics:
 - a. How to adjust, operate, and maintain secondary unit substation equipment.
2. **[Provide video recordings of training sessions to Owner][Allow Owner to record training sessions].**

3.7 PROTECTION

- #### A.
- After installation, protect secondary unit substation equipment from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

3.8 MAINTENANCE

- #### A.
- Voltage Monitoring and Adjusting: After Substantial Completion, if requested by Owner, but not more than six months after Final Acceptance, perform the following voltage monitoring:
1. During period of normal load cycles as evaluated by Owner, perform seven days of three-phase voltage recording at outgoing section of secondary unit substation. Use voltmeters with calibration traceable to National Institute of Science and Technology standards and with chart speed of not less than **1 inch/h (25 mm/h)**. Voltage unbalance greater than 1 percent between phases, or deviation of phase voltage from nominal value by more than plus or minus 5 percent during test period, is unacceptable.
 2. Corrective Action: If test results are unacceptable, perform the following corrective action, as appropriate:
 - a. Adjust transformer taps.
 - b. Rebalance loads.
 - c. Prepare written request for voltage adjustment by electric utility.
 3. Retests: Repeat monitoring, after corrective action has been performed, until satisfactory results are obtained.
 4. Field Reports for Voltage Monitoring and Adjusting:
 - a. Prepare written report covering monitoring performed and corrective action taken.
 - b. For relay and adjustable circuit breaker, tag device with adjusting technician's initials and date of adjustment. Record settings and file with test records specified in "Field Quality Control" Article.
- #### B.
- Infrared Scanning of Secondary Unit Substation Equipment: Perform survey during periods of maximum possible loading. Remove necessary covers prior to inspection. Take visible light photographs at same

locations and orientations as infrared scans for documentation to ensure follow-on scans match same conditions for valid comparison.

1. After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared inspection of electrical power connections of unit substation.
 2. Follow-On Infrared Scanning: Perform additional follow-up infrared scan of switchgear 11 months after date of Substantial Completion.
 3. Instrument: Inspect distribution systems with imaging equipment capable of detecting minimum temperature difference of 1 deg C at 30 deg C. Provide documentation of device calibration.
 4. Field Reports for Infrared Scanning: Prepare certified report that identifies testing technician and equipment used, and lists results as follows:
 - a. Description of equipment to be tested.
 - b. Discrepancies.
 - c. Temperature difference between area of concern and reference area.
 - d. Probable cause of temperature difference.
 - e. Areas inspected. Identify inaccessible and unobservable areas and equipment.
 - f. Identify load conditions at time of inspection.
 - g. Provide photographs and thermograms of deficient area.
 5. Act on inspection results in accordance with recommendations of NETA ATS, Table 100.18. Correct possible and probable deficiencies as soon as Owner's operations permit. Retest until deficiencies are corrected.
- C. Maintenance Service Agreement: Beginning at Substantial Completion, verify that maintenance service agreement includes **[one year]<Insert duration>** period for full maintenance by **[skilled employees of substation equipment Installer][manufacturer's authorized service representative]**. Include annual preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper substation equipment operation. Verify that parts and supplies are manufacturer's authorized replacement parts and supplies.

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SECTION 26 11 16 11 - SECONDARY UNIT SUBSTATIONS WITH SWITCHGEAR SECONDARY

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Articulated secondary unit substations with switchgear secondary.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. Section 260513 "Medium-Voltage Cables" for requirements for terminating cables in substation medium-voltage sections.
5. Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for requirements for terminating cables in substation low-voltage sections.
6. Section 260523 "Control-Voltage Electrical Power Cables" for requirements for terminating cables in substation instrumentation sections.
7. Section 260526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding referenced by this Section.
8. Section 260529 "Hangers and Supports for Electrical Systems" specifies hangers, supports, and concrete bases referenced by this Section.
9. Section 260548 "Vibration and Seismic Controls for Electrical Systems" specifies vibration isolation and seismic[**and wind**] control devices referenced by this Section.
10. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs referenced by this Section.
11. Section 260573 "Power System Studies" specifies coordination studies, arc-flash hazard analysis, warning labels, and circuit-breaker trip ranges referenced by this Section.
12. Section 262300 "Low-Voltage Switchgear" specifies low-voltage distribution sections referenced by this Section.

1.2 DEFINITIONS

- A. NETA ATS: Acceptance testing specification.
- B. PCB: Polychlorinated biphenyl.
- C. RTD: Resistance temperature detector (IEEE C37.2 Device No. 26).
- D. SCR: Silicon-controlled rectifier.
- E. SPD: Surge protective device.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, operating characteristics, and furnished specialties and accessories.
 - 2. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing agency, certifying product's compliance with specified listing criteria.
 - a. If listed manufacturer differs from selling manufacturer, indicate relationship between entities on submittal. Clearly indicate which entity warrants product performance and fitness for purpose.
 - b. Listing criteria identified in approval letter must match specified listing criteria. UL label indicating approval of equipment's enclosure is not considered approval of equipment for intended application.
 - c. Product identification in approval letter must match product branding and model numbers in submittal. Approval letters for discontinued or superseded products are unacceptable for submitted product.
 - 3. Include manufacturer's sample extended warranty language.
- B. Factory test reports.
- C. Shop Drawings: Prepare and submit the following:
 - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Wiring Diagrams: Power, signal, and control wiring.
 - 3. Dimensioned plans and elevations showing major components and features.
 - a. Include a plan view and cross section of equipment base, showing clearances, workspace that accounts for breaker service and removal, and locations of penetrations for grounding and conduits in accordance with manufacturer's published instructions.
 - 4. One-line diagram.
 - 5. List of materials.
 - 6. Nameplate legends.
 - 7. The material, size and number of bus bars, and current rating for each bus, including mains and branches of phase, neutral, and ground buses.
 - 8. Short-time and short-circuit current ratings of secondary unit substations and components.
 - 9. Ratings of individual protective devices.
 - 10. Mimic-bus diagram.
 - 11. Utility company's metering provisions with indication of approval by utility company.
- D. Time-Current Characteristic Curves: For overcurrent protective devices.
- E. Primary Fuses: Submit recommendations and size calculations.
- F. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

- A. Manufacturer's published instructions.

B. Field Reports:

1. Manufacturer's field reports for field quality-control support.
2. Manufacturer's field reports for system startup support.
3. Field reports for voltage monitoring and adjusting.
4. Field reports for infrared scanning.
5. Field reports for software and firmware upgrades.

1.5 CLOSEOUT SUBMITTALS

- A. Warranty documentation.
- B. Maintenance service agreement.
- C. Software and firmware service agreement.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Spare parts.
- B. Special tools.
- C. Consumable items.

1.7 REGULATORY AGENCY APPROVALS

- A. Submittals for secondary unit substations requiring approval by authorities having jurisdiction must be signed by qualified electrical professional engineer responsible for their preparation. **[Obtain approval by authorities having jurisdiction prior to submitting for action by Architect.][Submit for action by Architect prior to submitting for approval by authorities having jurisdiction.]**

1.8 QUALIFICATIONS

- A. Electrical Power Testing (EPT) Technician III: Possessing active NICET EPT Level III certification. Able to manage switching procedures, conduct tests of complex equipment, analyze test and equipment data, plan a job, and lead a team. Has experience performing NFPA 70B, IEEE, and NETA electrical tests.
- B. Electrical Power Testing (EPT) Technician IV: Possessing active NICET EPT Level IV certification. Able to conduct tests of complex metering and relay systems; evaluate tests, test equipment, test results, and power system performance; recommend actions to maintain or improve system performance; and lead multi-team projects.
- C. Electrical Power Testing and Inspecting Agency: Entities possessing active credentials from qualified electrical testing laboratory recognized by authorities having jurisdiction.
 1. On-site electrical testing supervisors must possess active NICET EPT Technician [III][IV] certification.
- D. Electrical Professional Engineer: Professional engineer possessing active qualifications specified in Section 014000 "Quality Requirements," with expertise in electrical engineering, including electrical

power system modeling and analysis of electrical safety in accordance with NFPA 70E.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Deliver in shipping splits in sizes that can be moved past obstructions in delivery path.
- B. Coordinate delivery of secondary unit substations to allow movement into designated space.
- C. Store secondary unit substation components[**protected from weather and**] so condensation does not form on or in units. Provide temporary heating in accordance with manufacturer's published instructions.
- D. Handle secondary unit substation components in accordance with manufacturer's published instructions. Use factory-installed lifting provisions.

1.10 SERVICE CONDITIONS FOR ELECTRICAL EQUIPMENT

- A. Modeling, analysis, product selection, installation, and quality control for all electrical Work on the Project must comply with service condition requirements specified in Section 018116 "Facility Environmental Requirements" and Section 018123 "Facility Seismic and Wind Criteria."
- B. Usual Service Conditions: Unless unusual service conditions have been specified in "General Environmental Conditions," "Outdoor Conditions," and "Indoor Conditions" articles of Section 018116 "Facility Environmental Requirements," electrical service and distribution equipment must be suitable for operation under usual service conditions specified in applicable IEEE C37 series and IEEE C57 series standards.

1.11 WARRANTY FOR SECONDARY UNIT SUBSTATIONS

- A. Special Installer Extended Warranty: Installer warrants that assembled and installed secondary unit substation performs in accordance with specified requirements and agrees to repair or replace components or products that fail to perform as specified within extended-warranty period. Warranty must convey to Owner upon acceptance of the Work.
 - 1. Extended-Warranty Period: [**Two**][**Three**][**Four**]**<Insert number>** years from date of Substantial Completion; full coverage for labor, materials, and equipment.
- B. Special Manufacturer Extended Warranty: Manufacturer warrants that secondary unit substation performs in accordance with specified requirements and agrees to provide repair or replacement of components or products that fail to perform as specified within extended-warranty period. Warranty must convey to Owner upon acceptance of the Work.
 - 1. Initial Extended-Warranty Period: [**Three**][**Four**][**Five**]**<Insert number>** years from date of Substantial Completion; [**full**][**prorated**] coverage for labor, materials, and equipment.
 - 2. Follow-On Extended-Warranty Period: [**Eight**]**<Insert number>** years from date of Substantial Completion; [**full**][**prorated**] coverage for materials only, free on board [**origin**][**destination**], freight prepaid.

1.12 WARRANTY FOR BATTERIES

- A. Special DC Control System Manufacturer Extended Warranty: Manufacturer warrants that components

of DC control system perform in accordance with specified requirements and agrees to provide repair or replacement of batteries that fail to perform as specified within extended warranty period.

1. DC Control System Equipment (Excluding Batteries) Extended Warranty Period: **[Two]<Insert number>** year(s) from date of Substantial Completion, for labor, materials, and equipment.
2. Standard VRLA Batteries:
 - a. Initial Extended Warranty Period: **[Two]<Insert number>** year(s) from date of Substantial Completion, full coverage for materials only.
 - b. Follow-on Extended Warranty Period: **[Nine]<Insert number>** year(s) from date of Substantial Completion, pro-rated coverage for materials only.
3. Premium VRLA Batteries:
 - a. Initial Extended Warranty Period: **[Two]<Insert number>** year(s) from date of Substantial Completion, full coverage for materials only.
 - b. Follow-on Extended Warranty Period: **[19]<Insert number>** year(s) from date of Substantial Completion, pro-rated coverage for materials only.
4. Vented Ni-Cd Batteries:
 - a. Initial Extended Warranty Period: **[Five]<Insert number>** year(s) from date of Substantial Completion, full coverage for materials only.
 - b. Follow-on Extended Warranty Period: **[15]<Insert number>** year(s) from date of Substantial Completion, pro-rated coverage for materials only.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- B. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 1. Unit Substations over 600 V: UL CCN YEFV, including IEEE C37.121 and the following:
 - a. Metal-Clad Switchgear: IEEE C37.20.2 and NEMA C 37.55.
 - b. Metal-Enclosed Switchgear: IEEE C37.20.3 and NEMA C 37.57.
 - c. Liquid-Filled Transformer: IEEE C57.12.00.
 - d. Dry-Type Transformer: UL 1562.
- C. Seismic and Wind Performance: Installed product must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:
 1. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events[**and unit must be fully operational after seismic events**].
 2. Component Importance Factor (Ip): **[1.0][1.5]**.
 3. Component Amplification Factor (ap):



- a. Batteries: [1.0]<Insert value>.
 - b. Transformers: [1.0]<Insert value>.
 - c. Sheet Metal Enclosed Electrical Equipment: [2.5]<Insert value>.
 - d. Cabling and Bus Ducts: [2.5]<Insert value>.
4. Component Response Modification Factor (R_p):
- a. Batteries: [2.5]<Insert value>.
 - b. Transformers: [2.5]<Insert value>.
 - c. Sheet Metal Enclosed Electrical Equipment: [6.0]<Insert value>.
 - d. Cabling and Bus Ducts: [6.0]<Insert value>.
5. Component Overstrength Factor (Ω_o): [1.5][2.5]<Insert value>.
- a. Batteries: [2.5]<Insert value>.
 - b. Transformers: [2.5]<Insert value>.
 - c. Sheet Metal Enclosed Electrical Equipment: [2.5]<Insert value>.
 - d. Cabling and Bus Ducts: [1.5]<Insert value>.

2.2 ARTICULATED SECONDARY UNIT SUBSTATIONS WITH SWITCHGEAR SECONDARY

- A. Description: **[Medium-voltage, primary incoming section; transformer section; and low-voltage secondary switchgear section; and including coordinated circuit breakers, fusible switches, and metering components]<Insert brief description of desired system, assembly, or equipment>.**
- B. Indoor Unit Arrangement: **[Single assembly][Separate secondary distribution equipment connected with busway].**
- C. Outdoor Unit Arrangement: **[Single assembly][Separate secondary distribution equipment connected with busway].**
 - 1. Weatherproof, listed for installation outdoors, complying with IEEE C37.20.1.
 - 2. Aisle-less Construction: Full-height doors in front of basic weatherproof equipment.
- D. Selection of Components for Secondary Unit Substation:
 - 1. Source Limitations: Obtain components for secondary unit substation from sources approved by **[manufacturer][fabricator]** warranting performance of entire **[system][assembly]**.
 - 2. Provide the following specified products with the secondary unit substation:
 - a. Secondary Unit Substation No. 1 :
 - 1) Medium-voltage terminal compartment section .
 - 2) Medium-voltage metal-clad switchgear section .
 - 3) Medium-voltage metal-enclosed switchgear section .
 - 4) Medium-voltage instruments section .
 - 5) Liquid-filled medium-voltage transformer section .
 - 6) Dry-type medium-voltage transformer section .
 - 7) Secondary distribution terminal compartment section .
 - 8) Secondary distribution network protectors section .
 - 9) Secondary distribution low-voltage instrument section .
 - 10) Secondary distribution switchgear section .
 - 11) Secondary Distribution Low-Voltage Distribution Section : As specified in Section 262300 "Low-Voltage Switchgear."

E. General Criteria:

1. Connections between primary device and transformer must be **[cable][bus]**, and between transformer and secondary must be flexible bus braid unless noted otherwise.
2. Indoor Enclosure: Steel.
3. Outdoor Enclosure: **[Weatherproof, aisle-less construction][Weatherproof, sheltered-aisle construction, with interior-lighted walk-in aisle]** for outdoor service. Galvanized-steel, weatherproof construction; integral structural-steel base frame with factory-applied asphaltic undercoating.
 - a. Enclosure: **[Flat][Downward, rearward sloping]** roof; **[bolt-on rear covers][rear hinged doors]** for each section, with provisions for padlocking.
 - b. Each compartment must have the following features:
 - 1) Structural design and anchorage adequate to resist loads imposed by **[125 mph (200 km/h)]<Insert wind speed>** wind.
 - 2) Space heater operating at one-half or less of rated voltage, sized to prevent condensation, controlled by **[thermostats to maintain temperature of each section above expected dew point][manual switching of branch-circuit protective device]**.
 - 3) Louvers equipped with insect and rodent screens and filters, and arranged to permit air circulation while excluding rodents and exterior dust.
 - 4) LED lighting fixtures, ceiling mounted; wired to a three-way light switch at each end of aisle
 - 5) Weatherproof ground-fault circuit interrupter (GFCI) duplex receptacle.
 - 6) Power for heaters, lights, and receptacles must be provided **[by control power transformer][as indicated]**.
 - c. Weatherproof internal-aisle construction must have the following features:
 - 1) Common internal aisle of sufficient width to permit protective device withdrawal, disassembly, and servicing in aisle.
 - 2) Doors: Personnel door at each end of aisle, minimum width of **[30 inch (762 mm)]<Insert dimension>**; opening outwards; with panic hardware and provisions for **[padlocking][cylinder lock]**.
 - 3) Aisle space heaters operating at one-half or less of rated voltage and thermostatically controlled.
 - 4) Vapor-proof fluorescent aisle lights with low-temperature ballasts and controlled by wall switch at each entrance.
 - 5) Emergency battery pack lighting fixture installed on wall of aisle midway between personnel doors
 - 6) GFCI duplex receptacles, a minimum of two, located in aisle.
 - 7) Factory-installed electric unit heater(s), wall or ceiling mounted, with integral thermostat and disconnect and with capacities to maintain switchboard interior temperature of **[plus 10 deg F (minus 12 deg C)]<Insert temperature>** with outside design temperature of **[minus 20 deg F (minus 29 deg C)]<Insert temperature>**.
 - 8) Factory-installed exhaust fan with capacities to maintain switchboard interior temperature of **[85 deg F (29 deg C)]<Insert temperature>** with outside design temperature of **[104 deg F (40 deg C)]<Insert temperature>**.
 - 9) Ventilating openings **[complete with replaceable fiberglass air filters]**.
 - 10) Thermostat: Single stage; wired to control heat and exhaust fan.
4. Skid Mounted: Mount each shipping group on an integral base frame as a complete weatherproof unit.
5. Unit Substation Enclosures Finish:

- a. Factory-applied finish in manufacturer's standard color, including under surfaces treated with corrosion-resistant undercoating.
- b. Factory-applied finish in manufacturer's standard gray over a rust-inhibiting primer on treated metal surface.
- c. Factory-applied corrosion-resistant finish in manufacturer's standard color that withstands **[120][480]** hours of exposure to salt spray test specified in ASTM B117 without loss of paint or release of adhesion of paint primer coat to metal surface in excess of **1/16 inch (1.6 mm)** from test mark. The scribed test mark and test evaluation must be conducted in accordance with ASTM D1654, with a rating of not less than 7 arrived at in accordance with Table 1 (procedure A). Cut edges or otherwise damaged surfaces of hot-dip galvanized sheet steel or mill-galvanized sheet steel must be coated with a manufacturer's standard zinc-rich paint.

F. Source Quality Control:

1. Factory Tests:

- a. Owner will witness required factory tests. Notify Architect at least 14 days before date of tests and indicate their approximate duration.
- b. Testing Administrant: **[Owner will engage][Engage]** qualified electrical testing agency to evaluate secondary unit substation components.
- c. Factory Tests and Inspections: Perform the following tests and inspections on secondary unit substation components, by, or under supervision of, qualified electrical testing laboratory recognized by authorities having jurisdiction before delivering to site. Affix label with name and date of **[manufacturer's][qualified electrical testing laboratory's]** certification of system compliance.
 - 1) Perform design and routine tests in accordance with standards specified for components. Conduct transformer tests in accordance with IEEE C57.12.90. Conduct switchgear and switchboard tests in accordance with NEMA C 37.51.
 - 2) Perform the following factory-certified tests on each secondary unit substation:
 - a) Resistance measurements of all windings on rated voltage connection and on tap extreme connections.
 - b) Ratios on rated voltage connection and on tap extreme connections.
 - c) Polarity and phase relation on rated voltage connection.
 - d) No-load loss at rated voltage on rated voltage connection.
 - e) Exciting current at rated voltage on rated voltage connection.
 - f) Impedance and load loss at rated current on rated voltage connection and on tap extreme connections.
 - g) Applied potential.
 - h) Induced potential.
 - i) Temperature Test: If a transformer is supplied with auxiliary cooling equipment to provide more than one rating, test at lowest kVA Class ONAN or Class AA rating and highest kVA Class ONAF or Class AFA rating. Temperature test is not required if a record of a temperature test on an essentially duplicate unit is available.
- d. Nonconforming Work:
 - 1) Equipment that does not pass tests and inspections will be considered defective.
- e. Factory Test Reports: Compile and submit factory test and inspection reports.

G. Medium-Voltage Terminal Compartment Section :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[Eaton]**
 - c. **[Hitachi Energy USA Inc.; business of Hitachi, Ltd.]**
 - d. **[Siemens Industry, Inc., Energy Management Division]**
 - e. **[Square D; Schneider Electric USA]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Eaton]**
 - c. **[Hitachi Energy USA Inc.; business of Hitachi, Ltd.]**
 - d. **[Siemens Industry, Inc., Energy Management Division]**
 - e. **[Square D; Schneider Electric USA]**
 - f. **<Insert manufacturer's name>**
3. Standard Features:
 - a. Primary Incoming Section: Terminal assembly with adequate space for incoming-cable terminations and surge arresters, complying with NEMA SG 4 and meeting thermal, mechanical, and dielectric requirements specified for transformer section.
 - b. Ratings: Suitable for application in three-phase, 60 Hz, solidly grounded-neutral system.
 - c. System Voltage: **[4.16 kV nominal; 4.76 kV maximum][7.2 kV nominal; 15 kV maximum][13.8 kV nominal; 15 kV maximum][34.5 kV nominal; 38 kV maximum]<Insert other voltage>**.
 - d. Surge Arresters: Comply with IEEE C62.11, Distribution Class; metal-oxide-varistor type, connected in each phase of incoming circuit and ahead of any disconnecting device.

H. Medium-Voltage Metal-Clad Switchgear Section :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[Eaton]**
 - c. **[Hitachi Energy USA Inc.; business of Hitachi, Ltd.]**
 - d. **[Siemens Industry, Inc., Energy Management Division]**
 - e. **[Square D; Schneider Electric USA]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Eaton]**
 - c. **[Hitachi Energy USA Inc.; business of Hitachi, Ltd.]**



- d. [Siemens Industry, Inc., Energy Management Division]
- e. [Square D; Schneider Electric USA]
- f. <Insert manufacturer's name>

3. Standard Features:

- a. Metal-clad, circuit-breaker switchgear, complying with IEEE C37.20.2 and NEMA SG 4 and tested for compliance in accordance with NEMA C 37.55.
 - 1) Arc Resistant: Comply with IEEE C37.20.7, [Type 1][Type 2][Type 1C][Type 2C].
- b. Ratings must comply with IEEE C37.04, suitable for application in three-phase, 60 Hz, solidly grounded-neutral system.
 - 1) System Voltage: [4.16 kV nominal; 4.76 kV maximum][7.2 kV nominal; 15 kV maximum][13.8 kV nominal; 15 kV maximum][34.5 kV nominal; 38 kV maximum]<Insert other voltage>.
 - 2) Nominal Interrupting-Capacity Class: [250][350][500][750][1000] MVA.
 - 3) Main-Bus Rating: [1200][2000][3000] A, continuous.
- c. Circuit Breakers: Electrically operated, drawout mounting; using three individual vacuum-sealed interrupter modules, and including the following features:
 - 1) Designed to operate at rated voltage to interrupt fault current within its rating within [three][five] cycles of trip initiation. For systems with X/R ratio of 17 or less, transient voltage during interruption must not exceed twice rated line-to-ground voltage of system.
 - 2) Contact-Wear Indicator: Readily accessible to field maintenance personnel.
 - 3) Minimum of six Type A and six Type B spare contacts.
 - 4) Interchangeability: Interchangeable with vacuum circuit breakers of same current and interrupting ratings.
 - 5) Operating Mechanism: Electrically charged, mechanically and electrically trip-free, stored-energy operation.
- d. Control Power:
 - 1) [48][125]<Insert voltage> V(dc) for closing and tripping.
 - 2) [120][240]<Insert voltage> V(ac) for closing and tripping.
- e. Low-DC-Voltage Alarm: Monitor DC control power voltage with a remote alarm. Alarm must sound if voltage falls to an adjustable value to indicate an impending battery failure. Factory set alarm value at 80 percent of full-charge voltage.
- f. Remote-Tripping Device: Wall-mounting emergency control station to open circuit breakers; located in red cast-metal box with break-glass operation.
- g. Surge Arresters: Comply with IEEE C62.11, Distribution Class; metal-oxide-varistor type, connected in each phase of incoming circuit and ahead of any disconnecting device.

I. Medium-Voltage Metal-Enclosed Switchgear Section :

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

- b. **[Eaton]**
 - c. **[Hitachi Energy USA Inc.; business of Hitachi, Ltd.]**
 - d. **[Siemens Industry, Inc., Energy Management Division]**
 - e. **[Square D; Schneider Electric USA]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Eaton]**
 - c. **[Hitachi Energy USA Inc.; business of Hitachi, Ltd.]**
 - d. **[Siemens Industry, Inc., Energy Management Division]**
 - e. **[Square D; Schneider Electric USA]**
 - f. **<Insert manufacturer's name>**
3. Standard Features:
 - a. Metal-enclosed, air-interrupter switchgear, **[with][without]** fuses, complying with IEEE C37.20.3.
 - 1) Switchgear must be arc resistant, complying with IEEE C37.20.7, **[Type 1][Type 2][Type 1C][Type 2C]**.
 - b. Ratings: Comply with IEEE C37.04; and suitable for application in three-phase, 60 Hz, solidly grounded-neutral system.
 - 1) System Voltage: **[4.16 kV nominal; 4.76 kV maximum][7.2 kV nominal; 15 kV maximum][13.8 kV nominal; 15 kV maximum][34.5 kV nominal; 38 kV maximum]<Insert other voltage>**.
 - 2) Design Level of Available-Source Fault Current: Integrated short-circuit rating consistent with value of fault current indicated.
 - 3) Main-Bus Rating: **[600][1200][2000]** A, continuous.
 - c. Interrupter Switches: Stationary, gang operated, and suitable for application at maximum short-circuit rating of integrated switchgear assembly.
 - 1) Rating: **[600][1200]** A continuous duty and load break.
 - 2) Two-Time Duty-Cycle Fault Closing: **[25 000][40 000]** A, asymmetrical.
 - 3) Switch Action: No external arc and no significant quantities of ionized gas released into enclosure.
 - 4) Switch Construction: Supported entirely by interior framework of structure, with copper switchblades and stored-energy operating mechanism.
 - 5) Phase Barriers: Full length of switchblades and fuses for each pole; designed for easy removal; allow visual inspection of switch components if barrier is in place.
 - 6) Protective Shields: Cover live components and terminals.
 - 7) Fuse Mounts: Single-frame mounted and de-energized when switch is open.
 - 8) Mechanical Interlock: Prevent opening of switch compartment door unless switchblades are open, and prevent closing switch if door is open. **[Interlock air-interrupter switch with transformer secondary main circuit breaker, preventing switch from being opened or closed unless secondary main circuit breaker is open.]**
 - 9) Window: Permits viewing switchblade positions when door is closed.
4. Surge Arresters: Comply with IEEE C62.11, Distribution Class; metal-oxide-varistor type, with

ratings as indicated, connected in each phase of incoming circuit and ahead of any disconnecting device.

J. Medium-Voltage Instruments Section :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[Eaton]**
 - c. **[Hitachi Energy USA Inc.; business of Hitachi, Ltd.]**
 - d. **[Siemens Industry, Inc., Energy Management Division]**
 - e. **[Square D; Schneider Electric USA]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Eaton]**
 - c. **[Hitachi Energy USA Inc.; business of Hitachi, Ltd.]**
 - d. **[Siemens Industry, Inc., Energy Management Division]**
 - e. **[Square D; Schneider Electric USA]**
 - f. **<Insert manufacturer's name>**
3. Standard Features:
 - a. Instrument Transformers: Comply with IEEE C57.13.
 - 1) Potential Transformers: Secondary voltage rating of 120 V and NEMA C 12.11 Accuracy Class of 0.3 with burdens of W, X, and Y.
 - 2) Current Transformers: Burden and Accuracy Class suitable for connected relays, meters, and instruments.
 - b. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems.
 - 1) Inputs from sensors or 5 A current-transformer secondaries, and potential terminals rated to 600 V.
 - 2) Switch-selectable digital display with the following features:
 - a) Phase Currents, Each Phase: Plus or minus 1 percent.
 - b) Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
 - c) Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
 - d) Three-Phase Real Power: Plus or minus 2 percent.
 - e) Three-Phase Reactive Power: Plus or minus 2 percent.
 - f) Power Factor: Plus or minus 2 percent.
 - g) Frequency: Plus or minus 0.5 percent.
 - h) Integrated Demand, with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
 - i) Accumulated energy, in **MWh (MJ)**, plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.

- 3) Communications module suitable for remote monitoring of meter quantities and functions. Interface communication and metering requirements in accordance with Section 260913 "Electrical Power Monitoring."
 - 4) Mounting: Display and control unit that is flush or semiflush mounted in instrument compartment door.
- c. Analog Instruments: Rectangular, **4-1/2 inch (115 mm)** square, 1 percent accuracy, semiflush mounting, with antiparallax 250-degree scale and external zero adjustment.
- 1) Voltmeters: Cover an expanded scale range of normal voltage plus 10 percent.
 - 2) Voltmeter Selector Switch: Rotary type with off position to provide readings of phase-to-phase[**and phase-to-neutral**] voltages.
 - 3) Ammeters: Cover an expanded scale range of bus rating plus 10 percent.
 - 4) Ammeter Selector Switch: Permits current reading in each phase and keeps current-transformer secondary circuits closed in off position.
 - 5) Locate meter and selector switch on circuit-breaker compartment door for indicated feeder circuits only.
 - 6) Watt-Hour Meters: Flush- or semiflush-mounting type, 5 A, 120 V, three phase, three wire; with three elements, [**15-minute**]<Insert value> indicating demand register, and provision for testing and adding pulse initiation.
 - 7) Recording Demand Meter: Usable as totalizing relay or indicating and recording maximum demand meter with [**15-minute**]<Insert value> interval.
 - a) Operation: Counts and records a succession of pulses entering two channels.
 - b) Housing: Drawout, back-connected case arranged for semiflush mounting.
- d. Overcurrent and Ground-Fault Protective Relays: Multifunctional, solid-state microprocessor-based, medium-voltage relay, for operation from specified control power. Comply with IEEE C37.90.
- 1) Field-Selectable Relay Settings: Required by overcurrent protective device coordination study and arc-flash study.
 - 2) Primary Current-Transformer Ratings: Programmable from 5 to 5000 A.
 - 3) Phase and Ground Protection: Field-selectable curves from IEEE moderately inverse, very inverse, or extremely inverse.
 - 4) Phase Instantaneous Overcurrent Trip Pickup Point: Field selectable as "none" or from 1.0 to 25 times current-transformer primary rating. Include discriminator circuit with "on" and "off" switch, so that when phase instantaneous overcurrent has been programmed to "none," discriminator circuit protects against currents exceeding 11 times current-transformer primary rating when breaker is being closed and must be deactivated after approximately eight cycles.
 - 5) Contacts: Two Form A contacts, field selectable into contact pairs as follows and as required by overcurrent protective device coordination study and arc-flash study:
 - a) One contact assigned IEEE Device No. 51 phase and IEEE Device No. 51 ground, and other contact assigned IEEE Device No. 50 phase and IEEE Device No. 50 ground.
 - b) One contact assigned IEEE Device No. 51/50 phase, and other contact assigned 51/50 ground.
 - 6) Alphameric display to show the following parameters with metering accuracy not to exceed 2 percent of full scale:
 - a) Individual phase currents.
 - b) Ground current.
 - c) Cause of trip.



- d) Magnitude and phase of current causing trip.
 - e) Phase or ground indication.
 - f) Peak current demand for each phase and ground since last reset.
 - g) Current-transformer primary rating.
 - h) Programmed phase and ground set points.
- 7) Communications module to transmit the following data in accordance with Section 260913 "Electrical Power Monitoring."
- a) Relay's metered and target data, such as currents, set points, cause of trip, magnitude of trip current, and open-close trip status.
 - b) Ability to close and open associated breaker with proper access code from remote location over communication network when relay is configured in remote open-close mode.
- 8) Relay alarm and trip contacts must not change state if power is lost or an undervoltage occurs. These contacts must only cause a trip on detection of an overcurrent or fault condition based on programmed settings. Provide a "protection off" alarm, which must be normally energized when relay is powered and self-diagnostics indicates unit is functional. On loss of power or relay failure, this alarm relay must be de-energized providing a fail-safe protection off alarm.
- 9) The relay must operate reliably solely from breaker main current transformers during a fault condition, if normally connected auxiliary AC voltage is not available, even after an extended power outage.
- 10) Mount relay in a drawout case with a two-stage quick-release operation. The removal of relay from case must disconnect trip circuits and short current-transformer secondaries before unit control power is disconnected. When relay is inserted into case, control power connections must be made before trip circuits are activated. Include a self-shorting contact on case terminal block to provide alarm indication and tripping of circuit breaker upon removal of relay from case.
- e. **<Insert other relay types>.**
- f. Control Power Supply Transformer:
- 1) Control power transformer supplies 120 V control circuits through secondary disconnect devices.
 - a) Dry-type transformers, in separate compartments for units larger than 3 kVA, including primary and secondary fuses.
 - b) Two control power transformers in separate compartments with necessary interlocking relays; each transformer connected to line side of associated main circuit breaker.
 - c) Secondary windings connected through relay(s) to control bus to affect an automatic transfer scheme.
 - d) Secondary windings connected through an internal automatic transfer switch to switchgear control power bus.
 - e) Control Power Fuses: Primary and secondary fuses provide current-limiting and overload protection.
- g. Control Power Supply DC Battery System:
- 1) System Requirements: Battery must have number of cells and ampere-hour capacity based on an initial specific gravity of 1.210 at **77 deg F (25 deg C)** with electrolyte at normal level and minimum ambient temperature of **55 deg F (13 deg C)**. Cycle battery before shipment to guarantee rated capacity on installation. Arrange battery

to operate ungrounded. Battery system capacity must be in accordance with switchgear manufacturer's published instructions to operate circuit breakers for intended duty.

- 2) Battery: **[Standard VRLA][Premium VRLA][Vented Ni-Cd]** batteries, with battery disconnect and overcurrent protective device.
- 3) Rack: Two-step rack with electrical connections between battery cells and between rows of cells; include two flexible connectors with bolted-type terminals for output leads. **[Rate battery rack, cell supports, and anchorage for seismic requirements.]**
 - a) Thermometers with specific-gravity correction scales.
 - b) Hydrometer syringes.
 - c) Set of cell numerals.
- 4) Charger: Static-type silicon rectifier equipped with automatic regulation and provision for manual and automatic adjustment of charging rate. Unit must automatically maintain output voltage within 0.5 percent from no load to rated charger output current, with AC input-voltage variation of plus or minus 10 percent and input-frequency variation of plus or minus 3 Hz.
 - a) DC ammeter.
 - b) DC Voltmeter: Maximum error of 5 percent at full-charge voltage, with toggle switch to select between battery and charger voltages.
 - c) Ground Indication: Two appropriately labeled lights to indicate circuit ground, connected in series between negative and positive terminals, with midpoint junction connected to ground by N.O. push-button contact.
 - d) Capacity: Sufficient to supply steady load, float-charge battery between 2.20 and 2.25 V per cell and equalizing charge at 2.33 V per cell.
 - e) Charging-Rate Switch: Manually operated switch to transfer to higher charging rate. Charger operation must be automatic until manually reset.
 - f) AC Power Supply: 120 V, 60 Hz, subject to plus or minus 10 percent variation in voltage and plus or minus 3 Hz variation in frequency. Automatic charger operation must resume after loss of AC power supply for any interval.
 - g) Charging Regulator: Protect charger from damage due to overload, including short circuit on output terminals. The device must regulate charging current, but must not disconnect charger from either battery or AC supply.
 - h) Charger's Audible Noise: Less than 26 dB(A-weighted).
- 5) Control Wiring: Factory installed, complete with bundling, lacing, and protection.
 - a) Conductors across Hinges and for Interconnections between Shipping Units: Flexible conductors for 8 AWG and smaller.
 - b) Conductors: Sized in accordance with NFPA 70 for duty required.

K. Liquid-Filled Medium-Voltage Transformer Section :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[Eaton]**
 - c. **[Hitachi Energy USA Inc.; business of Hitachi, Ltd.]**
 - d. **[Siemens Industry, Inc., Energy Management Division]**
 - e. **[Square D; Schneider Electric USA]**

- f. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [ABB, Electrification Business]
 - b. [Eaton]
 - c. [Hitachi Energy USA Inc.; business of Hitachi, Ltd.]
 - d. [Siemens Industry, Inc., Energy Management Division]
 - e. [Square D; Schneider Electric USA]
 - f. <Insert manufacturer's name>
 3. Standard Features:
 - a. IEEE C57.12.00 [and UL 1062,] liquid-filled, two-winding, secondary unit substation transformer.
 - b. Primary Incoming Section: Transformer cover-mounted bushings. The bushings must meet thermal, mechanical, and dielectric requirements as specified for transformer section.
 - c. Insulating Liquid:
 - 1) Mineral oil complying with ASTM D3487, Type II, and tested in accordance with ASTM D117.
 - 2) Less flammable, edible-seed-oil based, and listed and labeled for fire point of not less than 300 deg C when tested in accordance with ASTM D92. Liquid must be biodegradable and nontoxic.
 - 3) Less flammable, dielectric, and listed and labeled for fire point of not less than 300 deg C when tested in accordance with ASTM D92. Liquid must be biodegradable and nontoxic.
 - 4) Less flammable, silicone-based dielectric, and listed and labeled for fire point of not less than 300 deg C when tested in accordance with ASTM D92. Liquid must have low toxicity and be nonhazardous.
 - d. Insulation Temperature Rise:
 - 1) 55 deg C, based on an average ambient temperature of **86 deg F (30 deg C)** over 24 hours with a maximum ambient temperature of **104 deg F (40 deg C)**. Insulation system must be rated to continuously allow an additional 12 percent kVA output, at 65 deg C temperature rise, without decreasing rated transformer life.
 - 2) 65 deg C, based on an average ambient temperature of **86 deg F (30 deg C)** over 24 hours with a maximum ambient temperature of **104 deg F (40 deg C)**.
 - e. BIL: [60][75][95][110][150][200] kV.
 - f. Full-Capacity Voltage Taps:
 - 1) Four nominal 2.5 percent taps, two above and two below rated primary voltage; with externally operable tap changer for de-energized use and with position indicator and padlock hasp.
 - 2) Four nominal 2.5 percent taps below rated primary voltage, with externally operable tap changer for de-energized use and with position indicator and padlock hasp.
 - g. Cooling System: [Class ONAN, liquid cooled][Class ONAN/ONAF, liquid cooled, and with forced-air rating][Class ONAN/OFAP, liquid cooled, and with provisions for future forced-air rating]. Cooling systems must include auxiliary cooling equipment, automatic controls, and status indicating lights.

h. Impedance: **<Insert number>** percent.

L. Dry-Type Medium-Voltage Transformer Section :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[Eaton]**
 - c. **[Hitachi Energy USA Inc.; business of Hitachi, Ltd.]**
 - d. **[Siemens Industry, Inc., Energy Management Division]**
 - e. **[Square D; Schneider Electric USA]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Eaton]**
 - c. **[Hitachi Energy USA Inc.; business of Hitachi, Ltd.]**
 - d. **[Siemens Industry, Inc., Energy Management Division]**
 - e. **[Square D; Schneider Electric USA]**
 - f. **<Insert manufacturer's name>**
3. Standard Features:
 - a. IEEE C57.12.01 and IEEE C57.12.51, dry-type, two-winding, secondary unit substation transformer.
 - b. Primary Incoming Section: Transformer cover-mounted bushings. The bushings must meet thermal, mechanical, and dielectric requirements as specified for transformer section.
 - c. Style:
 - 1) **[Indoor, ventilated][Outdoor, ventilated][Totally enclosed, nonventilated]**, cast coil/encapsulated coil, with primary and secondary windings individually cast in epoxy; with insulation system rated at 185 deg C with an 80 deg C average winding temperature rise above a maximum ambient temperature of **104 deg F (40 deg C)**.
 - 2) **[Indoor, ventilated][Outdoor, ventilated][Totally enclosed, nonventilated]**, vacuum-pressure, impregnated type, and with insulation system rated at 220 deg C with an 80 deg C average winding temperature rise above a maximum ambient temperature of **104 deg F (40 deg C)**.
 - d. Cooling System:
 - 1) Class AA, air cooled, complying with IEEE C57.12.01.
 - 2) Class AFA, air cooled with forced-air rating, complying with IEEE C57.12.01.
 - a) Manual forced-air cooling system controls, including manual switch for fans, fan controller and associated power and control wiring, and power panel with current-limiting fuses.
 - b) Include mounting provision for fans.
 - 3) Class AA/AFA, air cooled with provisions for future forced-air rating, complying with IEEE C57.12.01.



- a) Automatic forced-air cooling system controls, including thermal sensors, fans, control wiring, temperature controller with test switch, power panel with current-limiting fuses, indicating lights, alarm, and alarm-silencing relay.
 - b) Include mounting provision for fans.
- 4) Class AFA, forced-air cooling, complying with IEEE C57.12.01.
 - a) Automatic forced-air cooling system controls, including thermal sensors, fans, control wiring, temperature controller with test switch, power panel with current-limiting fuses, indicating lights, alarm, and alarm-silencing relay.
 - b) Include cooling fans.
- e. Insulation Materials: IEEE C57.12.01, rated **[220]<Insert number> deg C**.
- 1) Insulation Temperature Rise: **[80][115][150] deg C** maximum rise above **104 deg F (40 deg C)**.
- f. BIL: **[60][75][95][110][150][200] kV**.
- g. Full-Capacity Voltage Taps:
 - 1) Four nominal 2.5 percent taps, two above and two below rated primary voltage.
 - 2) Four nominal 2.5 percent taps below rated primary voltage.
- h. Impedance: **<Insert number> percent**.
- i. High-Temperature Alarm: Sensor at transformer with local audible and visual alarm and contacts for remote alarm.

M. Secondary Distribution Terminal Compartment Section :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[Eaton]**
 - c. **[Hitachi Energy USA Inc.; business of Hitachi, Ltd.]**
 - d. **[Siemens Industry, Inc., Energy Management Division]**
 - e. **[Square D; Schneider Electric USA]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Eaton]**
 - c. **[Hitachi Energy USA Inc.; business of Hitachi, Ltd.]**
 - d. **[Siemens Industry, Inc., Energy Management Division]**
 - e. **[Square D; Schneider Electric USA]**
 - f. **<Insert manufacturer's name>**
3. Standard Features:
 - a. Low-Voltage Terminal Compartment: Bus **[bars mounted on standoff insulators][duct**

flange for close coupling with busway].

N. Secondary Distribution Switchgear Section :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[Eaton]**
 - c. **[Hitachi Energy USA Inc.; business of Hitachi, Ltd.]**
 - d. **[Siemens Industry, Inc., Energy Management Division]**
 - e. **[Square D; Schneider Electric USA]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Eaton]**
 - c. **[Hitachi Energy USA Inc.; business of Hitachi, Ltd.]**
 - d. **[Siemens Industry, Inc., Energy Management Division]**
 - e. **[Square D; Schneider Electric USA]**
 - f. **<Insert manufacturer's name>**
3. Standard Features:
 - a. The secondary distribution section must be drawout, **[fused][fused where indicated]**, low-voltage switchgear, complying with IEEE C37.20.1 and UL 1558.
 - 1) Section barriers between main and tie circuit-breaker compartments must be extended to rear of section.
 - b. Switchgear Structure:
 - 1) Match and align front and back of switchgear.
 - 2) Isolate line bus from load bus at each main and tie circuit breaker with bus isolation barriers.
 - 3) Allow the following circuit-breaker functions to be performed when compartment door is closed:
 - a) Operate manual charging system.
 - b) Open and close circuit breaker.
 - c) Examine and adjust trip unit.
 - d) Read breaker nameplate.
 - 4) Locate instrumentation transformers within breaker cell, and make front accessible and removable.
 - c. Switchgear Bus:
 - 1) Use bus bars to connect compartments and vertical sections. Cable connections are not permitted.
 - 2) Main Phase Bus: Uniform capacity the entire length of section.

- 3) Neutral Bus: **[50][100]** percent of phase-bus ampacity, except as indicated. Equip bus with pressure-connector terminations for outgoing circuit neutral conductors. Include braces for neutral-bus extensions for busway feeders.
 - 4) Vertical Section Bus Size: Comply with IEEE C37.20.1, including allowance for spare circuit breakers and spaces for future circuit breakers.
 - 5) Phase- and Neutral-Bus Material:
 - a) Hard-drawn copper of 98 percent minimum conductivity, with copper feeder circuit-breaker line connections.
 - b) Silver- or tin-plated, high-strength, electrical-grade aluminum alloy, with copper or tin-plated aluminum circuit-breaker line connections.
 - c) Hard-drawn copper of 98 percent minimum conductivity or tin-plated, high-strength, electrical-grade aluminum alloy.
 - 6) Use silver-plated copper or tin-plated aluminum for connecting circuit-breaker line to aluminum bus.
 - 7) Use copper for connecting circuit-breaker line to copper bus.
 - 8) Contact Surfaces of Buses: Silver plated.
 - 9) Feeder Circuit-Breaker Load Terminals: Silver-plated copper bus extensions equipped with pressure connectors for outgoing circuit conductors.
 - 10) Ground Bus: Hard-drawn copper of 98 percent minimum conductivity, with pressure connector for feeder and branch-circuit ground conductors, minimum size **1/4 by 2 inch (6 by 50 mm)**.
 - 11) Neutral bus equipped with pressure-connector terminations for outgoing circuit neutral conductors. Neutral-bus extensions for busway feeders are braced.
 - 12) Neutral Disconnect Link: Bolted, uninsulated, **1/4 by 2 inch (6 by 50 mm)** copper bus, arranged to connect neutral bus to ground bus.
 - 13) Provide for future extensions from either end of main phase, neutral, and ground bus by means of predrilled bolt-holes and connecting links.
 - 14) Bus-Bar Insulation: Individual bus bars wrapped with factory-applied, flame-retardant tape or spray-applied, flame-retardant insulation.
 - 15) Sprayed Insulation Thickness: **3 mils (0.08 mm)**, minimum.
 - 16) Bolted Bus Joints: Insulate with secure joint covers that can easily be removed and reinstalled.
- d. Circuit-Breaker Compartment:
- 1) Drawout Features: Circuit-breaker mounting assembly equipped with a racking mechanism to position circuit breaker and hold it rigidly in "connected," "test," and "disconnected" positions. Include the following features:
 - a) Interlocks: Prevent movement of circuit breaker to or from "connected" position when it is closed, and prevent closure of circuit breaker unless it is in "connected," "test," or "disconnected" position.
 - b) Primary Disconnect: Mount on stationary part of compartment. The disconnect must consist of a set of contacts extending to rear through an insulating support barrier, and of corresponding moving finger contacts on power circuit-breaker studs, which engage in only "connected" position. The assembly must provide multiple silver-to-silver full floating, spring-loaded, high-pressure-point contacts with uniform pressure on each finger. Load studs must connect to bus extensions that terminate in solderless terminals in rear cable compartment.
 - c) Secondary Disconnect: Floating terminals mounted on stationary part of compartment that engage mating contacts at front of breaker. Disconnecting devices must be gold plated, and engagement must be maintained in

"connected" and "test" positions.

- e. Circuit-Breaker Positioning: Permit racking of an open circuit breaker to or from "connected," "test," and "disconnected" positions only when compartment door is closed unless live parts are covered by a full dead-front shield. Permit manual withdrawal of an open circuit breaker to a position for removal from structure. When compartment door is open, status for connection devices for different positions includes the following:
 - 1) Test Position: Primary disconnects disengaged, and secondary disconnect devices and ground contact engaged.
 - 2) Disconnected Position: Primary and secondary devices and ground contact disengaged.
- f. Circuit Breakers:
 - 1) Comply with IEEE C37.13 and UL 1066.
 - 2) Ratings: Continuous, interrupting, and short-time current ratings for each circuit breaker must match voltage and frequency ratings for switchgear.
 - 3) Operating Mechanism: Mechanically and electrically trip-free, stored-energy operating mechanism with the following features:
 - a) Normal Closing Speed: Independent of both control and operator.
 - b) Slow Closing Speed: Optional with operator for inspection and adjustment.
 - c) Stored-Energy Mechanism: **[Manually charged][Electrically charged][Electrically charged, and operator's choice of manual charging]**.
 - d) Operating Handle: One for each circuit breaker capable of manual operation.
 - e) Electric Close Button: One for each electrically operated circuit breaker.
 - f) Operation counter.
 - 4) Trip Devices: Solid-state, overcurrent trip-device system consisting of one or two current transformers or sensors per phase, a release mechanism, and the following features:
 - a) Functions: Long-time-delay, short-time-delay, and instantaneous-trip functions, independent of each other in both action and adjustment.
 - b) Temperature compensation that ensures accuracy and calibration stability from **plus 23 to 104 deg F (minus 5 to plus 40 deg C)**.
 - c) Field-adjustable, time-current characteristics.
 - d) Current Adjustability: Dial settings and rating plugs on trip units, or sensors on circuit breakers, or a combination of these methods.
 - e) Three bands, minimum, for long-time- and short-time-delay functions; marked "minimum," "intermediate," and "maximum."
 - 5) Pickup Points:
 - a) Five minimum, for long-time- and short-time-trip functions. Equip short-time-trip function for switchable I-squared-t operation.
 - b) Five minimum, for instantaneous-trip functions.
 - 6) Ground-fault protection with at least three short-time-delay settings and three trip-time-delay bands; adjustable current pickup.
 - a) Arrange to provide protection for three-wire circuit or system.
 - b) Arrange to provide protection for four-wire circuit or system.
 - c) Arrange to provide protection for four-wire, double-ended substation.



- 7) Trip Indication: Labeled, battery-powered lights or mechanical targets on trip device to indicate type of fault.
 - 8) Auxiliary Contacts:
 - a) Contacts and switches required for normal circuit-breaker operation, sufficient for interlocking and remote indication of circuit-breaker position.
 - b) Spare auxiliary switches, at least two, unless other quantity is indicated. Each switch must consist of two Type A and two Type B contacts wired through secondary disconnect devices to a terminal block in stationary circuit-breaker compartment.
 - 9) Arc Chutes: Readily removable from associated circuit breaker when it is in "disconnected" position, and arranged to permit inspection of contacts without removing circuit breaker from switchgear.
 - 10) Padlocking Provisions: For installing at least three padlocks on each circuit breaker to secure its enclosure and prevent movement of drawout mechanism.
- g. Mechanical Interlocking of Circuit Breakers: Uses a mechanical tripping lever or equivalent design and electrical interlocks.
- h. Key Interlocks: Arranged to prevent opening or closing interlocked circuit breakers, except in a specified sequence. Include mountings and hardware for future installation of key interlocks.
- i. Undervoltage Trip Devices:
- 1) Instantaneous, with adjustable pickup voltage.
 - 2) Adjustable time-delay and pickup voltage.
- j. Shunt-trip devices.
- k. Fused Circuit Breakers: Circuit-breaker and fuse combinations complying with requirements for circuit breakers and trip devices.
- 1) Fuses: NEMA FU 1, Class L current limiting, sized to coordinate with and protect associated circuit breaker.
 - 2) Circuit Breakers with Frame Size **[1600]<Insert number> A and Smaller**: Mount fuses on line side of associated circuit breaker, **on a common drawout carriage**, arranged so fuses are accessible only when circuit breaker is in "disconnected" position.
 - 3) Circuit Breakers with Frame Sizes More than **[1600]<Insert number> A**: Fuses and circuit breakers **[may][must]** be installed in separate compartments on separate drawout mountings. Interlock fuse drawout element with associated power circuit breaker to prevent drawing out fuse element unless circuit breaker is in "open" position.
 - 4) Open-Fuse Trip Device: Provide for a positive means of tripping and holding circuit breaker in "open" position when a fuse opens. Indicate open-fuse status **[at front of circuit breaker][or][fuse drawout element]**.
- l. Indicating Lights: To indicate circuit breaker is open or closed, for main and bus tie circuit breakers interlocked either with each other or with external devices.

O. Secondary Distribution Network Protectors Section :

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

- a. [ABB, Electrification Business]
 - b. [Eaton]
 - c. [Hitachi Energy USA Inc.; business of Hitachi, Ltd.]
 - d. [Siemens Industry, Inc., Energy Management Division]
 - e. [Square D; Schneider Electric USA]
 - f. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [ABB, Electrification Business]
 - b. [Eaton]
 - c. [Hitachi Energy USA Inc.; business of Hitachi, Ltd.]
 - d. [Siemens Industry, Inc., Energy Management Division]
 - e. [Square D; Schneider Electric USA]
 - f. <Insert manufacturer's name>
3. Standard Features:
 - a. The secondary distribution section must be composed of drawout, fused, low-voltage network protectors, complying with IEEE C57.12.44 and IEEE C37.20.1. The switch must comply with UL 1066.
 - 1) Rated for continuous service in an ambient temperature of up to **104 deg F (40 deg C)**, applied to three-phase, four-wire, solidly grounded wye secondary networks. Comply with IEEE C57.12.44.
 - 2) Dead-front, drawout design with externally mounted fuses, using hand-cranked rail system. Include mechanical interlocks to prevent racking in and racking out when protector is closed.
 - 3) Locate relay and control panel on a separate drawout module.
 - 4) Protector Operator: [**Spring-close**][and][or][**stored-energy**] mechanism, rated to close on a [**25 000**][**40 000**] A RMS symmetrical load.
 - 5) Control Voltage: 125 V.
 - 6) Program relay with factory default values. Provide one hand-held pendant to field adjust these values using relay calibration procedures. Include an anti-pumping program to lock protector open under abnormal conditions.
 - 7) Include current-limiting fuses on network side of protector for protection against switchboard bus faults.
 - b. Coordinate and comply with requirements of low-voltage switchgear supplied by network.
 - c. Controls: Microprocessor-based, three-phase network relay, with features and functions as follows:
 - 1) The protector control must use a positive and negative sequence-based algorithm for current and voltage.
 - 2) Close protector if positive sequence power flows into network. Adjustable closing range must be from 0.5 to 3.5 V in phase difference between network and transformer voltages.
 - 3) Trip protector if there is a net, three-phase, reverse power flow through protector. Trip protectors must be adjustable from 0.05 to 5 percent of continuous-current rating of current transformers within protector.
 - 4) Trip protector if there is a flow of reverse magnetizing current to its associated transformer.
 - 5) Relay parameters and watt or watt-var trip values must be field adjustable.
 - 6) Protector must not open under any fault on network side of protector.



- 7) Include auxiliary contacts and control wiring for use with remote pilot devices that provide remote trip and lockout functions in low-voltage switchgear. Include **[two]<Insert number>** spare auxiliary contacts and an equal number of N.O. and N.C. types.
- d. Network Communications: Data and digital data-transmission interface must be compatible with system specified in Section 260913 "Electrical Power Monitoring." Communicate the following network relay parameters:
 - 1) Current in each phase.
 - 2) Phase-to-phase and phase-to-neutral voltages.
 - 3) Three-phase watts, VARs, and VA.
 - 4) Frequency.
 - 5) Power factor.
 - 6) Network relay set points.
- e. Enclosure:
 - 1) With top-mounted transition to connect to low-voltage power network.
 - 2) Network Switchgear-Mounted Disconnect Switch:
 - a) Supply each network-protector circuit with a switchgear-mounted fuse truck, with Class L fuses rated for 200 kA interrupting capacity and key interlocked with each associated protector.
 - b) Supply each network-protector circuit with a switchgear-mounted main circuit breaker rated for fault current that can be delivered by network transformers, less one. Use drawout type to provide a means of isolating load side of each protector from network bus.

P. Secondary Distribution Low-Voltage Instrument Section :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[Eaton]**
 - c. **[Hitachi Energy USA Inc.; business of Hitachi, Ltd.]**
 - d. **[Siemens Industry, Inc., Energy Management Division]**
 - e. **[Square D; Schneider Electric USA]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Eaton]**
 - c. **[Hitachi Energy USA Inc.; business of Hitachi, Ltd.]**
 - d. **[Siemens Industry, Inc., Energy Management Division]**
 - e. **[Square D; Schneider Electric USA]**
 - f. **<Insert manufacturer's name>**
3. Standard Features:

- a. Instrument Transformers: Comply with IEEE C57.13.
 - 1) Potential Transformers: Secondary voltage rating of 120 V and NEMA C 12.11 Accuracy Class of 0.3 with burdens of W, X, and Y.
 - 2) Current Transformers: Burden and Accuracy Class suitable for connected relays, meters, and instruments.
- b. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems.
 - 1) Inputs from sensors or 5 A current-transformer secondaries, and potential terminals rated to 600 V.
 - 2) Switch-selectable digital display with the following features:
 - a) Phase Currents, Each Phase: Plus or minus 1 percent.
 - b) Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
 - c) Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
 - d) Three-Phase Real Power: Plus or minus 2 percent.
 - e) Three-Phase Reactive Power: Plus or minus 2 percent.
 - f) Power Factor: Plus or minus 2 percent.
 - g) Frequency: Plus or minus 0.5 percent.
 - h) Integrated Demand, with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
 - i) Accumulated energy, in **MWh (MJ)**, plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.
 - 3) Communications module suitable for remote monitoring of meter quantities and functions. Interface communication and metering requirements in accordance with Section 260913 "Electrical Power Monitoring."
 - 4) Mounting: Display and control unit that is flush or semiflush mounted in instrument compartment door.
- c. Analog Instruments: Rectangular, **4-1/2 inch (115 mm)** square, 1 percent accuracy, semiflush mounting, with antiparallax 250-degree scale and external zero adjustment.
 - 1) Voltmeters: Cover an expanded scale range of normal voltage plus 10 percent.
 - 2) Voltmeter Selector Switch: Rotary type with "off" position to provide readings of phase-to-phase[**and phase-to-neutral**] voltages.
 - 3) Ammeters: Cover an expanded scale range of bus rating plus 10 percent.
 - 4) Ammeter Selector Switch: Permits current reading in each phase and keeps current-transformer secondary circuits closed in "off" position.
 - 5) Locate meter and selector switch on circuit-breaker compartment door for indicated feeder circuits only.
 - 6) Watt-Hour Meters: Flush- or semiflush-mounting type, 5 A, 120 V, three phase, three wire; with three elements, 15-minute indicating demand register, and provision for testing and adding pulse initiation.
 - 7) Recording Demand Meter: Usable as totalizing relay or indicating and recording maximum demand meter with 15-minute interval.
 - a) Operation: Counts and records a succession of pulses entering two channels.
 - b) Housing: Drawout, back-connected case arranged for semiflush mounting.
- d. Relays: Comply with IEEE C37.90, types and settings as indicated; with test blocks and plugs.
- e. Surge Suppression:



- 1) Factory installed as an integral part of low-voltage switchgear, complying with UL 1449 SPD, Type 1, with the following features and accessories:
 - a) Integral disconnect switch.
 - b) Internal thermal protection that disconnects SPD before damaging internal suppressor components.
 - c) Indicator light display for protection status.
 - d) Form-C contacts rated at 5 A 250 V(ac), one N.O. and one N.C., for remote monitoring of protection status. [**Contacts must reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.**]
 - e) Surge counter.
- 2) Field-mounted surge suppressors complying with Section 264313 "Surge Protective Devices for Low-Voltage Electrical Power Circuits." Include the following features and accessories:
 - a) Integral disconnect switch.
 - b) Internal thermal protection that disconnects SPD before damaging internal suppressor components.
 - c) Indicator light display for protection status.
 - d) Form-C contacts rated at 5 A 250 V(ac), one N.O. and one N.C., for remote monitoring of protection status. [**Contacts must reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.**]
 - e) Surge counter.
- f. Control Power Supply:
 - 1) From medium-voltage instruments section.
 - 2) Control power transformer supplying 120 V control circuits through secondary disconnect devices.
- g. Control Wiring: Factory installed, complete with bundling, lacing, and protection; and complying with the following:
 - 1) Flexible conductors for 8 AWG and smaller, for conductors across hinges and for conductors for interconnections between shipping units.
 - 2) Conductors sized in accordance with NFPA 70 for duty required.

2.3 MAINTENANCE MATERIAL ITEMS

- A. Spare Parts: Furnish to Owner spare parts, for repairing secondary unit substation, that are packaged with protective covering for storage on-site and identified with labels describing contents. [**Include the following:**]
 1. Spare Fuses: [Six]<Insert number> of each type and rating of fuse and fusible device used, except for medium-voltage fuses [**and fuses associated with network protector**]. Include spares for the following:
 - a. Fuses: Sizes recommended by secondary unit substation manufacturer, considering fan cooling, temperature-rise specification, and cycle loading.
 - 1) Current-Limiting Fuses: Full-range, fast-replaceable, current-limiting type that will

- operate without explosive noise or expulsion of gas, vapor, or foreign matter from tube.
 - 2) Expulsion Fuses: Furnished in disconnect-type mountings and renewable with replacement fuse units. Gases emitted on interruption are controlled and silenced by chambers designed for that purpose.
 - 3) Indicator integral with each fuse to show when it has blown.
 - 4) Spares: Include three fuses in use and three spare fuses in storage clips in each switch.
 2. Spare Indicating Lights: Six of each type installed.
 3. **[One]<Insert number>** set(s) of spare mounting gaskets for bushings, handholes, and gasket between relief cover and flange of pressure-relief device.
- B. Special Tools: Furnish to Owner proprietary equipment, keys, and software required to operate, maintain, repair, adjust, or implement future changes to secondary unit substation, that are packaged with protective covering for storage on-site and identified with labels describing contents. **[Include the following:]**
1. Control-power battery hoist.
 2. Switchgear Circuit-Breaker Test Cabinet:
 - a. Separately mounted.
 - b. Containing push buttons for circuit-breaker closing and tripping, control relay, fuses, and secondary coupler with cable approximately **108 inch (2740 mm)** long.
 - c. Include secondary devices for operating circuit breaker if removed from switchgear and moved near test cabinet.
 - d. Include provision for storage of test and maintenance accessories in cabinet.
 3. Switchgear Maintenance Tools: Furnish tools and miscellaneous items required for switchgear test, inspection, maintenance, and operation.
 - a. Fuse-handling tool.
 - b. Relay and meter test plugs.
 - c. Extension rails, lifting device, transport or dockable dolly or mobile lift, and all other items necessary to remove circuit breaker from housing and transport to remote location.
 - d. Racking handle to move circuit breaker manually between "connected" and "disconnected" positions, and a secondary test coupler to permit testing of circuit breaker without removal from switchgear.
 4. Transformer Accessories Set: Grounding pads, lifting lugs, and provisions for jacking under base. Transformers must have a steel base and frame allowing use of pipe rollers in any direction, and an insulated, low-voltage, neutral bushing with removable ground strap. **[Include the following additional accessories:]**
 - a. Liquid-level gauge.
 - b. Pressure-vacuum gauge.
 - c. Liquid temperature indicator.
 - d. Drain and filter valves.
 - e. Pressure-relief device.
 5. Low-Voltage Instruments Maintenance Tools: Furnish tools and miscellaneous items required for circuit-breaker and switchgear test, inspection, maintenance, and operation.
 - a. Racking handle to manually move circuit breaker between "connected" and "disconnected" positions.
 - b. Portable test set for testing all functions of circuit-breaker, solid-state trip devices without

- removal from switchgear.
- c. Relay and meter test plugs suitable for testing switchgear meters and switchgear class relays.
- d. Circuit-Breaker Removal Apparatus:
 - 1) Portable, floor-supported, roller-base, elevating carriage arranged for moving circuit breakers in and out of compartments.
 - 2) Overhead-circuit-breaker lifting device, track mounted at top front of switchgear and complete with hoist and lifting yokes matching each size of drawout circuit breaker installed.
- e. Spare-Fuse Cabinet: Identified and compartmented steel box or cabinet with lockable door.
- f. Storage for Manual: Include a rack or holder, near operating instructions, for a copy of maintenance manual.

C. Consumable Items:

- 1. After completion of field quality control, startup, commissioning, adjusting, and closeout activities, replace air filters and refill fuel tanks and fluid reservoirs.
- 2. Furnish to Owner extra consumable items for storage on-site, identified with labels describing contents.[**Include the following:**]
 - a. Touchup Paint: **[Three]<Insert number>** half-pint containers of paint matching enclosure's exterior finish.
 - b. Primary Switch Contact Lubricant: **[One]<Insert number>** container(s).

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and space conditions for compliance with requirements for secondary unit substations and other conditions affecting performance of the Work.
- B. Examine roughing-in of conduits and grounding systems to verify the following:
 - 1. Wiring entries comply with layout requirements.
 - 2. Entries are within conduit-entry tolerances specified by manufacturer, and no feeders will have to cross section barriers to reach load or line lugs.
- C. Examine walls, floors, roofs, and concrete bases for suitable conditions for secondary unit substation installation.
- D. Verify that ground connections are in place and that requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance must be 5 Ω at secondary unit substation location.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF SECONDARY UNIT SUBSTATIONS

- A. Comply with manufacturer's published instructions.

- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:
1. Electrical Construction: ICC IBC, ICC IFB, NFPA 1, NFPA 70, and NECA NEIS 1.
 2. Electrical Maintenance: NFPA 70B.
 3. Electrical Safety: NFPA 70E.
 4. Commissioning of Electrical Systems: NECA NEIS 90.
 5. Hot Work: NFPA 51B.
 6. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
 7. Communications Work: BICSI N1.
 8. Emergency and Standby Power Work: NFPA 110, NFPA 111, and NECA NEIS 416.
 9. Work in Confined Spaces: NFPA 350.
 10. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
 11. Evaluation of Unlabeled Electrical Equipment: NFPA 791.
 12. Installation of Switchboards: NECA NEIS 400.
 13. Installation of Liquid-Filled Transformers: NECA NEIS 410.
 14. Installation of Medium-Voltage Metal-Clad Switchgear: NECA NEIS 430.
 15. Installation and Maintenance of AC Outdoor High-Voltage Circuit Breakers: NEMA SG 11.
 16. Consult Architect for resolution of conflicting requirements.
- C. Special Installation Techniques:
1. Maintain minimum clearances and workspace at equipment in accordance with manufacturer's instructions and NFPA 70.
- D. Interfaces with Other Work:
1. Identification: Provide signs and labels for secondary unit substation and associated electrical equipment.
 - a. Identify field-installed conductors, interconnecting wiring, and components.
 - b. Label each enclosure with engraved metal or laminated-plastic nameplate.
 - c. Provide warning signs and arc-flash hazard warning labels for electrical equipment.
 - d. Install number of signs required to be readable from each accessible side, but space signs a maximum of **30 ft (9 m)** apart.
 - e. Operating Instructions: Place printed operating instructions for secondary unit substations, including key interlocking, control sequences, elementary single-line diagram, and emergency procedures with maintenance materials.
 2. Install secondary unit substations on concrete equipment base(s).
 3. Provide vibration isolation and seismic control devices.
 4. Grounding and Bonding:
 - a. At Interior Locations: For grounding to grounding electrodes, use bare copper cable not smaller than 4/0 AWG. Bond surge arrester and neutrals directly to transformer enclosure and then to grounding electrode system with bare copper conductors. Keep leads as short as practicable with no kinks or sharp bends. Make joints in grounding conductors and loops by exothermic weld or compression connector.
 - b. At Exterior Locations:
 - 1) For counterpoise, use tinned bare copper cable not smaller than 4/0 AWG, buried not less than **30 inch (765 mm)** below grade interconnecting grounding electrodes. Bond surge arrester and neutrals directly to transformer enclosure and then to grounding electrode system with bare copper conductors, sized as indicated. Keep lead lengths as short as practicable with no kinks or sharp bends.
 - 2) Fence and equipment connections must not be smaller than 4 AWG. Ground fence



at each gate post and corner post and at intervals not exceeding 10 ft (3 m). Bond each gate section to fence post using 1/8 by 1 inch (3 by 25 mm) [tinned]flexible braided copper strap and clamps.

- 3) Make joints in grounding conductors and loops by exothermic weld or compression connector.

5. Connect feeder, branch-circuit, and instrumentation wiring.

3.3 FIELD QUALITY CONTROL

A. Administrant for Electrical Power Tests and Inspections:

1. [Owner][Tenant] will engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
2. Engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].

B. Field tests must be witnessed by [Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>.

C. General Field Testing Requirements:

1. Comply with provisions of NFPA 70B, "Testing and Test Methods" Chapter.
2. Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.
3. After installing secondary unit substation but before primary is energized, verify that grounding system at substation is tested at specified value or less.
4. After installing secondary unit substation and after electrical circuitry has been energized, test for compliance with requirements.
5. Visual and Mechanical Inspection:
 - a. Verify equipment nameplate data complies with Contract Documents.
 - b. Inspect bolted electrical connections for high resistance using one of the following two methods:
 - 1) Use a low-resistance ohmmeter to compare bolted-connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of lowest value.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels must be in accordance with manufacturer's published data. In absence of manufacturer's published data, use NETA ATS, Table 100.12.
6. Remove and replace malfunctioning units and retest.
7. Prepare test and inspection reports. Record as-left set points of all adjustable devices.

D. Switchgear Field Tests:

1. Visual and Mechanical Inspection:

- a. Inspect physical and mechanical condition.
- b. Inspect anchorage, alignment, grounding, and required area clearances.
- c. Verify unit is clean and shipping bracing, loose parts, and documentation shipped inside cubicles have been removed.
- d. Verify that fuse and circuit-breaker sizes and types correspond to Drawings and coordination study as well as to address of circuit breaker that is used to identify it in microprocessor-communication software.
- e. Verify that current and voltage-transformer ratios correspond to Drawings.
- f. Confirm correct operation and sequencing of electrical and mechanical interlock systems.
 - 1) Attempt closure on locked-open devices. Attempt to open locked-closed devices.
 - 2) Make key exchange with devices operated in off-normal positions.
- g. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
- h. Inspect insulators for evidence of physical damage or contaminated surfaces.
- i. Verify correct barrier and shutter installation and operation.
- j. Exercise all active components.
- k. Inspect mechanical indicating devices for correct operation.
- l. Verify that filters are in place and vents are clear.
- m. Inspect control power transformers as follows:
 - 1) Inspect for physical damage, cracked insulation, broken leads, connection tightness, defective wiring, and overall general condition.
 - 2) Verify that primary- and secondary-fuse or circuit-breaker ratings match Drawings and comply with manufacturer's published instructions.
 - 3) Verify correct functioning of drawout disconnecting and grounding contacts and interlocks.

2. Electrical Tests:

- a. Perform DC voltage insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground, for one minute. If temperature of bus is other than plus or minus 20 deg C, adjust resulting resistance as provided in NETA ATS, Table 100.11.
 - 1) Insulation-resistance values of bus insulation must be in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's published instructions or NETA ATS, Table 100.1.
 - 2) Do not proceed to dielectric-withstand-voltage tests until insulation-resistance levels are raised above minimum values.
- b. Perform a dielectric-withstand-voltage test on each bus section, each phase-to-ground with phases not under test grounded, in accordance with manufacturer's published data. If manufacturer has no recommendation for this test, conduct it in accordance with NETA ATS, Table 100.2. Apply test voltage for one minute.
 - 1) If no evidence of distress or insulation failure is observed by end of total time of voltage application during dielectric-withstand-voltage test, test specimen is considered to have passed test.
- c. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential must be 500 V(dc) for 300 V rated cable and 1000 V(dc) for 600 V rated cable. Test duration must be one minute. For units with solid-state components or control devices that cannot tolerate applied voltage, follow manufacturer's published instructions.

- 1) Minimum insulation-resistance values of control wiring must not be less than 2 MΩ.
 - d. Voltage Transformers:
 - 1) Perform secondary wiring integrity test. Verify correct potential at all devices.
 - 2) Verify secondary voltages by energizing primary winding with system voltage.
 - e. Perform current-injection tests on entire current circuit in each section of switchgear.
 - 1) Perform current tests by secondary injection with magnitudes such that a minimum current of 1.0 A flows in secondary circuit. Verify correct magnitude of current at each device in circuit.
 - 2) Perform current tests by primary injection with magnitudes such that a minimum of 1.0 A flows in secondary circuit. Verify correct magnitude of current at each device in circuit.
 - f. Verify operation of space heaters.
 - g. Perform phasing checks on double-ended or dual-source switchgear to ensure correct bus phasing from each source.
- E. Medium-Voltage Surge Arrester Field Tests:
1. Visual and Mechanical Inspection:
 - a. Inspect physical and mechanical condition.
 - b. Inspect anchorage, alignment, grounding, and clearances.
 - c. Verify arresters are clean.
 - d. Verify that ground lead on each device is individually attached to a ground bus or ground electrode.
 - e. Verify that stroke counter is correctly mounted and electrically connected if applicable. Record stroke counter reading.
 2. Electrical Tests:
 - a. Perform an insulation-resistance test on each arrester, phase terminal-to-ground. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Replace units that fail to meet recommended minimum insulation resistance listed in table.
 - b. Perform a watts-loss test. Evaluate watts-loss values by comparison with similar units and test equipment manufacturer's published data.
- F. Medium-Voltage Vacuum Circuit Breaker Field Tests:
1. Visual and Mechanical Inspection:
 - a. Inspect physical and mechanical condition.
 - b. Inspect anchorage, alignment, grounding, and required clearances.
 - c. Verify that maintenance devices such as special tools and gauges specified by manufacturer are available for servicing and operating breaker.
 - d. Verify unit is clean.
 - e. Perform mechanical operation tests on operating mechanism in accordance with manufacturer's published data.
 - f. Measure critical distances on operating mechanism in accordance with manufacturer's published instructions. Critical distances of operating mechanism must be in accordance with manufacturer's published data.

- g. Verify cell fit and element alignment.
- h. Verify racking mechanism operation.
- i. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
- j. Perform time-travel analysis. Travel and velocity values must be in accordance with manufacturer's published data.
- k. Record as-found and as-left operation counter reading. Operation counter must advance one digit per close-open cycle.

2. Electrical Tests:

- a. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Insulation-resistance values must be in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than this table or manufacturer's published instructions. Dielectric-withstand-voltage tests must not proceed until insulation-resistance levels are raised above minimum values.
- b. Perform a contact/pole-resistance test. Compare bolted-connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of lowest value. Microhm or DC millivolt drop values must not exceed high levels of normal range as indicated in manufacturer's published data. If manufacturer's published data is not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of lowest value.
- c. Perform minimum pickup voltage tests on trip and close coils in accordance with manufacturer's published data. Minimum pickup voltage of trip and close coils must comply with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.20.
- d. Verify correct operation of any auxiliary features, such as electrical close and trip operation, trip-free operation, and anti-pump function. Auxiliary features must operate in accordance with manufacturer's published data.
- e. Trip circuit breaker by operation of each protective device. Reset all trip logs and indicators.
- f. Perform power-factor or dissipation-factor tests on each pole with breaker open and each phase with breaker closed. Power-factor or dissipation-factor values must meet manufacturer's published data.
- g. Perform vacuum bottle integrity (dielectric-withstand-voltage) test across each vacuum bottle, with contacts in "open" position in accordance with manufacturer's published data. If no evidence of distress or insulation failure is observed by end of total time of voltage application during vacuum bottle integrity test, test specimen is considered to have passed test.
- h. Perform a dielectric-withstand-voltage test in accordance with manufacturer's published data. If no evidence of distress or insulation failure is observed by end of total time of voltage application during dielectric-withstand-voltage test, test specimen is considered to have passed test.
- i. Verify operation of heaters.

G. Instrument Transformer Field Tests:

1. Visual and Mechanical Inspection:

- a. Inspect physical and mechanical condition.
- b. Verify correct connection of transformers with system requirements.
- c. Verify that adequate clearances exist between primary and secondary circuit wiring.

- d. Verify unit is clean.
- e. Verify that required grounding and shorting connections provide contact.
- f. Verify correct operation of transformer withdrawal mechanism and grounding operation.
- g. Verify correct primary- and secondary-fuse sizes for voltage transformers.
- h. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

2. Electrical Tests of Current Transformers:

- a. Perform insulation-resistance test of each current transformer and its secondary wiring with respect to ground at 1000 V(dc) for one minute. For units with solid-state components that cannot tolerate applied voltage, comply with manufacturer's published instructions. Insulation-resistance values of instrument transformers must not be less than values shown in NETA ATS, Table 100.5.
- b. Perform a polarity test of each current transformer in accordance with IEEE C57.13.1. Polarity results must agree with transformer markings.
- c. Perform a ratio-verification test using voltage or current method in accordance with IEEE C57.13.1. Ratio errors must comply with IEEE C57.13.
- d. Perform an excitation test on transformers used for relaying applications in accordance with IEEE C57.13.1. Excitation results must match curve supplied by manufacturer or must comply with IEEE C57.13.1.
- e. Measure current circuit burdens at transformer terminals in accordance with IEEE C57.13.1. The measured burdens must match instrument transformer Accuracy Class rating.
- f. Perform insulation-resistance tests on primary winding with secondary grounded. Test voltages must comply with NETA ATS, Table 100.5. The insulation-resistance value must be in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.5.
- g. Perform dielectric-withstand-voltage tests on primary winding with secondary grounded. Test voltages must comply with NETA ATS, Table 100.9. If no evidence of distress or insulation failure is observed by end of total time of voltage application, primary winding is considered to have passed test.
- h. Perform power-factor or dissipation-factor tests in accordance with test equipment manufacturer's published data. Power-factor or dissipation-factor values must be in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with test equipment manufacturer's published data.
- i. Verify that current-transformer secondary circuits are grounded and have only one grounding point in accordance with IEEE C57.13.3.

3. Electrical Tests of Voltage and Potential Transformers:

- a. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply test voltage for one minute in accordance with NETA ATS, Table 100.5. For units with solid-state components that cannot tolerate applied voltage, follow manufacturer's published instructions. Insulation-resistance values of instrument transformers must be in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.5.
- b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Test voltages must be applied for one minute in accordance with NETA ATS, Table 100.5. Insulation-resistance values of transformers must not be less than values shown in NETA ATS, Table 100.5.
- c. Perform a polarity test on each transformer to verify polarity marks or H(1)-X(1) relationship. Polarity results must agree with transformer markings.
- d. Perform a turns-ratio test on all tap positions. Ratio errors must not exceed tolerances specified in IEEE C57.13.

- e. Measure voltage circuit burdens at transformer terminals. Measured burdens must be compared to instrument transformer ratings. The measured burdens must match instrument transformer Accuracy Class rating.
- f. Perform a dielectric-withstand-voltage test on primary windings with secondary windings connected to ground. The dielectric voltage must comply with NETA ATS, Table 100.9. The test voltage must be applied for one minute. If no evidence of distress or insulation failure is observed by end of total time of voltage application during dielectric-withstand-voltage test, primary windings are considered to have passed test.
- g. Perform power-factor or dissipation-factor tests in accordance with test equipment manufacturer's published data. Power-factor or dissipation-factor values must be in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with test equipment manufacturer's published data.
- h. Verify that voltage-transformer secondary circuits are grounded and have only one grounding point in accordance with IEEE C57.13.3.

H. Microprocessor-Based Protective Relay Field Tests:

1. Visual and Mechanical Inspection:

- a. Record model number, style number, serial number, firmware revision, software revision, and rated control voltage.
- b. Verify operation of light-emitting diodes, display, and targets.
- c. Record passwords for each access level.
- d. Clean front panel and remove foreign material from case.
- e. Check tightness of connections.
- f. Verify that frame is grounded in accordance with manufacturer's published instructions.
- g. Set relay in accordance with results in Section 260573 "Power System Studies."
- h. Download settings from relay. Print a copy of settings for report and compare settings to those specified in coordination study.

2. Electrical Tests:

- a. Perform insulation-resistance tests from each circuit to grounded frame in accordance with manufacturer's published data.
- b. Apply voltage or current to analog inputs, and verify correct registration of relay meter functions.
- c. Functional Operation: Check functional operation of each element used in protection scheme as follows:
 - 1) Timing Relay (IEEE C37.2 Device No. 2):
 - a) Determine time delay.
 - b) Verify operation of instantaneous contacts.
 - 2) Volts Per Hertz Relay (IEEE C37.2 Device No. 24):
 - a) Determine pickup frequency at rated voltage.
 - b) Determine pickup frequency at a second voltage level.
 - c) Determine time delay.
 - 3) Sync Check Relay (IEEE C37.2 Device No. 25):
 - a) Determine closing zone at rated voltage.
 - b) Determine maximum voltage differential that permits closing at zero degrees.
 - c) Determine live line, live bus, dead line, and dead bus set points.
 - d) Determine time delay.

- e) Verify dead bus/live line, dead line/live bus, and dead bus/dead line control functions.
- 4) Undervoltage Relay (IEEE C37.2 Device No. 27):
- a) Determine dropout voltage.
 - b) Determine time delay.
 - c) Determine time delay at a second point on timing curve for inverse time relays.
- 5) Directional Power Relay (IEEE C37.2 Device No. 32):
- a) Determine minimum pickup at maximum torque angle.
 - b) Determine closing zone.
 - c) Determine maximum torque angle.
 - d) Determine time delay.
 - e) Verify time delay at a second point on timing curve for inverse time relays.
 - f) Plot operating characteristic.
- 6) Loss of Excitation/Field Relay (IEEE C37.2 Device No. 40):
- a) Determine maximum reach.
 - b) Determine maximum torque angle.
 - c) Determine offset.
 - d) Plot impedance circle.
- 7) Phase Balance Current Relay (IEEE C37.2 Device No. 46):
- a) Determine pickup of each unit.
 - b) Determine percent slope.
 - c) Determine time delay.
- 8) Negative Sequence Current Relay (IEEE C37.2 Device No. 46):
- a) Determine negative sequence alarm level.
 - b) Determine negative sequence minimum trip level.
 - c) Determine maximum time delay.
 - d) Verify two points on I-two-squared-t curve.
- 9) Phase Sequence or Phase Balance Voltage Relay (IEEE C37.2 Device No. 47):
- a) Determine positive sequence voltage to close N.O. contact.
 - b) Determine positive sequence voltage to open N.C. contact (undervoltage trip).
 - c) Verify negative sequence trip.
 - d) Determine time delay to close N.O. contact with sudden application of 120 percent of pickup.
 - e) Determine time delay to close N.C. contact upon removal of voltage when previously set to rated system voltage.
- 10) Thermal Replica Relay (IEEE C37.2 Device No. 49):
- a) Determine time delay at 300 percent of setting.
 - b) Determine a second point on operating curve.
 - c) Determine pickup.

- 11) RTD Biased Thermal Overload Relay (IEEE C37.2 Device No. 49RTD):
 - a) Determine RTD resistance trip setting.
 - b) Determine RTD resistance reset setting.
- 12) Instantaneous Overcurrent Relay (IEEE C37.2 Device No. 50):
 - a) Determine pickup.
 - b) Determine dropout.
 - c) Determine time delay.
- 13) Time Overcurrent Relay (IEEE C37.2 Device No. 51):
 - a) Determine minimum pickup.
 - b) Determine time delay at two points on time current curve.
- 14) Power-Factor Relay (IEEE C37.2 Device No. 55):
 - a) Determine tripping angle.
 - b) Determine time delay.
- 15) Overvoltage Relay (IEEE C37.2 Device No. 59):
 - a) Determine overvoltage pickup.
 - b) Determine time delay to close contact with sudden application of 120 percent of pickup.
- 16) Voltage Balance Relay (IEEE C37.2 Device No. 60):
 - a) Determine voltage difference to close contacts with one source at rated voltage.
 - b) Plot operating curve for relay.
- 17) Sudden Pressure Relay (IEEE C37.2 Device No. 63):
 - a) Determine rate-of-rise or pickup level of suddenly applied pressure in accordance with manufacturer's published data.
 - b) Verify operation of auxiliary relay (IEEE C37.2 Device No. 63X) seal-in circuit.
 - c) Verify trip circuit to remote operating device.
- 18) Ground Detector Relay (IEEE C37.2 Device No. 64):
 - a) Determine maximum impedance to ground causing relay pickup.
- 19) Directional Overcurrent Relay (IEEE C37.2 Device No. 67):
 - a) Determine directional unit minimum pickup at maximum torque angle.
 - b) Determine closing zone.
 - c) Determine maximum torque angle.
 - d) Plot operating characteristics.
 - e) Determine overcurrent unit pickup.
 - f) Determine overcurrent unit time delay at two points on time current curve.
- 20) Reclosing Relay (IEEE C37.2 Device No. 79):

- a) Determine time delay for each programmed reclosing interval.
- b) Verify lockout for unsuccessful reclosing.
- c) Determine reset time.
- d) Determine close pulse duration.
- e) Verify instantaneous overcurrent lockout.

21) Frequency Relay (IEEE C37.2 Device No. 81):

- a) Verify frequency set points.
- b) Determine time delay.
- c) Determine undervoltage cutoff.

22) Pilot Wire Monitor (IEEE C37.2 Device No. 85):

- a) Determine overcurrent pickup.
- b) Determine undercurrent pickup.
- c) Determine pilot wire ground pickup level.

23) Differential Protective Relay (IEEE C37.2 Device No. 87):

- a) Determine operating unit pickup.
- b) Determine operation of each restraint unit.
- c) Determine slope.
- d) Determine harmonic restraint.
- e) Determine instantaneous pickup.
- f) Plot operating characteristics for each restraint.

d. Control Verification:

1) Functional Tests:

- a) Check operation of all active digital inputs.
- b) Check output contacts or SCRs, preferably by operating controlled device, such as circuit breaker, auxiliary relay, or alarm.
- c) Check internal logic functions used in protection scheme.
- d) For pilot schemes, perform a loop-back test to check receive and transmit communication circuits.
- e) For pilot schemes, perform satellite synchronized end-to-end tests.
- f) For pilot schemes with direct transfer trip (DTT), perform transmit and received DTT at each terminal.
- g) Upon completion of testing, reset min/max recorders, communications statistics, fault counters, sequence-of-events recorder, and event records.

2) In-Service Monitoring: After equipment is initially energized, measure magnitude and phase angle of inputs and verify expected values.

I. DC System VRLA Batteries Field Tests:

1. Visual and Mechanical Inspection:

- a. Verify that batteries are adequately located.
- b. Verify that battery area ventilation system is operable.
- c. Verify existence of suitable eyewash equipment.
- d. Verify equipment nameplate data complies with Contract Documents.
- e. Inspect physical and mechanical condition.

- f. Verify adequacy of battery support racks, mounting, anchorage, alignment, grounding, and clearances.
- g. Verify units are clean.
- h. Inspect spill containment installation.
- i. Verify application of an oxide inhibitor on battery terminal connections.

2. Electrical Tests:

- a. Measure charger float and equalizing voltage levels. Adjust voltage in accordance with battery manufacturer's published instructions.
- b. Verify charger functions and that alarms comply with system manufacturer's published instructions.
- c. Measure negative post temperature. Negative post temperature must comply with manufacturer's published data or IEEE 1188.
- d. Measure charger float and equalizing voltage levels. Charger float and equalizing voltage levels must be in accordance with battery manufacturer's published data.
- e. Measure each monoblock/cell voltage and total battery voltage with charger energized and in float mode of operation. Monoblock/cell voltages must be in accordance with manufacturer's published data.
- f. Measure intercell connection resistances.
- g. Perform internal ohmic measurement tests. Cell internal ohmic values (resistance, impedance, or conductance) must not vary by more than 25 percent between identical cells that are in a fully charged state. Monoblock/cell internal ohmic values (resistance, impedance, or conductance) must not vary by more than 25 percent between identical monoblocks/cells in a fully charged state.
- h. Perform a load test in accordance with manufacturer's published data or IEEE 1188. Replace units that fail to pass test.
- i. Measure battery system voltage from positive-to-ground and negative-to-ground. Voltage measured from positive-to-ground must be equal in magnitude to voltage measured from negative-to-ground.

J. DC System Vented Ni-Cd Batteries Field Tests:

1. Visual and Mechanical Inspection:

- a. Verify that batteries are adequately located.
- b. Verify that battery area ventilation system is operable.
- c. Verify existence of suitable eyewash equipment.
- d. Verify equipment nameplate data complies with Contract Documents.
- e. Inspect physical and mechanical condition.
- f. Verify adequacy of battery support racks, mounting, anchorage, alignment, grounding, and clearances.
- g. Verify electrolyte level. Measure pilot-cell electrolyte temperature, and correct in accordance with manufacturer's maintenance procedures to bring temperature and electrolyte level to within normal limits.
- h. Verify units are clean.
- i. Inspect spill containment installation.
- j. Verify application of an oxide inhibitor on battery terminal connections.

2. Electrical Tests:

- a. Measure charger float and equalizing voltage levels. Adjust voltage in accordance with battery manufacturer's published instructions.
- b. Verify charger functions and that alarms comply with system manufacturer's published instructions.
- c. Measure each cell voltage and total battery voltage with charger energized and in float

mode of operation. Cell voltages must be within 0.05 volt of each other or in accordance with manufacturer's published data.

- d. Measure intercell connection resistances.
- e. Perform internal ohmic measurement tests. Cell internal ohmic values (resistance, impedance, or conductance) must not vary by more than 25 percent between identical cells that are in a fully charged state.
- f. Perform a load test in accordance with manufacturer's published data or IEEE 1106. Replace units that fail to pass test.
- g. Measure battery system voltage from positive-to-ground and negative-to-ground. Voltage measured from positive-to-ground must be equal in magnitude to voltage measured from negative-to-ground.

K. DC System Charger Field Tests:

1. Visual and Mechanical Inspection:

- a. Inspect for physical and mechanical condition.
- b. Inspect anchorage, alignment, and grounding.
- c. Verify unit is clean.
- d. Inspect filter and tank capacitors.
- e. Verify operation of cooling fans and presence of filters.

2. Electrical Tests:

- a. Verify float voltage, equalizing voltage, and overvoltage shutdown settings. Float and equalizing voltage settings must be in accordance with battery manufacturer's published data.
- b. Verify current limit. Current limit must be set in accordance with manufacturer's published instructions.
- c. Verify operation of alarms. Results of alarm operation must be in accordance with manufacturer's published data and system design.
- d. Measure and record input and output voltage and current. Input and output voltage must be in accordance with manufacturer's published data.
- e. Measure and record AC ripple current and voltage imposed on battery. AC ripple current and voltage imposed on battery must be in accordance with manufacturer's published data.
- f. Perform full-load testing of charger. Charger must be capable of manufacturer's specified full load.

L. Liquid-Filled Transformer Section Field Tests:

1. Visual and Mechanical Inspection:

- a. Inspect physical and mechanical condition.
- b. Inspect impact recorder prior to unloading.
- c. Test dew point of tank gases if applicable.
- d. Inspect anchorage, alignment, and grounding.
- e. Verify presence of PCB content labeling.
- f. Verify removal of any shipping bracing after placement.
- g. Verify bushings are clean.
- h. Verify that alarm, control, and trip settings on temperature and level indicators are set and operate in accordance with manufacturer's published instructions.
- i. Verify that cooling fans and pumps operate correctly and have appropriate overcurrent protection.
- j. Verify that liquid level in tanks and bushings is within manufacturer's published tolerances.
- k. Perform specific inspections and mechanical tests recommended by manufacturer's

- published instructions.
- l. Verify presence of transformer surge arresters and that their ratings are as specified.
- m. Verify that as-left tap connections are as specified.
- n. Verify presence of surge arresters and that their ratings are as specified.

2. Electrical Tests:

- a. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index; value of index must not be less than 1.0.
- b. Perform power-factor or dissipation-factor tests on all windings in accordance with test equipment manufacturer's published data. Maximum winding insulation power-factor/dissipation-factor values must be in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.3.
- c. Measure core insulation resistance at 500 V(dc) if core is insulated and core ground strap is removable. Core insulation-resistance values must not be less than 1 MΩ at 500 V(dc).
- d. Perform a power-factor or dissipation-factor tip-up test on windings greater than 2.5 kV.
- e. Perform turns-ratio tests at tap positions. Turns-ratio test results must not deviate by more than one-half percent from either adjacent coils or calculated ratio. If test fails, replace transformer.
- f. Perform an excitation-current test on each phase. The typical excitation-current test data pattern for a three-legged core transformer is two similar current readings and one lower current reading. Investigate and correct if test shows a different pattern.
- g. Measure resistance of each winding at each tap connection, and record temperature-corrected winding-resistance values in Operations and Maintenance Manual.
- h. Perform an applied-voltage test on primary and secondary windings-to-ground. Comply with IEEE C57.12.91, Sections 10.2 and 10.9.
- i. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.
- j. Remove a sample of insulating liquid in accordance with ASTM D923. Insulating liquid values must comply with NETA ATS, Table 100.4. Sample must be tested for the following:
 - 1) Dielectric Breakdown Voltage: ASTM D877/D877M or ASTM D1816.
 - 2) Acid Neutralization Number: ASTM D974.
 - 3) Specific Gravity: ASTM D1298.
 - 4) Interfacial Tension: ASTM D971.
 - 5) Color: ASTM D1500.
 - 6) Visual Condition: ASTM D1524.
 - 7) Water in Insulating Liquids: ASTM D1533.
 - 8) Power Factor or Dissipation Factor: ASTM D924.
- k. Remove a sample of insulating liquid in accordance with ASTM D923 and perform dissolved-gas analysis in accordance with IEEE C57.104 or ASTM D3612.

M. Small Dry-Type Transformer Section Field Tests:

- 1. Visual and Mechanical Inspection:
 - a. Inspect physical and mechanical condition.
 - b. Inspect anchorage, alignment, and grounding.
 - c. Verify that resilient mounts are free and that any shipping brackets have been removed.
 - d. Verify unit is clean.
 - e. Perform specific inspections and mechanical tests recommended by manufacturer's published instructions.
 - f. Verify that as-left tap connections are as specified.

- g. Verify presence of surge arresters and that their ratings are as specified.

2. Electrical Tests:

- a. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index; value of index must not be less than 1.0.
- b. Perform turns-ratio tests at all tap positions. The test results must not deviate by more than one-half percent from either adjacent coils or calculated ratio. If test fails, replace transformer.
- c. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

N. Large Dry-Type Transformer Section Field Tests:

1. Visual and Mechanical Inspection:

- a. Inspect physical and mechanical condition.
- b. Inspect anchorage, alignment, and grounding.
- c. Verify that resilient mounts are free and that any shipping brackets have been removed.
- d. Verify unit is clean.
- e. Verify that alarm, control, and trip settings on temperature and level indicators are set and operate in accordance with manufacturer's published instructions.
- f. Verify that cooling fans operate and that fan motors have correct overcurrent protection.
- g. Perform specific inspections and mechanical tests recommended by manufacturer's published instructions.
- h. Verify that as-left tap connections are as specified.
- i. Verify presence of surge arresters and that their ratings are as specified.

2. Electrical Tests:

- a. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index; value of index must not be less than 1.0.
- b. Perform power-factor or dissipation-factor tests on windings in accordance with test equipment manufacturer's published data. Investigate and correct power-factor values that exceed:
 - 1) 2.0 percent for power transformers.
 - 2) 5.0 percent for distribution transformers.
- c. Measure core insulation resistance at 500 V(dc) if core is insulated and core ground strap is removable. Core insulation-resistance values must not be less than 1 M Ω at 500 V(dc).
- d. Perform a power-factor or dissipation-factor tip-up test on windings greater than 2.5 kV. Tip-up test result exceeding 1.0 percent must be investigated.
- e. Perform turns-ratio tests at all tap positions. The test results must not deviate by more than one-half percent from either adjacent coils or calculated ratio. If test fails, replace transformer.
- f. Perform an excitation-current test on each phase. The typical excitation-current test data pattern for a three-legged core transformer is two similar current readings and one lower current reading. Investigate and correct if test shows a different pattern.
- g. Measure resistance of each winding at each tap connection.
- h. Perform an applied-voltage test on all primary and secondary windings-to-ground. See

IEEE C57.12.91, Sections 10.2 and 10.9. The AC dielectric-withstand-voltage test result must not exceed 75 percent of factory test voltage for one-minute duration. The DC dielectric-withstand-voltage test result must not exceed 100 percent of AC RMS test voltage specified in IEEE C57.12.91, Section 10.2, for one-minute duration. If no evidence of distress or insulation failure is observed by end of total time of voltage application during dielectric-withstand-voltage test, test specimen is considered to have passed test.

- i. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

O. Secondary Distribution Section Network Protector Field Tests:

1. Visual and Mechanical Inspection:

- a. Inspect physical and mechanical condition.
- b. Inspect anchorage, alignment, and grounding.
- c. Verify unit is clean.
- d. Verify arc chutes are intact.
- e. Inspect moving and stationary contacts for condition and alignment.
- f. Verify that maintenance devices are available for servicing and operating network protector.
- g. Verify that primary and secondary contact wipe and other dimensions vital to satisfactory operation of network protector are correct.
- h. Perform mechanical operator and contact alignment tests on both network protector and its operating mechanism. Operations counter must advance one digit per close-open cycle.
- i. Verify cell fit and element alignment.
- j. Verify racking mechanism operation.
- k. Verify compliance with manufacturer's published instructions for lubrication on moving current-carrying parts and on moving and sliding surfaces.
- l. Record as-found and as-left operation counter readings.
- m. Perform a leak test on submersible enclosure in accordance with manufacturer's published data.

2. Electrical Tests:

- a. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with network protector closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.1.
 - 1) Insulation-resistance values of bus insulation must be in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's published instructions or Table 100.1.
 - 2) Do not conduct insulation-resistance tests of control wiring until insulation-resistance levels of power circuits are raised above minimum values.
- b. Perform a contact/pole-resistance test. Microhm or DC millivolt drop values must not exceed high levels of normal range as indicated in manufacturer's published data. In absence of manufacturer's published data, investigate values that deviate from adjacent poles or similar protectors by more than 50 percent of lowest value.

3. Perform insulation-resistance tests on all control wiring with respect to ground. Applied potential must be 500 V(dc) for 300 V rated cable and 1000 V(dc) for 600 V rated cable. Test duration must be one minute. For units with solid-state components or control devices that cannot tolerate applied voltage, follow manufacturer's published instructions.

- a. Minimum insulation-resistance values of control wiring must not be less than 2 MΩ.
- b. Verify current-transformer ratios in accordance with IEEE C57.13.
- c. Measure resistance of each network protector power fuse. Investigate and correct fuse-resistance values that deviate from each other by more than 15 percent.
- d. Measure minimum pickup voltage of motor-control relay. Minimum pickup voltage of motor-control relay must be in accordance with manufacturer's published data, but not more than 75 percent of rated control circuit voltage.
- e. Verify that motor can charge closing mechanism at minimum voltage specified by manufacturer. Minimum operating voltage of motor on closing mechanism must not exceed 75 percent of rated control circuit voltage.
- f. Measure minimum pickup voltage of trip actuator. Trip actuator minimum pickup voltage must not exceed 7.5 percent of rated control circuit voltage. Verify that actuator resets correctly.
- g. Calibrate network protector relays in accordance with "Medium-Voltage Instruments Section" Paragraph, "Overcurrent and Ground-Fault Protective Relays" Subparagraph, specifying microprocessor-based protective relays.
- h. Perform the following operational tests:
 - 1) Verify correct operation of all mechanical and electrical interlocks.
 - 2) Verify trip-free operation.
 - 3) Verify correct operation of auto-open-close control handle.
 - 4) Verify protector will close with voltage on transformer side only.
 - 5) Verify protector will open when source feeder breaker is opened.
- i. Verify phase rotation, phasing, and synchronized operation.

P. Low-Voltage Power Circuit-Breaker Field Tests:

1. Visual and Mechanical Inspection:

- a. Inspect physical and mechanical condition.
- b. Inspect anchorage, alignment, and grounding.
- c. Verify that all maintenance devices are available for servicing and operating breaker.
- d. Verify unit is clean.
- e. Verify that arc chutes are intact.
- f. Inspect moving and stationary contacts for condition and alignment.
- g. Verify that primary and secondary contact wipe and other dimensions vital to satisfactory operation of breaker are correct.
- h. Perform mechanical operator and contact alignment tests on both breaker and its operating mechanism in accordance with manufacturer's published data.
- i. Verify cell fit and element alignment.
- j. Verify racking mechanism operation.
- k. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
- l. Perform adjustments for final protective-device settings in accordance with coordination study provided by end user.
- m. Record as-found and as-left operation counter readings.

2. Electrical Tests:

- a. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, use NETA ATS, Table 100.1. Insulation-resistance values must be in accordance with manufacturer's published data. In absence of manufacturer's published data, comply

with NETA ATS, Table 100.1. Values of insulation resistance less than this table or manufacturer's published instructions must be investigated.

- b. Measure contact resistance across each power contact of circuit breaker. Microhm or DC millivolt drop values must not exceed high levels of normal range as indicated in manufacturer's published data. If manufacturer's published data is not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of lowest value.
- c. Determine long-time pickup and delay by primary current injection. Long-time pickup values must be as specified, and trip characteristic must not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors. If manufacturer's curves are not available, trip times must not exceed value shown in NETA ATS, Table 100.7.
- d. Determine short-time pickup and delay by primary current injection. Short-time pickup values must be as specified, and trip characteristic must not exceed manufacturer's published time-current tolerance band.
- e. Determine ground-fault pickup and delay by primary current injection. Ground-fault pickup values must be as specified, and trip characteristic must not exceed manufacturer's published time-current tolerance band.
- f. Determine instantaneous pickup value by primary current injection. Instantaneous pickup values must be as specified and within manufacturer's published tolerances. In absence of manufacturer's published data, comply with NETA ATS, Table 100.8.
- g. Test functions of trip unit by means of secondary injection. Pickup values and trip characteristic must be as specified and within manufacturer's published tolerances.
- h. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data. Minimum pickup voltage of shunt trip and close coils must conform to manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.20.
- i. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.
- j. Verify correct operation of any auxiliary features, such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free operation, anti-pump function, and trip unit battery condition. Reset trip logs and indicators. Auxiliary features must operate in accordance with manufacturer's published data.
- k. Verify operation of charging mechanism. The charging mechanism must operate in accordance with manufacturer's published data.

Q. Metering Device Field Tests:

1. Visual and Mechanical Inspection:

- a. Inspect physical and mechanical condition.
- b. Inspect cover gasket, cover glass, condition of spiral spring, disk clearance, contacts, and case shorting contacts, as applicable.
- c. Verify unit is clean.
- d. Verify freedom of movement, end play, and alignment of rotating disk(s).

2. Electrical Tests:

- a. Verify accuracy of meters at cardinal points. Meter accuracy must be in accordance with manufacturer's published data.
- b. Calibrate meters in accordance with manufacturer's published data. Calibration results must be within manufacturer's published tolerances.
- c. Verify instrument multipliers. Instrument multipliers must be in accordance with system design specifications.
- d. Verify that current-transformer and voltage-transformer secondary circuits are intact. Test results must confirm integrity of secondary circuits of current and voltage transformers.



R. Nonconforming Work:

1. Equipment will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

S. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

T. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.

1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.

3.4 SYSTEM STARTUP

A. Perform startup service.

1. Complete installation and startup checks in accordance with manufacturer's published instructions.
2. Complete installation and startup checks required by electric utility provider.
3. **<Insert startup steps if any>**.

B. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** system startup.

1. Manufacturer's Field Reports for System Startup Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.

3.5 ADJUSTING

A. Voltage Monitoring and Adjusting: After Substantial Completion, if requested by Owner, but not more than six months after Final Acceptance, perform the following voltage monitoring:

1. During a period of normal load cycles as evaluated by Owner, perform seven days of three-phase voltage recording at outgoing section of each secondary unit substation. Use voltmeters with calibration traceable to National Institute of Science and Technology standards and with a chart speed of not less than **1 inch (25 mm)** per hour. Voltage unbalance greater than 1 percent between phases, or deviation of any phase voltage from nominal value by more than plus or minus 5 percent during test period, is unacceptable.
2. Corrective Action: If test results are unacceptable, perform the following corrective action, as appropriate:
 - a. Adjust transformer taps.
 - b. Rebalance loads.
 - c. Prepare written request for voltage adjustment by electric utility.
3. Retests: Repeat monitoring, after corrective action has been performed, until satisfactory results are obtained.
4. Report:

- a. Prepare a written report covering monitoring performed and corrective action taken.
 - b. For each relay and adjustable circuit breaker, tag device with adjusting technician's initials and date of adjustment. Record settings and file with test records specified in "Field Quality Control" Article.
- B. Infrared Inspection and Adjusting: Perform survey during periods of maximum possible loading. Remove all necessary covers prior to inspection.
 1. After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared inspection of electrical power connections of unit substation.
 2. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchgear 11 months after date of Substantial Completion.
 3. Instrument: Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of **1.8 deg F (1 deg C) at 104 deg F (30 deg C)**.
 4. Record of Infrared Inspection: Prepare a certified report that identifies testing technician and equipment used, and lists the following results:
 - a. Description of equipment to be tested.
 - b. Discrepancies.
 - c. Temperature difference between area of concern and reference area.
 - d. Probable cause of temperature difference.
 - e. Areas inspected. Identify inaccessible and unobservable areas and equipment.
 - f. Identify load conditions at time of inspection.
 - g. Provide photographs and thermograms of deficient area.
 5. Act on inspection results in accordance with recommendations of NETA ATS, Table 100.18. Correct possible and probable deficiencies as soon as Owner's operations permit. Retest until deficiencies are corrected.

3.6 CLEANING

- A. After completing equipment installation and before energizing, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish. Vacuum interiors of secondary unit substation sections.

3.7 CLOSEOUT ACTIVITIES

- A. Training:
 1. **[With assistance from factory-authorized service representatives, train][Train]** Owner's maintenance personnel on the following topics:
 - a. How to operate normal and emergency electrical systems, including justifications for, and limitations of, protective device settings recommended in coordination study report.
 - b. How to adjust, operate, and maintain secondary unit substation equipment.
 2. **[Provide video recordings of training sessions to Owner.][Allow Owner to record training sessions.]**

3.8 MAINTENANCE

- A. Maintenance Service Agreement: Beginning at Substantial Completion, verify that maintenance service agreement includes **[three month][six month][nine month][one year]<Insert duration>** period for full

maintenance by **[skilled employees of secondary unit substation Installer][manufacturer's authorized service representative]**. Include periodic preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper secondary unit substation equipment operation. Verify that parts and supplies are manufacturer's authorized replacement parts and supplies.

B. Software and Firmware Service Agreement:

1. Technical Support: Beginning at Substantial Completion, verify that software and firmware service agreement includes secondary unit substation equipment software and firmware support for **[two years]<Insert duration>**.
2. Upgrade Service: At Substantial Completion, update software and firmware to latest version. Install and program software and firmware upgrades that become available within **[two years]<Insert duration>** from date of Substantial Completion. **[Verify that upgrading software includes operating system and new or revised licenses for using software.]**
 - a. Upgrade Notice: Not less than **[30 days]<Insert duration>**; to allow Owner to schedule and access the system **[and to upgrade computer equipment if necessary]**.
3. Field Reports for Software and Firmware Upgrades: Prepare and submit report after each update, documenting upgrades installed.

END OF SECTION 26 11 16 11



Task	Specification	Specification Description
26 11 16 11	26 11 16 00	Secondary Unit Substations with Switchboard Secondary
26 11 16 11	26 11 16 00a	Secondary Unit Substations with Motor Control Center Secondary



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SECTION 26 12 13 00 - LIQUID-FILLED, MEDIUM-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Liquid-filled, medium-voltage substation transformers, with primary and secondary bushings within or without air-terminal enclosures.
2. Control network.
3. Warning labels and signs.

B. Products Furnished, but Not Installed, under This Section:

1. **<Insert products furnished, but not installed>.**

C. Products Installed, but Not Furnished, under This Section:

1. **<Insert products installed, but not furnished>.**

D. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
3. **[Section 013100 "Project Management and Coordination"]<Insert Section number and title>** for preinstallation conference procedures.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at **[Project site]<Insert location>.**

B. Preinstallation Coordination Meeting(s): For liquid-filled, medium-voltage transformers. Conduct meeting(s) **[as videoconference][or][at Project site]<Insert location>** before **<Insert construction activity>.**

1. Attendees: Installers, fabricators, representatives of manufacturers, and administrators for field tests and inspections. Notify Architect[, **Construction Manager**][, and **Owner's Commissioning Authority**] of scheduled meeting dates.

1.3 ACTION SUBMITTALS

A. Product Data:

1. For each type of product.
 - a. Include rated capacities, operating characteristics, and furnished specialties and

accessories.

B. Shop Drawings:

1. For liquid-filled, medium-voltage transformers.

a. Include plans and elevations showing major components and features.

1) Include plan view and cross section of equipment base, showing clearances, manufacturer's recommended workspace, and locations of penetrations for grounding and conduits.

b. Include details of equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of field connections.

c. Include single-line diagram.

d. Include list of materials.

e. Include nameplate legends.

C. Field Quality-Control Submittals:

1. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

A. Product Certificates: For transformers, signed by product manufacturer.

B. Source quality-control reports.

PART 2 - PRODUCTS

2.1 OWNER-FURNISHED PRODUCTS

A. Basis for Pricing: **<Insert name of manufacturer; model number or series for product that Owner intends to furnish to Contractor>.**

B. Description: **<Insert description of product, including special features, options, and finishes for Owner-furnished product that may impact Contractor's installation>.**

C. Accessories: **<Insert accessories that will be provided with product>.**

2.2 EXISTING PRODUCTS TO BE MODIFIED

A. Basis for Pricing: **<Insert name of manufacturer; model number or series for existing product>.**

B. Description: **<Insert description of existing product, including special features, options, and finishes that may impact Work>.**

C. Accessories: **<Insert accessories included with existing product>.**

2.3 EXISTING PRODUCTS TO BE REMOVED AND RE-INSTALLED

- A. Basis for Pricing: **<Insert name of manufacturer; model number or series for existing product>.**
- B. Description: **<Insert description of existing product, including special features, options, and finishes that may impact Work>.**
- C. Accessories: **<Insert accessories included with existing product>.**

2.4 LIQUID-FILLED, MEDIUM-VOLTAGE TRANSFORMERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1. **[Eaton]**
 - 2. **[GE Power; General Electric Company]**
 - 3. **[Prolec GE; A Xignux and General Electric Company Joint Venture]**
 - 4. **[Siemens Industry, Inc., Energy Management Division]**
 - 5. **[Square D; Schneider Electric USA]**
 - 6. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Eaton]**
 - 2. **[GE Power; General Electric Company]**
 - 3. **[Prolec GE; A Xignux and General Electric Company Joint Venture]**
 - 4. **[Siemens Industry, Inc., Energy Management Division]**
 - 5. **[Square D; Schneider Electric USA]**
 - 6. **<Insert manufacturer's name>**

2.5 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- B. Comply with IEEE C2.
- C. Comply with IEEE C57.12.00.

2.6 PERFORMANCE REQUIREMENTS

- A. Windings Material: **[Aluminum][Copper].**
- B. Surge Arresters: Comply with IEEE C62.11, Distribution Class; metal-oxide-varistor type, connected in each phase of incoming circuit and ahead of disconnecting device.
- C. Winding Connections: Connection of windings and terminal markings must comply with IEEE C57.12.70.

- D. Efficiency: Comply with 10 CFR 431, Subpart K.
- E. Insulation:
1. Transformer kVA Rating[, **when Indicated at 65 deg C Rise,**] Must Be as Follows: Average winding temperature rise above ambient temperature must not exceed 65 deg C and 80 deg C hottest-spot temperature rise at rated kVA when tested in accordance with IEEE C57.12.90, using combination of connections and taps that give highest average winding temperature rise.
 2. Transformer kVA Rating[, **when Indicated at 55/65 deg C Rise,**] Must Be as Follows: Average winding temperature rise above ambient temperature must not exceed 55 deg C, based on average ambient temperature of 30 deg C over 24 hours with maximum ambient temperature of 40 deg C. Insulation system must be rated to continuously allow additional 12-percent kVA output, at 65 deg C temperature rise, without decreasing rated transformer life. Rating must conform to requirements of IEEE C57.12.90.
- F. Bushings must comply with IEEE C57.19.01 requirements for impulse and low-frequency insulation levels.
- G. Tap Changer: External, for de-energized operation.
- H. Tank: Sealed, with welded-on cover. [**Designed to withstand internal pressure of not less than 7 psi (50 kPa) without permanent distortion and 15 psig (104 kPa) without rupture. Comply with IEEE C57.12.36.**]
- I. Mounting: Integral skid mounting frame, suitable to allow skidding or rolling of transformer in any direction, and with provision for anchoring frame to pad.
- J. Insulating Liquids:
1. Mineral Oil: ASTM D3487, Type II, and tested for compliance with ASTM D117.
 2. Less-Flammable Liquids:
 - a. Edible-Seed-Oil-Based Dielectric: Listed and labeled by qualified electrical testing laboratory recognized by authorities having jurisdiction as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested in accordance with ASTM D92. Liquid must be biodegradable and nontoxic, having passed Organisation for Economic Co-operation and Development G.L.203 with zero mortality, and must be certified by U.S. Environmental Protection Agency as biodegradable, meeting Environmental Technology Verification requirements.
 - b. Biodegradable and Nontoxic Dielectric: Listed and labeled by qualified electrical testing laboratory recognized by authorities having jurisdiction as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested in accordance with ASTM D92.
 - c. Silicone-Based Dielectric: Listed and labeled by qualified electrical testing laboratory recognized by authorities having jurisdiction as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested in accordance with ASTM D92. Liquid must have low toxicity and be nonhazardous.
- K. Sound level must comply with NEMA TR 1 requirements.
- L. Capacities and Characteristics:
1. Location: [**Indoors**][**Outdoors**].
 2. Additional Standards: Comply with [**IEEE C57.12.10**][**IEEE C57.12.36**].

- a. Comply with **[IEEE C57.12.10][IEEE C57.12.36]**.
 - b. Comply with UL 1062 listing requirements.
 - c. Comply with FM Global Class No. 3990.
 - d. Comply with UL listing requirements for combination classification and listing for transformer and less-flammable insulating liquid.
3. Connections:
 - a. Primary: **[Air-filled terminal cabinet for cable connection][Throat for busway connection][Terminals for close connection to primary switch][Open wire]**.
 - b. Secondary: **[Air-filled terminal cabinet for cable connection][Throat for busway connection][Open wire]**.
4. Transformer Ratings. Comply with IEEE C57.12.00 for cooling class.
 - a. Self-Cooled Rating, Class **<Insert letters>**: **<Insert number>** kVA.
 - b. Future Forced-Air-Cooled Rating, Class **<Insert letters>**:
 - 1) Self-Cooled: **<Insert number>** kVA.
 - 2) Forced-Air Cooled: **<Insert number>** kVA.
 - 3) Make provision for future addition of forced-air-cooling equipment. Transformer bushings, leads, and related components must be sized for future equipment. Provide fan mounts, conduit supports, and terminal boxes.
 - c. Forced-Air-Cooled Rating, Class **<Insert letters>**:
 - 1) Self-Cooled: **<Insert number>** kVA.
 - 2) Forced-Air Cooled: **<Insert number>** kVA.
 - 3) Equip with forced-air-cooling equipment, including fans, conduit, wiring, motor controllers, and top liquid thermometer for fan control.
 - d. Impedance: Not less than **[5.75]<Insert number>** percent.
 - e. Temperature Rise: **[65 deg C][55/65 deg C]**.
 - f. Coils Connection:
 - 1) Line-Side Winding: **[Delta]<Insert connection>**.
 - 2) Load-Side Winding: **[Wye]<Insert connection>**.
 - g. Voltage and BIL Ratings:
 - 1) Nominal primary phase-to-phase voltage and BIL: **[4160 V, 60 kV][13 800 V, 95 kV][34 500 V, 125 kV]<Insert requirements>**.
 - 2) Nominal secondary voltage and BIL: **[208Y/120 V, 45 kV][480Y/277 V, 45 kV]<Insert requirements>**.
 - h. K-Factor: **<Insert number>**, complying with UL 1561.
5. Finish:
 - a. Outdoor Transformer Enclosure Finish: Factory-applied finish in manufacturer's standard color, corrosion resistance complying with IEEE C57.12.28.
 - b. Indoor Transformer Enclosure Finish: Factory-applied finish in manufacturer's standard gray over rust-inhibiting primer on treated metal surface.
 - c. Special Corrosion-Resistant Enclosure Finish: Factory-applied, corrosion-resistant finish in manufacturer's standard color that withstands **[120][480]** hours of exposure to salt-spray test specified in ASTM B117 without loss of paint or release of adhesion of paint primer



coat to metal surface in excess of **1/16 inch (2 mm)** from test mark. Scribed test mark and test evaluation must be in accordance with ASTM D1654 with rating of not less than 7, in accordance with Table 1 (Procedure A). Cut edges or otherwise damaged surfaces of hot-dip galvanized sheet steel, or mill-galvanized sheet steel must be coated with manufacturer's standard zinc-rich paint.

6. Taps: Two 2-1/2 percent, full-capacity taps above, and two 2-1/2 percent, full-capacity taps below rated voltage. Comply with IEEE C57.12.36 requirements.
7. Transformer Accessories:
 - a. Drain and filter connection.
 - b. Filling and top filter press connections.
 - c. Pressure-vacuum gauge.
 - d. Dial-type analog thermometer with alarm contacts.
 - e. Magnetic liquid level indicator with high and low alarm contacts.
 - f. Pressure-relief device set to operate at 10 psig, plus or minus 2 psig, and then automatically reseal when pressure drops to 6 psig minimum. Device flow must be as recommended by manufacturer. With alarm contacts and manual bleeder.
 - g. At least four stainless steel ground connection pads.
 - h. Provisions for jacking, lifting, and towing.
 - i. Machine-engraved nameplate made of anodized aluminum or stainless steel.
 - j. Sudden pressure relay for remote alarm or trip when internal transformer pressure rises at field-set rate. Provide **[with][without]** seal-in delay.

2.7 CONTROL NETWORK

- A. Controllers: Support serial MS/TP and Ethernet IP communications, and able to communicate directly via RS-485 serial networks and Ethernet 10Base-T networks as native device.

2.8 WARNING LABELS AND SIGNS

- A. Comply with requirements for labels and signs specified in Section 260553 "Identification for Electrical Systems."
 1. Warning signs must be made of baked enamel.
 2. Equipment Identification Labels: **[Engraved, laminated-acrylic or -melamine label][Stenciled legend 4 inch (100 mm) high]**.

2.9 SOURCE QUALITY CONTROL

- A. Owner will witness required factory tests. Notify Architect at least 14 days before date of tests and indicate their approximate duration.
- B. Testing Administrator: **[Owner will engage][Engage]** qualified testing agency to evaluate liquid-filled, medium-voltage transformer.
- C. Testing: Test and inspect liquid-filled, medium-voltage transformer in accordance with IEEE C57.12.90.
- D. Factory Tests and Inspections: Perform the following tests and inspections on liquid-filled, medium-voltage transformer, by, or under supervision of, qualified electrical testing laboratory recognized by authorities having jurisdiction, before delivering to site. Affix label with name and date of **[manufacturer's][qualified electrical testing laboratory's]** certification of system compliance on

control units.

1. Resistance.
2. Turns ratio, polarity, and phase relation.
3. Transformer no-load losses and excitation current at 100 percent of ratings.
4. Transformer impedance voltage and load loss.
5. Operation of devices.
6. Control (auxiliary) and consumption losses.
7. Lightning impulse.
8. Low frequency.
9. Leak.
10. Transformer no-load losses and excitation current at 110 percent of ratings.
11. Insulation power factor.
12. Applied potential.
13. Induced potential.
14. Resistance measurements of windings on rated voltage connection and at tap extreme connections.
15. Ratios on rated voltage connection and at tap extreme connections.
16. Polarity and phase relation on rated voltage connection.
17. No-load loss at rated voltage on rated voltage connection.
18. Exciting current at rated voltage on rated voltage connection.
19. Impedance.

E. Nonconforming Work:

1. System equipment that does not pass tests and inspections will be considered defective.

F. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine liquid-filled, medium-voltage transformers upon delivery.

1. Upon delivery of transformers and prior to unloading, inspect equipment for damage that may have occurred during shipment or storage.
2. Verify that tie rods and chains are undamaged and tight, and that blocking and bracing is tight. Verify that there is no evidence of load shifting in transit, and that readings from transportation shock recorders, if equipped, are within manufacturer's recommendations.
3. Verify that there is no indication of external damage and no dents or scratches in doors and sill, tank walls, radiators and fins, or termination provisions.
4. Verify that there is no evidence of insulating-liquid leakage on transformer surfaces, at weld seams, on line- or load-side bushing parts, and at transformer base.
5. Verify that there is positive pressure or vacuum on tank. Check pressure gauge; it is required to read other than zero.
6. Compare transformers and accessories received with bill of materials to verify that shipment is complete. Verify that transformers and accessories conform with manufacturer's quotation and shop drawings. If shipment is incomplete or does not comply with Project requirements, notify manufacturer in writing immediately.
7. Verify presence of polychlorinated biphenyl content labeling.
8. Unload transformers carefully, observing packing label warnings and handling instructions.
9. Open termination compartment doors and inspect components for damage or displaced parts, loose or broken connections, cracked or chipped insulators, bent mounting flanges, dirt or foreign

material, and water or moisture.

B. Handling:

1. Handle transformers carefully, in accordance with manufacturer recommendations, to avoid damage to enclosure, termination compartments, base, frame, tank, and internal components. Do not subject transformers to impact, jolting, jarring, or rough handling.
2. Protect transformer termination compartments against entrance of dust, rain, and snow.
3. Transport transformers upright, to avoid internal stresses on core and coil mounting assembly and to prevent trapping air in windings. Do not tilt or tip transformers.
4. Verify that transformer weights are within rated capacity of handling equipment.
5. Use only manufacturer-recommended points for lifting, jacking, and pulling. Use lifting lugs when lifting transformers.
6. Use jacks only at corners of tank base plate.
7. Use nylon straps of same length to balance and distribute weight when handling transformers with crane.
8. Use spreaders or lifting beam to obtain vertical lift and to protect transformer from straps bearing against enclosure. Lifting cable pull angles may not be greater than 15 degrees from vertical.
9. Exercise care not to damage tank base structure when handling transformer using skids or rollers. Use skids to distribute stresses over tank base when using rollers under large transformers.

C. Storage:

1. Store transformers in accordance with manufacturer's recommendations.
2. Transformers may be stored outdoors. If possible, store transformers at final installation locations on concrete pads. If dry concrete surfaces are unavailable, use pallets of adequate strength to protect transformers from direct contact with ground. Ensure transformer is level.
3. Ensure that transformer storage location is clean and protected from severe conditions. Protect transformers from dirt, water, contamination, and physical damage. Do not store transformers in presence of corrosive or explosive gases. Protect transformers from weather when stored for more than three months.
4. Store transformers with compartment doors closed.
5. Regularly inspect transformers while in storage and maintain documentation of storage conditions, noting discrepancies or adverse conditions. Verify that effective pressure seal is maintained using pressure gauges. Visually check for insulating-liquid leaks and rust spots.

D. Examine areas and space conditions for compliance with requirements for liquid-filled, medium-voltage transformers and other conditions affecting performance of the Work.

E. Examine roughing-in of conduits and grounding systems to verify the following:

1. Wiring entries comply with layout requirements.
2. Entries are within conduit-entry tolerances specified by manufacturer, and no feeders will cross section barriers to reach load or line lugs.

F. Examine walls, floors, roofs, and concrete bases for suitable conditions for transformer installation.

G. Pre-Installation Checks:

1. Verify removal of shipping bracing after placement.
2. Remove sample of insulating liquid in accordance with ASTM D923. Insulating-liquid values must comply with NETA ATS, Table 100.4. Sample must be tested for the following:
 - a. Dielectric Breakdown Voltage: ASTM D877 or ASTM D1816.

- b. Acid Neutralization Number: ASTM D974.
 - c. Specific Gravity: ASTM D1298.
 - d. Interfacial Tension: ASTM D971.
 - e. Color: ASTM D1500.
 - f. Visual Condition: ASTM D1524.
 - g. Water in Insulating Liquids: ASTM D1533.
 - h. Power Factor or Dissipation Factor: ASTM D924.
- H. Verify that ground connections are in place and that requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance must be 5Ω at transformer location.
- I. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install transformers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 260529 "Hangers and Supports for Electrical Systems."
- B. Transformer must be installed level and plumb and must tilt less than 1.5 degrees while energized.
- C. Comply with requirements for vibration isolation and seismic control devices specified in Section 260529 "Hangers and Supports for Electrical Systems" and **[Section 260548 "Vibration and Seismic Controls for Electrical Systems."][Section 260548.16 "Seismic Controls for Electrical Systems."]**
- D. Maintain minimum clearances and workspace at equipment in accordance with manufacturer's written instructions and NFPA 70.

3.3 CONNECTIONS

- A. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
 - 1. At Interior Locations: For grounding to grounding electrodes, use bare copper cable not smaller than 4/0 AWG. Bond surge arrester and neutrals directly to transformer enclosure and then to grounding electrode system with bare copper conductors. Keep leads as short as practicable, with no kinks or sharp bends. Make joints in grounding conductors and loops by exothermic weld or compression connector.
 - 2. At Exterior Locations:
 - a. For counterpoise, use tinned bare copper cable not smaller than 4/0 AWG, buried not less than **30 inch (765 mm)** below grade interconnecting grounding electrodes. Bond surge arrester and neutrals directly to transformer enclosure and then to grounding electrode system with bare copper conductors. Keep lead lengths as short as practicable, with no kinks or sharp bends.
 - b. Fence and equipment connections must not be smaller than 4 AWG. Ground fence at gate post and corner post and at intervals not exceeding **10 ft (3 m)**. Bond gate section to fence post using **1/8 by 1 inch (3 by 25 mm) [tinned]** flexible braided copper strap and clamps.
 - c. Make joints in grounding conductors and loops by exothermic weld or compression connector.
 - 3. Terminate grounding and bonding conductors on common equipment grounding terminal on transformer enclosure. Install supplemental terminal bars, lugs, and bonding jumpers as required to accommodate number of conductors for termination.

4. Complete transformer tank grounding and lightning arrester connections prior to making other electrical connections.

- B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

1. Maintain air clearances between energized live parts and between live parts and ground for exposed connections in accordance with manufacturer recommendations.
2. Bundle associated phase, neutral, and equipment grounding conductors together within transformer enclosure. Arrange conductors such that there is not excessive strain that could cause loose connections. Allow adequate slack for expansion and contraction of conductors.

- C. Terminate medium-voltage cables in incoming section of substations in accordance with Section 260513 "Medium-Voltage Cables."

3.4 SIGNS AND LABELS

- A. Comply with installation requirements for labels and signs specified in Section 260553 "Identification for Electrical Systems."
- B. Install warning signs as required to comply with 29 CFR 1910.269.

3.5 FIELD QUALITY CONTROL

- A. **[Acceptance]**Testing Preparation:

1. **<Insert requirements>**.

- B. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.

- C. Tests and Inspections:

1. General Field-Testing Requirements:

- a. Comply with provisions of "Testing and Test Methods" Chapter in NFPA 70B.
- b. Perform visual and mechanical inspection and electrical test. Certify compliance with test parameters.
- c. After installing transformer but before primary is energized, verify that grounding system at substation is tested at specified value or less.
- d. After installing transformer and after electrical circuitry has been energized, test for compliance with requirements.
- e. Visual and Mechanical Inspection:
 - 1) Verify equipment nameplate data complies with Contract Documents.
 - 2) Inspect bolted electrical connections for high resistance using one of the following two methods:
 - a) Use low-resistance ohmmeter to compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of lowest value.
 - b) Verify tightness of accessible bolted electrical connections by calibrated

torque-wrench method in accordance with manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels must be in accordance with manufacturer's published data. In absence of manufacturer's published data, use NETA ATS, Table 100.12.

2. Medium-Voltage Surge Arrester Field Tests:

a. Visual and Mechanical Inspection:

- 1) Inspect physical and mechanical condition.
- 2) Inspect anchorage, alignment, grounding, and clearances.
- 3) Verify arresters are clean.
- 4) Verify that ground lead on device is individually attached to ground bus or ground electrode.
- 5) Verify that stroke counter is correctly mounted and electrically connected if applicable. Record stroke counter reading.

b. Electrical Test:

- 1) Perform insulation-resistance test on arrester, phase terminal-to-ground. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Replace units that fail to comply with recommended minimum insulation resistance listed in that table.
- 2) Perform watts-loss test. Evaluate watts-loss values by comparison with similar units and test equipment manufacturer's published data.

3. Liquid-Filled Transformer Field Tests:

a. Visual and Mechanical Inspection:

- 1) Test dew point of tank gases if applicable.
- 2) Inspect anchorage, alignment, and grounding.
- 3) Verify bushings are clean.
- 4) Verify that alarm, control, and trip settings on temperature and level indicators are set and operate within manufacturer's recommended settings.
- 5) Verify that cooling fans and pumps operate correctly and have appropriate overcurrent protection.
- 6) Verify that liquid level in tanks and bushings is within manufacturer's published tolerances.
- 7) Perform specific inspections and mechanical tests recommended by manufacturer.
- 8) Verify presence of transformer surge arresters and that their ratings are as specified.
- 9) Verify that as-left tap connections are as specified.
- 10) Verify presence of surge arresters and that their ratings are as specified.

b. Electrical Tests:

- 1) Perform insulation-resistance tests winding-to-winding and winding-to-ground. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index; value of index must not be less than 1.0.
- 2) Perform power-factor or dissipation-factor tests on windings in accordance with test equipment manufacturer's published data. Maximum winding insulation power-factor/dissipation-factor values must be in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.3.

- 3) Measure core insulation resistance at 500 V(dc) if core is insulated and core ground strap is removable. Core insulation-resistance values must not be less than 1 M Ω at 500 V(dc).
- 4) Perform power-factor or dissipation-factor tip-up test on windings greater than 2.5 kV.
- 5) Perform turns-ratio tests at tap positions. Turns-ratio test results must not deviate by more than one-half percent from either adjacent coils or calculated ratio. If test fails, replace transformer.
- 6) Perform excitation-current test on each phase. Typical excitation-current test data pattern for three-legged core transformer is two similar current readings and one lower current reading. Investigate and correct if test shows different pattern.
- 7) Measure resistance of winding at tap connection, and record temperature-corrected winding-resistance values in Operations and Maintenance Manual.
- 8) Perform applied-voltage test on high- and low-voltage windings-to-ground. Comply with IEEE C57.12.91, Sections 10.2 and 10.9.
- 9) Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.
- 10) Remove sample of insulating liquid in accordance with ASTM D923, and perform dissolved-gas analysis in accordance with IEEE C57.104 or ASTM D3612.

D. Nonconforming Work:

1. Equipment and devices will be considered defective if they do not pass tests and inspections.
2. Remove and replace malfunctioning units and retest.

E. Assemble and submit test and inspection reports. Record as-left set points of adjustable devices.

F. Manufacturer Services:

1. Engage factory-authorized service representative to [support][supervise] field tests and inspections.

3.6 MAINTENANCE

A. Voltage Monitoring and Adjusting: After Substantial Completion, if requested by Owner, but not more than six months after Final Acceptance, perform the following voltage monitoring:

1. During period of normal load cycles as evaluated by Owner, perform seven days of three-phase voltage recording at outgoing section of transformer. Use voltmeters with calibration traceable to National Institute of Science and Technology standards and with chart speed of not less than **1 inch (25 mm)** per hour. Voltage unbalance greater than 1 percent between phases, or deviation of phase voltage from nominal value by more than plus or minus 5 percent during test period, is unacceptable.
2. Corrective Action: If test results are unacceptable, perform the following corrective action, as appropriate:
 - a. Adjust transformer taps.
 - b. Prepare written request for voltage adjustment by electric utility.
3. Retests: Repeat monitoring, after corrective action is performed, until satisfactory results are obtained.
4. Report:
 - a. Prepare written report covering monitoring performed and corrective action taken.

- B. Infrared Inspection: Perform survey during periods of maximum possible loading. Remove necessary covers prior to inspection.
1. After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared inspection of transformer's electrical power connections.
 2. Instrument: Inspect distribution systems with imaging equipment capable of detecting minimum temperature difference of 1 deg C at 30 deg C.
 3. Record of Infrared Inspection: Prepare certified report that identifies testing technician and equipment used, and lists results as follows:
 - a. Description of equipment to be tested.
 - b. Discrepancies.
 - c. Temperature difference between area of concern and reference area.
 - d. Probable cause of temperature difference.
 - e. Areas inspected. Identify inaccessible and unobservable areas and equipment.
 - f. Identify load conditions at time of inspection.
 - g. Provide photographs and thermograms of deficient area.
 4. Act on inspection results in accordance with recommendations of NETA ATS, Table 100.18. Correct possible and probable deficiencies as soon as Owner's operations permit. Retest until deficiencies are corrected.

END OF SECTION 26 12 13 00



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Task	Specification	Specification Description
26 12 13 00	26 22 13 00	Low-Voltage Distribution Transformers



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SECTION 26 12 16 00 - DRY-TYPE, MEDIUM-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Dry-type, medium-voltage transformers.

B. Products Installed, but Not Furnished, under This Section:

1. **<Insert products identified in "Existing Products to be Modified" or "Existing Products to be Removed and Reinstalled" Article>.**

C. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. **[Section 013100 "Project Management and Coordination"]<Insert Section number and title>** for preinstallation conference procedures.
5. Section 260513 "Medium-Voltage Cables" specifies installation of medium-voltage cables.
6. Section 260519 "Low-Voltage Electrical Power Conductors and Cables" specifies installation of low-voltage wiring.
7. Section 260526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding referenced by this Section.
8. Section 260529 "Hangers and Supports for Electrical Systems" specifies hangers, supports, and concrete bases referenced by this Section.
9. Section 260548 "Vibration and Seismic Controls for Electrical Systems" specifies vibration isolation and seismic control devices referenced by this Section.
10. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs referenced by this Section.
11. Section 260573 "Power System Studies" specifies arc-flash hazard analysis, warning labels, and circuit-breaker trip ranges referenced by this Section.

1.2 DEFINITIONS

A. VPE: Vacuum Pressure Encapsulation.

B. VPI: Vacuum Pressure Impregnation.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at **[Project site]<Insert location>**.



- B. Preinstallation Coordination Meeting(s): For dry-type, medium-voltage transformers. Conduct meeting(s) **[as videoconference][or][at Project site]<Insert location> before <Insert construction activity>.**
1. Attendees: Installers, fabricators, representatives of manufacturers, and administrators for field tests and inspections. Notify Architect[, **Construction Manager**][, and **Owner's Commissioning Authority**] of scheduled meeting dates.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
1. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing agency, certifying product's compliance with specified listing criteria.
 - a. If listed manufacturer differs from selling manufacturer, indicate relationship between entities on submittal. Clearly indicate which entity warrants product performance and fitness for purpose.
 - b. Listing criteria identified in approval letter must match specified listing criteria. UL label indicating approval of equipment's enclosure is not considered approval of equipment for intended application.
 - c. Product identification in approval letter must match product branding and model numbers in submittal. Approval letters for discontinued or superseded products are unacceptable for submitted product.
 2. Product Certificates: Include product certificate stating compliance with IEEE C57.16, signed by manufacturer or fabricator.
- B. Factory test reports.
- C. Shop Drawings: Prepare and submit the following:
1. Include plans and elevations showing major components and features.
 - a. Include plan view and cross section of equipment base, showing clearances, manufacturer's recommended workspace, and locations of penetrations for grounding and conduits.
 2. Include details of equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of field connections.
 3. Include single-line diagram.
 4. Include list of materials.
 5. Include nameplate legends.
- D. Sustainable Design Submittals:
1. Product data for sustainable design features for each type of product.
- E. Field quality-control reports.

1.5 INFORMATIONAL SUBMITTALS

- A. Manufacturer's published instructions.

B. Field Reports:

1. Manufacturer's field reports for field quality-control support.
2. Field reports for voltage monitoring and adjusting.
3. Field reports for infrared scanning.

1.6 QUALIFICATIONS

- A. Electrical Power Testing (EPT) Technician III: Possessing active NICET EPT Level III certification. Able to manage switching procedures, conduct tests of complex equipment, analyze test and equipment data, plan a job, and lead a team. Has experience performing NFPA 70B, IEEE, and NETA electrical tests.
- B. Electrical Power Testing (EPT) Technician IV: Possessing active NICET EPT Level IV certification. Able to conduct tests of complex metering and relay systems; evaluate tests, test equipment, test results, and power system performance; recommend actions to maintain or improve system performance; and lead multi-team projects.
- C. Electrical Power Testing and Inspecting Agency: Entities possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
1. On-site electrical testing supervisors must possess active NICET EPT Technician [III][IV] certification.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Delivery:

1. Upon delivery of transformers and prior to unloading, inspect equipment for damage that may have occurred during shipment or storage.
2. Verify that tie rods and chains are undamaged and tight, and that blocking and bracing is tight. Verify that there is no evidence of load shifting in transit, and that readings from transportation shock recorders, if equipped, are within manufacturer's recommendations.
3. Verify that there is no indication of external damage and no dents or scratches in doors and sill, tank walls, radiators and fins, or termination provisions.
4. Compare transformers and accessories received with bill of materials to verify that shipment is complete. Verify that transformers and accessories conform with manufacturer's quotation and shop drawings. If shipment is incomplete or does not comply with Project requirements, notify manufacturer in writing immediately.
5. Unload transformers carefully, observing packing label warnings and handling instructions.
6. Open termination compartment doors and inspect components for damage or displaced parts, loose or broken connections, cracked or chipped insulators, bent mounting flanges, dirt or foreign material, and water or moisture.

B. Storage:

1. Store transformers in accordance with manufacturer's recommendations.
2. Transformers may be stored outdoors. If possible, store transformers at final installation locations on concrete pads. If dry concrete surfaces are unavailable, use pallets of adequate strength to protect transformers from direct contact with ground. Ensure transformer is level.
3. Ensure that transformer storage location is clean and protected from severe conditions. Protect transformers from dirt, water, contamination, and physical damage. Do not store transformers in presence of corrosive or explosive gases. Protect transformers from weather when stored for more than three months.

4. Store transformers with compartment doors closed.
5. Regularly inspect transformers while in storage and maintain documentation of storage conditions, noting discrepancies or adverse conditions. Visually check for rust spots.

C. Handling:

1. Handle transformers carefully, in accordance with manufacturer recommendations, to avoid damage to enclosure, termination compartments, base, frame, and internal components. Do not subject transformers to impact, jolting, jarring, or rough handling.
2. Protect transformer against entrance of dust, rain, and snow.
3. Transport transformers upright, to avoid internal stresses on core and coil mounting assembly and transformer case.
4. Verify that transformer weights are within rated capacity of handling equipment.
5. Use only manufacturer-recommended points for lifting, jacking, and pulling. Use lifting lugs when lifting transformers.
6. Use jacks only at corners of base plate of transformer case.
7. Use nylon straps of same length to balance and distribute weight when handling transformers with crane.
8. Use spreaders or lifting beam to obtain vertical lift and to protect transformer from straps bearing against enclosure. Lifting cable pull angles may not be greater than 15 degrees from vertical.
9. Exercise care not to damage base structure of case when handling transformer using skids or rollers. Use skids to distribute stresses over case base when using rollers under large transformers.

1.8 SERVICE CONDITIONS FOR ELECTRICAL EQUIPMENT

- A. Modeling, analysis, product selection, installation, and quality control for all electrical Work on the Project must comply with service condition requirements specified in Section 018116 "Facility Environmental Requirements" and Section 018123 "Facility Seismic and Wind Criteria."
- B. Usual Service Conditions: Unless unusual service conditions have been specified in "General Environmental Conditions," "Outdoor Conditions," and "Indoor Conditions" articles of Section 018116 "Facility Environmental Requirements," electrical service and distribution equipment must be suitable for operation under usual service conditions specified in applicable IEEE C57 series standards.

PART 2 - PRODUCTS

2.1 EXISTING PRODUCTS TO BE MODIFIED

- A. Basis for Pricing: **<Insert name of manufacturer and model number or series for existing product>.**
- B. Description: **<Insert description of existing product, including special features, options, and finishes that may impact the Work>.**
 1. Sustainable Design Features:
 - a. Material Reuse: Product is salvaged, refurbished, or reused.
- C. Accessories: **<Insert accessories included with existing product>.**

2.2 EXISTING PRODUCTS TO BE REMOVED AND REINSTALLED

- A. Basis for Pricing: **<Insert name of manufacturer and model number or series for existing product>.**
- B. Description: **<Insert description of existing product, including special features, options, and finishes that may impact the Work>.**
 - 1. Sustainable Design Features:
 - a. Material Reuse: Product is salvaged, refurbished, or reused.
- C. Accessories: **<Insert accessories included with existing product>.**

2.3 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2.4 MEDIUM-VOLTAGE TRANSFORMERS

- A. Source Quality Control:
 - 1. Factory Tests:
 - a. Owner will witness required factory tests. Notify Architect at least 14 days before date of tests and indicate their approximate duration.
 - b. Testing Administrant: **[Owner will engage][Engage]** qualified electrical testing agency to evaluate transformer.
 - c. Factory Tests and Inspections: Perform the following tests and inspections on transformer by, or under supervision of, qualified electrical testing laboratory recognized by authorities having jurisdiction, in accordance with IEEE C57.16 before delivering to site. Affix label with name and date of **[manufacturer's][qualified electrical testing laboratory's]** certification of system compliance.
 - 1) Tests for Transformers 500 kVA and Smaller:
 - a) Turns ratio, polarity, and phase relation on rated voltage connection.
 - b) Transformer no-load losses and excitation current at 100 percent of ratings. This test may be based on a statistical sample.
 - c) Applied voltage and induced voltage.
 - d) Partial discharge.
 - e) Impedance voltage and load loss at rated current and rated frequency on rated voltage connection and at tap extremes.
 - f) Temperature rise at minimum and maximum ratings.
 - g) Impulse.
 - h) Insulation power factor.
 - i) Insulation resistance.
 - j) Audible sound level.
 - k) Short-circuit capability.
 - l) Operation of devices.
 - m) Control (auxiliary) and consumption loss data values.
 - 2) Tests for Transformers 501 kVA and Larger:

- a) Resistance measurements of windings on rated voltage tap and at tap extremes.
 - b) Turns ratio, polarity, and phase relation on rated voltage connection.
 - c) Transformer no-load losses and excitation current at 100 percent of ratings.
 - d) Impedance voltage and load loss at rated current and rated frequency on rated voltage connection and at tap extremes.
 - e) Applied voltage and induced voltage.
 - f) Partial discharge.
 - g) Leak test.
 - h) Temperature rise at minimum and maximum ratings.
 - i) Impulse.
 - j) Insulation power factor.
 - k) Insulation resistance.
 - l) Audible sound level.
 - m) Short-circuit capability.
 - n) Operation of devices.
 - o) Control (auxiliary) and consumption loss data values.
- d. Nonconforming Work:
- 1) Equipment that does not pass tests and inspections will be considered defective.
- e. Factory Test Reports: Compile and submit factory test and inspection reports.

B. Dry-Type, Medium-Voltage Transformers :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[Eaton]**
 - c. **[GE Power; General Electric Company]**
 - d. **[Hammond Power Solutions Inc.]**
 - e. **[Siemens Industry, Inc., Energy Management Division]**
 - f. **[Square D; Schneider Electric USA]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Eaton]**
 - c. **[GE Power; General Electric Company]**
 - d. **[Hammond Power Solutions Inc.]**
 - e. **[Siemens Industry, Inc., Energy Management Division]**
 - f. **[Square D; Schneider Electric USA]**
 - g. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

- a. Transformers, Distribution, Dry Type, Over 600 V: UL CCN XPFS; including UL 1562 or IEEE C57.16.

4. Standard Features:

- a. Referenced Standards: IEEE C2 and IEEE C57.16.
- b. Windings Material: **[Aluminum][Copper]**.
- c. Surge Arresters: Comply with IEEE C62.11, Distribution Class; metal-oxide-varistor type, connected in each phase of incoming circuit and ahead of disconnecting device.
- d. Cooling Systems: Comply with IEEE C57.12.01 for cooling class.
 - 1) Self-Cooled Rating, Class **<Insert letters>**: **<Insert number>** kVA.
 - 2) Future Forced-Air-Cooled Rating, Class **<Insert letters>**:
 - a) Self-Cooled: **<Insert number>** kVA.
 - b) Forced-Air Cooled: **<Insert number>** kVA.
 - c) Make provision for future addition of forced-air-cooling equipment. Transformer bushings, leads, and related components must be sized for future equipment. Provide fan mounts, conduit supports, and terminal boxes.
 - 3) Forced-Air-Cooled Rating, Class **<Insert letters>**:
 - a) Self-Cooled: **<Insert number>** kVA.
 - b) Forced-Air Cooled: **<Insert number>** kVA.
 - c) Equip with forced-air-cooling equipment, including fans, conduit, wiring, motor controllers, and thermometer with alarm contacts for fan control.
 - d) Forced-air cooling must be regulated automatically by sensors placed in load-side winding's air ducts. Forced-air cooling must include three-phase electronic digital temperature monitor, fans, control wiring, control panel with test switch, indicating lights, alarm, and alarm silencing switch. **[Connect to control network.]**
- e. Coils Insulation Systems:
 - 1) Primary and secondary coil assemblies must be manufactured using polyester VPI system.
 - 2) Primary and secondary coil assemblies must be manufactured using silicone resin VPE system.
 - 3) Primary coil assembly must be manufactured using **<Insert system description>**. Secondary coil assembly must be manufactured using **<Insert system description>**.
- f. Winding Connections: Connection of windings and terminal markings must comply with IEEE C57.12.70.
- g. Efficiency: Comply with 10 CFR 431, Subpart K.
- h. Bushings must comply with IEEE C57.19.01 requirements for impulse and low-frequency insulation levels.
- i. Tap Changer: External, for de-energized operation.
 - 1) Taps: Two 2-1/2 percent, full-capacity taps above and two 2-1/2 percent, full-capacity taps below rated voltage. Comply with IEEE C57.12.36 requirements.
- j. Enclosure:
 - 1) Provide with provisions for lifting and anchoring frame to concrete pad.
 - 2) With integral skid-mounting frame, suitable to allow skidding or rolling of transformer

- in any direction.
- 3) Enclosure Finish:
- a) Outdoor Transformer Enclosure Finish: Factory-applied finish in manufacturer's standard color, corrosion resistant complying with IEEE C57.12.28.
 - b) Indoor Transformer Enclosure Finish: Factory-applied finish in manufacturer's standard gray over rust-inhibiting primer on treated metal surface.
 - c) Special Corrosion-Resistant Enclosure Finish: Factory-applied, corrosion-resistant finish in manufacturer's standard color that withstands **[120][480]** hours of exposure to salt-spray test specified in ASTM B117 without loss of paint or release of adhesion of paint primer coat to metal surface in excess of **1/16 inch (1.6 mm)** from test mark. Scribed test mark and test evaluation must be in accordance with ASTM D1654 with rating of not less than 7 in accordance with Table 1 (Procedure A). Cut edges or otherwise damaged surfaces of hot-dip galvanized sheet steel, or mill-galvanized sheet steel must be coated with manufacturer's standard zinc-rich paint.
- k. Sound level must comply with requirements of NEMA TR 1.
- l. Capacities and Characteristics:
- 1) Enclosure: **[Ventilated][Nonventilated]** power transformer, UL 50E **[Type 1][Type 2][Type 3R]** enclosure.
 - 2) Additional IEEE Standards: Comply with IEEE C57.12.51.
 - 3) Connections:
 - a) Primary: **[Air-filled terminal cabinet for cable connection][Throat for busway connection][Terminals for close connection to primary switch]**.
 - b) Secondary: **[Air-filled terminal cabinet for cable connection][Throat for busway connection]**.
 - 4) Transformer Ratings.
 - a) Impedance: Not less than **[5.75]<Insert number>** percent.
 - b) Temperature Rise: **[150 deg C]<Insert deg C>**.
 - 5) Coils Connection:
 - a) Line-Side Winding: **[Delta]<Insert connection>**.
 - b) Load-Side Winding: **[Wye]<Insert connection>**.
 - 6) Voltage and BIL Ratings:
 - a) Nominal primary phase-to-phase voltage and BIL: **[4160 V, 30 kV][13 800 V, 60 kV][34 500 V, 150 kV]<Insert requirements>**.
 - b) Nominal secondary voltage and BIL: **[208Y/120 V, 10 kV][480Y/277 V, 10 kV]<Insert requirements>**.
 - c) K-Factor: **<Insert number>**, complying with UL 1562.
 - 7) Taps: Two 2-1/2 percent, full-capacity taps above and two 2-1/2 percent, full-capacity taps below rated voltage. Comply with IEEE C57.12.51 requirements.
 - 8) Transformer Accessories:
 - a) Dial-type analog thermometer with alarm contacts.
 - b) At least four stainless steel ground connection pads.

- c) Provisions for jacking, lifting, and towing.
 - d) Machine-engraved nameplate made of anodized aluminum or stainless steel.
- 9) Heaters: Where outdoor cast-coil transformers are indicated on Drawings, they must include thermostatically controlled space heaters powered from **[external source that remains energized when transformer is de-energized][a fused control power transformer connected to primary side of substation transformer]**.
- m. Control Network: Support serial MS/TP and Ethernet IP communications, and able to communicate directly via TIA-485 serial networks and Ethernet 10Base-T networks as native device.
- 5. Seismic and Wind Performance: Installed product must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:
 - a. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events[**and unit must be fully operational after seismic events**].
 - b. Component Importance Factor (Ip): **[1.0][1.5]**.
 - c. Component Amplification Factor (ap): **[1.0]<Insert value>**.
 - d. Component Response Modification Factor (Rp): **[2.5]<Insert value>**.
 - e. Component Overstrength Factor (Ωo): **[2.5]<Insert value>**.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and space conditions for compliance with requirements for dry-type, medium-voltage transformers and other conditions affecting performance of the Work.
- B. Examine roughing-in of conduits and grounding systems to verify the following:
 - 1. Wiring entries comply with layout requirements.
 - 2. Entries are within conduit-entry tolerances specified by manufacturer, and no feeders may cross section barriers to reach load or line lugs.
- C. Examine walls, floors, roofs, and concrete bases for suitable conditions for transformer installation.
- D. Pre-Installation Checks:
 - 1. Verify removal of shipping bracing after placement.
- E. Verify that grounding and bonding connections are in place. Ground (earth) resistance at transformer location may not be greater than **[5 Ω]<Insert resistance in ohms>**.
- F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF TRANSFORMERS

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the

Contract Documents or manufacturer's published instructions, comply with the following:

1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
2. Electrical Maintenance: NFPA 70B.
3. Electrical Safety: NFPA 70E.
4. Commissioning of Electrical Systems: NECA NEIS 90.
5. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
6. Communications Work: BICSI N1.
7. Emergency and Standby Power Work: NFPA 110, NFPA 111, and NECA NEIS 416.
8. Work in Confined Spaces: NFPA 350.
9. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
10. Consult Architect for resolution of conflicting requirements.

C. Special Installation Techniques:

1. Transformer must be installed level and plumb and must tilt less than 1.5 degrees while energized.
2. Maintain minimum clearances and workspace at equipment in accordance with manufacturer's published instructions and NFPA 70.
3. Grounding and Bonding:
 - a. At Interior Locations: For grounding to grounding electrodes, provide bare copper cable not smaller than 4/0 AWG. Bond surge arrester and neutrals directly to transformer enclosure and then to grounding electrode system with bare copper conductors. Keep leads as short as practicable, with no kinks or sharp bends. Make joints in grounding conductors and loops by exothermic weld or compression connector.
 - b. At Exterior Locations:
 - 1) For counterpoise, provide tinned bare copper cable not smaller than 4/0 AWG, buried not less than **30 inch (765 mm)** below grade interconnecting grounding electrodes. Bond surge arrester and neutrals directly to transformer enclosure and then to grounding electrode system with bare copper conductors. Keep lead lengths as short as practicable, with no kinks or sharp bends.
 - 2) Fence and equipment connections may not be smaller than 4 AWG. Ground fence at gate posts and corner post and at intervals not exceeding **10 ft (3 m)**. Bond gate sections to fence posts using **1/8 by 1 inch (3 by 25 mm) [tinned]** flexible braided copper strap and clamps.
 - 3) Make joints in grounding conductors and loops by exothermic weld or compression connector.
 - c. Terminate grounding and bonding conductors on common equipment grounding terminal on transformer enclosure. Install supplemental terminal bars, lugs, and bonding jumpers as required to accommodate number of conductors for termination.
 - d. Complete transformer tank grounding and lightning arrester connections prior to making other electrical connections.
4. Connect low-voltage wiring.
 - a. Maintain air clearances between energized live parts and between live parts and ground for exposed connections in accordance with manufacturer's published instructions.
 - b. Bundle associated phase, neutral, and equipment grounding conductors together within transformer enclosure. Arrange conductors such that there is not excessive strain that could cause loose connections. Allow adequate slack for expansion and contraction of conductors.

5. Terminate medium-voltage cables in incoming section of substations.

D. Interfaces with Other Work:

1. Identification: Provide labels for transformers and associated electrical equipment.
 - a. Identify field-installed conductors, interconnecting wiring, and components.
 - b. Label each enclosure with engraved metal or laminated-plastic nameplate.
 - c. Provide warning signs and arc-flash hazard warning labels for electrical equipment.
2. Install transformers on cast-in-place concrete equipment base(s).
3. Provide vibration isolation and seismic control devices.

3.3 FIELD QUALITY CONTROL

A. Administrant for Electrical Power Tests and Inspections:

1. **[Owner][Tenant]** will engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
2. Engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].

B. Acceptance Testing Preparation:

1. **<Insert requirements>**.

C. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.

D. Tests and Inspections:

1. General Field-Testing Requirements:
 - a. Comply with provisions of "Testing and Test Methods" Chapter in NFPA 70B.
 - b. Perform visual and mechanical inspections and electrical tests. Certify compliance with test parameters.
 - c. After installing transformer but before primary is energized, verify that grounding system at substation is tested at specified value or less.
 - d. After installing transformer and after electrical circuitry has been energized, test for compliance with requirements.
 - e. Visual and Mechanical Inspection:
 - 1) Verify equipment nameplate data complies with Contract Documents.
 - 2) Inspect bolted electrical connections for high resistance using one of the following two methods:
 - a) Use low-resistance ohmmeter to compare bolted-connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of lowest value.
 - b) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or

NETA ATS, Table 100.12. Bolt-torque levels must be in accordance with manufacturer's published data. In absence of manufacturer's published data, use NETA ATS, Table 100.12.

2. Medium-Voltage Surge Arrester Field Tests:

a. Visual and Mechanical Inspection:

- 1) Inspect physical and mechanical condition.
- 2) Inspect anchorage, alignment, grounding, and clearances.
- 3) Verify arresters are clean.
- 4) Verify that ground leads on devices are individually attached to ground bus or ground electrode.
- 5) Verify that stroke counter is correctly mounted and electrically connected if applicable. Record stroke counter reading.

b. Electrical Test:

- 1) Perform insulation-resistance test on arresters, phase terminal-to-ground. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Replace units that fail to meet recommended minimum insulation resistance listed in that table.
- 2) Perform watts-loss test. Evaluate watts-loss values by comparison with similar units and test equipment manufacturer's published data.

3. Dry-Type Transformer Field Tests:

a. Visual and Mechanical Inspection:

- 1) Test dew point of tank gases if applicable.
- 2) Inspect anchorage, alignment, and grounding.
- 3) Verify that resilient mounts are free and that shipping brackets have been removed.
- 4) Verify bushings are clean.
- 5) Verify that alarm, control, and trip settings on temperature and level indicators are set and operate within manufacturer's recommended settings.
- 6) Verify that cooling fans operate correctly and have appropriate overcurrent protection.
- 7) Perform specific inspections and mechanical tests recommended by manufacturer.
- 8) Verify that as-left tap connections are as specified.

b. Electrical Tests:

- 1) Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index; value of index may not be less than 1.0.
- 2) Perform power-factor or dissipation-factor tests on windings in accordance with test equipment manufacturer's published data.
- 3) Perform power-factor or dissipation-factor tip-up test on windings greater than 2.5 kV.
- 4) Perform turns-ratio tests at tap positions. Turns-ratio test results may not deviate by more than one-half percent from either adjacent coils or calculated ratio. If test fails, replace transformer.
- 5) Perform excitation-current test on each phase. The typical excitation-current test data pattern for three-legged core transformer is two similar current readings and

- one lower current reading. Investigate and correct if test shows different pattern.
- 6) Measure resistance of windings at tap connections, and record temperature-corrected winding-resistance values in Operations and Maintenance Manual.
- 7) Perform applied-voltage test on high- and load-side windings-to-ground. Comply with IEEE C57.12.91 provisions for field-deployed dielectric tests. Measurements must be made only when voltage and current have reached stable value. Test must be discontinued immediately in the event current begins to increase without stabilizing. Record test values in Operations and Maintenance Manual.
- 8) Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

E. Nonconforming Work:

1. Equipment and devices will be considered defective if they do not pass tests and inspections.
2. Remove and replace malfunctioning units and retest.

F. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports. Record as-left set points of adjustable devices.

G. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.

1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.

3.4 CLOSEOUT ACTIVITIES

A. Training:

1. **[With assistance from factory-authorized service representatives, train][Train]** Owner's maintenance personnel on the following topics:
 - a. How to adjust, operate, and maintain transformer equipment.
2. **[Provide video recordings of training sessions to Owner.][Allow Owner to record training sessions.]**

3.5 PROTECTION

- A. After installation, protect transformer from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

3.6 MAINTENANCE

- A. Voltage Monitoring and Adjusting: After Substantial Completion, if requested by Owner, but not more than six months after Final Acceptance, perform the following voltage monitoring:

1. During period of normal load cycles as evaluated by Owner, perform seven days of three-phase voltage recording at outgoing section of transformers. Use voltmeters with calibration traceable to National Institute of Science and Technology standards and with chart speed of not less than 1 inch (25 mm) per hour. Voltage unbalance greater than 1 percent between phases, or

deviation of phase voltage from nominal value by more than plus or minus 5 percent during test period, is unacceptable.

2. Corrective Action: If test results are unacceptable, perform the following corrective action, as appropriate:

- a. Adjust transformer taps.
- b. Prepare written request for voltage adjustment by electric utility.

3. Retests: Repeat monitoring, after corrective action is performed, until satisfactory results are obtained.
4. Field Reports for Voltage Monitoring and Adjusting: Prepare written report covering monitoring performed and corrective action taken.

- B. Infrared Scanning of Transformers: Perform survey during periods of maximum possible loading. Remove necessary covers prior to inspection.

1. After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared inspection of transformer's electrical power connections. Remove covers so joints and connections are accessible to portable scanner. Take visible light photographs at same locations and orientations as infrared scans for documentation to ensure follow-on scans match same conditions for valid comparison.
2. Instrument: Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1 deg C at 30 deg C. Provide documentation of device calibration.
3. Field Reports for Infrared Scanning: Prepare certified report that identifies transformer equipment checked, testing technician, equipment used, and that describes scanning results. Include notation of deficiencies detected, remedial actions taken, and scanning observations after remedial action. List results as follows:
 - a. Description of equipment to be tested.
 - b. Discrepancies.
 - c. Temperature difference between area of concern and reference area.
 - d. Probable cause of temperature difference.
 - e. Areas inspected. Identify inaccessible and unobservable areas and equipment.
 - f. Identify load conditions at time of inspection.
 - g. Provide photographs and thermograms of deficient area.
4. Act on inspection results in accordance with recommendations of NETA ATS, Table 100.18. Correct possible and probable deficiencies as soon as Owner's operations permit. Retest until deficiencies are corrected.

END OF SECTION 26 12 16 00



Task	Specification	Specification Description
26 12 16 00	26 22 13 00	Low-Voltage Distribution Transformers



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SECTION 26 12 19 00 - PAD-MOUNTED, LIQUID-FILLED, MEDIUM-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pad-mounted, liquid-filled, medium-voltage transformers.

B. Products Installed, but Not Furnished, under This Section:

1. **<Insert products identified in "Existing Products to be Modified" Article or "Existing Products to be Removed and Reinstalled" Article>.**

C. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. **[Section 013100 "Project Management and Coordination"]<Insert Section number and title>** for preinstallation conference procedures.
5. Section 260513 "Medium-Voltage Cables" specifies installation of medium-voltage cables.
6. Section 260519 "Low-Voltage Electrical Power Conductors and Cables" specifies installation of low-voltage wiring.
7. Section 260526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding referenced by this Section.
8. Section 260529 "Hangers and Supports for Electrical Systems" specifies hangers, supports, and concrete bases referenced by this Section.
9. Section 260548 "Vibration and Seismic Controls for Electrical Systems" specifies vibration isolation and seismic control devices referenced by this Section.
10. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs referenced by this Section.
11. Section 260573 "Power System Studies" specifies arc-flash hazard analysis, warning labels, and circuit-breaker trip ranges referenced by this Section.

1.2 DEFINITIONS

- A. Bushing: An insulating structure including a central conductor, or providing a central passage for a conductor, with provision for mounting on a barrier, conducting or otherwise, for the purpose of insulating the conductor from the barrier and conducting current from one side of the barrier to the other.
- B. Bushing Elbow: An insulated device used to connect insulated conductors to separable insulated connectors on dead-front, pad-mounted transformers and to provide a fully insulated connection. This is also called an "elbow connector."
- C. Bushing Insert: That component of a separable insulated connector that is inserted into a bushing well to complete a dead-front, load break or nonload break, separable insulated connector (bushing).



- D. Bushing Well: A component of a separable insulated connector, either permanently welded or clamped to an enclosure wall or barrier, having a cavity that receives a replaceable component (bushing insert) to complete the separable insulated connector (bushing).
- E. Elbow Connector: See "bushing elbow" above.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at **[Project site]<Insert location>**.
- B. Preinstallation Coordination Meeting(s): For {Insert system or product}. Conduct meeting(s) **[as videoconference][or][at Project site]<Insert location>** before **<Insert construction activity>**.
 - 1. Attendees: Installers, fabricators, representatives of manufacturers, and administrators for field tests and inspections. Notify Architect[, **Construction Manager**][, and **Owner's Commissioning Authority**] of scheduled meeting dates.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing agency, certifying product's compliance with specified listing criteria.
 - a. If listed manufacturer differs from selling manufacturer, indicate relationship between entities on submittal. Clearly indicate which entity warrants product performance and fitness for purpose.
 - b. Listing criteria identified in approval letter must match specified listing criteria. UL label indicating approval of equipment's enclosure is not considered approval of equipment for intended application.
 - c. Product identification in approval letter must match product branding and model numbers in submittal. Approval letters for discontinued or superseded products are unacceptable for submitted product.
 - 2. Product Certificates: Include product certificate stating compliance with IEEE C57.12.00, signed by manufacturer or fabricator.
- B. Factory test reports.
- C. Shop Drawings: Prepare and submit the following:
 - 1. Plans and elevations showing major components and features.
 - a. Plan view and cross section of equipment base, showing clearances, required workspace, and locations of penetrations for grounding and conduits.
 - 2. Details of equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of field connections.
 - 3. Single-line diagram.
 - 4. List of materials.
 - 5. Nameplate data.

6. Manufacturer's published time-current curves of transformer line-side fuses, with transformer damage curve, inrush curve, and thru fault current indicated.

D. Sustainable Design Submittals:

1. Product data for sustainable design features for each type of product.

E. Field quality-control reports.

1.5 INFORMATIONAL SUBMITTALS

- A. Manufacturer's published instructions.
- B. Manufacturer's field reports for field quality-control support.
- C. Field reports for voltage monitoring and adjusting.
- D. Field reports for infrared scanning.

1.6 QUALIFICATIONS

- A. Electrical Power Testing (EPT) Technician III: Possessing active NICET EPT Level III certification. Able to manage switching procedures, conduct tests of complex equipment, analyze test and equipment data, plan a job, and lead a team. Has experience performing NFPA 70B, IEEE, and NETA electrical tests.
- B. Electrical Power Testing (EPT) Technician IV: Possessing active NICET EPT Level IV certification. Able to conduct tests of complex metering and relay systems; evaluate tests, test equipment, test results, and power system performance; recommend actions to maintain or improve system performance; and lead multi-team projects.
- C. Electrical Power Testing and Inspecting Agency: Entities possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
 1. On-site electrical testing supervisors must possess active NICET EPT Technician [III][IV] certification.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Delivery:

1. Upon delivery of transformers and prior to unloading, inspect equipment for damage that may have occurred during shipment or storage.
2. Verify that tie rods and chains are undamaged and tight, and that blocking and bracing is tight. Verify that there is no evidence of load shifting in transit, and that readings from transportation shock recorders, if equipped, are within manufacturer's recommendations.
3. Verify that there is no indication of external damage and no dents or scratches in doors and sill, tank walls, radiators and fins, or termination provisions.
4. Verify that there is no evidence of insulating-liquid leakage on transformer surfaces, at weld seams, on line- or load-side bushing parts, and at transformer base.
5. Verify that there is positive pressure or vacuum on tank. Check pressure gauge; it is required to read other than zero.

6. Compare transformers and accessories received with bill of materials to verify that shipment is complete. Verify that transformers and accessories conform with manufacturer's quotation and shop drawings. If shipment is incomplete or does not comply with Project requirements, notify manufacturer in writing immediately.
7. Verify presence of polychlorinated biphenyl content labeling.
8. Unload transformers carefully, observing packing label warnings and handling instructions.
9. Open termination compartment doors and inspect components for damage or displaced parts, loose or broken connections, cracked or chipped insulators, bent mounting flanges, dirt or foreign material, and water or moisture.

B. Storage:

1. Store transformers in accordance with manufacturer's recommendations.
2. Transformers may be stored outdoors. If possible, store transformers at final installation locations on concrete pads. If dry concrete surfaces are unavailable, use pallets of adequate strength to protect transformers from direct contact with ground. Ensure that transformer is level.
3. Ensure that transformer storage location is clean and protected from severe conditions. Protect transformers from dirt, water, contamination, and physical damage. Do not store transformers in the presence of corrosive or explosive gases. Protect transformers from weather when stored for more than three months.
4. Store transformers with compartment doors closed.
5. Regularly inspect transformers while in storage and maintain documentation of storage conditions, noting discrepancies or adverse conditions. Verify that effective pressure seal is maintained using pressure gauges. Visually check for insulating-liquid leaks and rust spots.

C. Handling:

1. Handle transformers carefully, in accordance with manufacturer's recommendations, to avoid damage to enclosure, termination compartments, base, frame, tank, and internal components. Do not subject transformers to impact, jolting, jarring, or rough handling.
2. Protect transformer termination compartments against entrance of dust, rain, and snow.
3. Transport transformers upright, to avoid internal stresses on core and coil mounting assembly and to prevent trapping air in windings. Do not tilt or tip transformers.
4. Verify that transformer weights are within rated capacity of handling equipment.
5. Use only manufacturer-recommended points for lifting, jacking, and pulling. Use lifting lugs when lifting transformers.
6. Use jacks only at corners of tank base plate.
7. Use nylon straps of same length to balance and distribute weight when handling transformers with crane.
8. Use spreaders or lifting beam to obtain vertical lift and to protect transformer from straps bearing against enclosure. Lifting cable pull angles may not be greater than 15 degrees from vertical.
9. Exercise care not to damage tank base structure when handling transformer using skids or rollers. Use skids to distribute stresses over tank base when using rollers under large transformers.

1.8 SERVICE CONDITIONS FOR ELECTRICAL EQUIPMENT

- A. Modeling, analysis, product selection, installation, and quality control for all electrical Work on the Project must comply with service condition requirements specified in Section 018116 "Facility Environmental Requirements" and Section 018123 "Facility Seismic and Wind Criteria."
- B. Usual Service Conditions: Unless unusual service conditions have been specified in "General Environmental Conditions," "Outdoor Conditions," and "Indoor Conditions" articles of Section 018116

"Facility Environmental Requirements," electrical service and distribution equipment must be suitable for operation under usual service conditions specified in applicable IEEE C57 series standards.

PART 2 - PRODUCTS

2.1 EXISTING PRODUCTS TO BE MODIFIED

- A. Basis for Pricing: **<Insert name of manufacturer; model number or series for existing product>.**
- B. Description: **<Insert description of existing product, including special features, options, and finishes that may impact the Work>.**
 - 1. Sustainable Design Features:
 - a. Material Reuse: Product is salvaged, refurbished, or reused.
- C. Accessories: **<Insert accessories included with existing product>.**

2.2 EXISTING PRODUCTS TO BE REMOVED AND REINSTALLED

- A. Basis for Pricing: **<Insert name of manufacturer; model number or series for existing product>.**
- B. Description: **<Insert description of existing product, including special features, options, and finishes that may impact the Work>.**
 - 1. Sustainable Design Features:
 - a. Material Reuse: Product is salvaged, refurbished, or reused.
- C. Accessories: **<Insert accessories included with existing product>.**

2.3 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2.4 PAD-MOUNTED, LIQUID-FILLED, MEDIUM-VOLTAGE TRANSFORMERS

- A. Source Quality Control:
 - 1. Factory Tests:
 - a. Owner will witness required factory tests. Notify Architect at least 14 days before date of tests and indicate their approximate duration.
 - b. Testing Administrator: **[Owner will engage][Engage]** qualified electrical testing agency to evaluate transformer.
 - c. Factory Tests and Inspections: Perform the following tests and inspections on transformer, by, or under supervision of, qualified electrical testing laboratory recognized by authorities having jurisdiction, in accordance with IEEE C57.12.00 before delivering to site. Affix label



with name and date of **[manufacturer's][qualified electrical testing laboratory's]** certification of system compliance.

- 1) Resistance.
- 2) Turns ratio, polarity, and phase relation.
- 3) Transformer no-load losses and excitation current at 100 percent of ratings.
- 4) Transformer impedance voltage and load loss.
- 5) Operation of devices.
- 6) Lightning impulse.
- 7) Low frequency.
- 8) Leak.
- 9) Perform Optional Tests:
 - a) Transformer no-load losses and excitation current at 110 percent of ratings.
 - b) Insulation power factor.
 - c) Applied potential, except that this test is not required for single-phase transformers or for three-phase Y-Y-connected transformers.
 - d) Induced potential.
 - e) Resistance measurements of windings on rated voltage connection and at tap extreme connections.
 - f) Ratios on rated voltage connection and at tap extreme connections.
 - g) Polarity and phase relation on rated voltage connection.
 - h) No-load loss at rated voltage on rated voltage connection.
 - i) Exciting current at rated voltage on rated voltage connection.
 - j) Impedance.

d. Nonconforming Work:

- 1) Equipment that does not pass tests and inspections will be considered defective.

e. Factory Test Reports: Compile and submit factory test and inspection reports.

B. Single-Phase, Pad-Mounted Transformers :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Eaton]**
 - b. **[ERMCO-ECI]**
 - c. **[GE Power; General Electric Company]**
 - d. **[Hitachi Energy USA Inc.; business of Hitachi, Ltd.]**
 - e. **[Howard Industries, Inc]**
 - f. **[Prolec GE; A Xignux and General Electric Company Joint Venture]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Eaton]**
 - b. **[ERMCO-ECI]**
 - c. **[GE Power; General Electric Company]**

- d. [Hitachi Energy USA Inc.; business of Hitachi, Ltd.]
 - e. [Howard Industries, Inc]
 - f. [Prolec GE; A Xignux and General Electric Company Joint Venture]
 - g. <Insert manufacturer's name>
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
- a. Transformers, Distribution, Liquid-Filled Type, Over 600 V: UL CCN XPLH; including IEEE C57.12.00 and IEEE C57.12.28.
4. Standard Features:
- a. [Oil-filled][Less-flammable-liquid-filled], two-winding, 60 Hz, 65 deg C rise above 30 deg C average ambient, self-cooled transformer.
 - b. Reference Standards: IEEE C2 and IEEE C57.12.38.
 - c. Windings Material: [Aluminum][Copper].
 - d. Surge Arresters: Comply with IEEE C62.11, Distribution Class; metal-oxide-varistor type, fully shielded, separable-elbow type, suitable for plugging into inserts provided in line-side section of transformer. Connected in each phase of incoming circuit and ahead of disconnecting device.
 - e. Winding Connections: Connection of windings and terminal markings must comply with IEEE C57.12.70.
 - f. Efficiency: Comply with 10 CFR 431, Subpart K.
 - g. Insulation: Transformer kVA rating must be as follows: Average winding temperature rise above 30 deg C ambient temperature must not exceed 65 deg C and 80 deg C hottest-spot temperature rise at rated kVA when tested in accordance with IEEE C57.12.90, using combination of connections and taps that give highest average winding temperature rise.
 - h. Tap Changer: External handle, for de-energized operation.
 - i. Tank: Sealed, with welded-on cover. **Designed to withstand internal pressure of not less than 7 psi (50 kPa) without permanent distortion and 15 psig (104 kPa) without rupture. Comply with IEEE C57.12.36.]**
 - j. Enclosure Integrity: Comply with IEEE C57.12.28 for pad-mounted enclosures that contain energized electrical equipment in excess of 600 V that may be exposed to public.
 - k. Mounting: Integral skid mounting frame, suitable to allow skidding or rolling of transformer in any direction, and with provision for anchoring frame to pad.
 - l. Insulating Liquids:
 - 1) Mineral Oil: ASTM D3487, Type II, and tested for compliance with ASTM D117.
 - 2) Less-Flammable Liquids:
 - a) Edible-Seed-Oil-Based Dielectric: Listed and labeled by qualified electrical testing laboratory recognized by authorities having jurisdiction as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested in accordance with ASTM D92. Liquid must be biodegradable and nontoxic, having passed Organisation for Economic Co-operation and Development G.L.203 with zero mortality, and must be certified by U.S. Environmental Protection Agency as biodegradable, meeting Environmental Technology Verification requirements.
 - b) Biodegradable and Nontoxic Dielectric: Listed and labeled by qualified electrical testing laboratory recognized by authorities having jurisdiction as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested in accordance with ASTM D92.
 - m. Sound level must comply with NEMA TR 1 requirements.



- n. Corrosion Protection:
- 1) Transformer coating system must be factory applied, complying with requirements of [IEEE C57.12.28][IEEE C57.12.29], in manufacturer's standard color [green]<Insert color>.
 - 2) Fabricate front sill, hood, and tank base of single-compartment transformers from stainless steel in accordance with ASTM A167, Type 304 or 304L, not less than No. 13 U.S. gage, complying with requirements of [IEEE C57.12.28][IEEE C57.12.29], standard color [green]<Insert color>.
 - 3) Base and Cabinets of Two Compartment Transformers: Fabricate from stainless steel in accordance with ASTM A167, Type 304 or 304L, not less than No. 13 U.S. gage. Coat transformer with manufacturer's standard green color coating complying with requirements of [IEEE C57.12.28][IEEE C57.12.29], in manufacturer's standard color [green]<Insert color>.
- o. Compartment Construction:
- 1) Single compartment for line- and load-side sections, clamshell style, with provision for padlocking hinged cover and single-point latching.
 - 2) Individual compartments for line- and load-side sections, formed by steel isolating barriers that extend full height and depth of compartments. With hinged, lift-off doors, with stop in open position, three-point latching, and provision for padlocking.
 - 3) Provide [Type 1][Type 2] terminal arrangement.
- p. Primary Fusing: Designed and rated to provide thermal protection of transformer by sensing overcurrent and high liquid temperature.
- 1) 150 kV BIL current-limiting fuses, conforming to requirements of IEEE C37.42.
 - 2) Interrupting Rating: 50 000 A(rms sym) at system voltage.
 - 3) Fuse Assembly: Bayonet-type, liquid-immersed, expulsion fuses in series with liquid-immersed, partial-range, current-limiting fuses. Bayonet fuse must sense both high currents and high oil temperatures to provide transformer with thermal protection.
 - 4) Provide bayonet fuse assembly with oil retention valve and external drip shield inside housing to eliminate or minimize oil spills. Valve must close when fuse holder is removed.
 - 5) Provide conspicuously displayed warning adjacent to bayonet fuse(s), cautioning against removing or inserting fuses unless transformer has been de-energized and tank pressure has been released.
- q. Line-Side Section: Dead-front design.
- 1) To connect primary cable, use separable insulated connectors. Bushings must be one-piece units, with ampere and BIL ratings same as connectors.
 - 2) Bushing inserts[**and feed-through inserts**]:
 - a) Conform to requirements of IEEE 386.
 - b) Rated at 200 A, with voltage class matching connectors. Provide parking stand near bushing wells.[**Parking stands must be with insulated standoff bushings for parking of energized load-break elbow connectors on parking stands.**]
 - c) Provide insulated protective caps for insulating and sealing out moisture from unused bushing inserts[**and insulated standoff bushings**].
 - 3) Bushing wells configured for loop-feed application.

- 4) Access to liquid-immersed fuses.
 - 5) Dead-front surge arrester(s).
 - 6) Tap-changer operator.
 - 7) Ground pad.
- r. Load-Side Section:
- 1) Bushings with spade terminals drilled for terminating number of conductors indicated on the Drawings, and lugs that comply with requirements of Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
 - 2) Metering: Coordinated with and complying with requirements of Section 262713 "Electricity Metering." **[Install][Make provision for installation by providing mounting space, brackets, and cable and conduit routing as well as]** the following:
 - a) Sensors.
 - b) BAS interface.
 - c) Kilowatt-hour meter.
 - d) Kilowatt-hour demand meter.
- s. Capacities and Characteristics:
- 1) Power Rating: **<Insert number>** kVA.
 - 2) Voltage Ratings: **<Insert primary voltage>** V - **[240/120][480/240]** V.
 - 3) Taps: **[Four 2.5 percent, full-capacity taps below rated primary voltage]<Insert description>**.
 - 4) Transformer BIL (kV): **[Comply with IEEE C57.12.38 requirements]<Insert number>**.
 - 5) Minimum Tested Impedance (Percent) at 85 deg C: **[1.25][2.1][3.0][3.2]<Insert number>**.
- t. Transformer Accessories:
- 1) Drain and filter connection.
 - 2) Filling and top filter press connections.
 - 3) Pressure-vacuum gauge.
 - 4) Dial-type analog thermometer with alarm contacts.
 - 5) Magnetic liquid level indicator with high and low alarm contacts.
 - 6) Automatically resetting pressure-relief device. Device flow must be as recommended by manufacturer. **[With alarm contacts and manual bleeder.]**
 - 7) Stainless steel ground connection pads.
 - 8) Machine-engraved nameplate made of anodized aluminum or stainless steel.
 - 9) Sudden pressure relay for remote alarm or trip when internal transformer pressure rises at field-set rate. Provide **[with][without]** seal-in delay.
- u. Control Network: Support serial MS/TP and Ethernet IP communications, and able to communicate directly via TIA-485 serial networks and Ethernet 10Base-T networks as native device.
5. Seismic and Wind Performance: Installed product must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:
- a. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events **[and unit must be fully operational after seismic events]**.
 - b. Component Importance Factor (Ip): **[1.0][1.5]**.



- c. Component Amplification Factor (ap): **[1.0]<Insert value>**.
- d. Component Response Modification Factor (Rp): **[2.5]<Insert value>**.
- e. Component Overstrength Factor (Ω_o): **[2.5]<Insert value>**.

C. Three-Phase, Pad-Mounted Transformers :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Eaton]**
 - b. **[ERMCO-ECI]**
 - c. **[GE Power; General Electric Company]**
 - d. **[Hitachi Energy USA Inc.; business of Hitachi, Ltd.]**
 - e. **[Howard Industries, Inc]**
 - f. **[Prolec GE; A Xignux and General Electric Company Joint Venture]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Eaton]**
 - b. **[ERMCO-ECI]**
 - c. **[GE Power; General Electric Company]**
 - d. **[Hitachi Energy USA Inc.; business of Hitachi, Ltd.]**
 - e. **[Howard Industries, Inc]**
 - f. **[Prolec GE; A Xignux and General Electric Company Joint Venture]**
 - g. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Transformers, Distribution, Liquid-Filled Type, Over 600 V: UL CCN XPLH; including IEEE C57.12.00 and IEEE C57.12.28.
4. Standard Features:
 - a. **[Oil-filled][Less-flammable-liquid-filled]**, two-winding, 60 Hz, 65 deg C rise above 30 deg C average ambient, self-cooled transformer.
 - b. Reference Standards: IEEE C2 and IEEE C57.12.26.
 - c. Windings Material: **[Aluminum][Copper]**.
 - d. Surge Arresters: Comply with IEEE C62.11, Distribution Class; metal-oxide-varistor type, fully shielded, separable-elbow type, suitable for plugging into inserts provided in line-side section of transformer. Connected in each phase of incoming circuit and ahead of disconnecting device.
 - e. Winding Connections: Connection of windings and terminal markings must comply with IEEE C57.12.70.
 - f. Efficiency: Comply with 10 CFR 431, Subpart K.
 - g. Insulation: Transformer kVA rating must be as follows: Average winding temperature rise above 30 deg C ambient temperature must not exceed 65 deg C and 80 deg C hottest-spot temperature rise at rated kVA when tested in accordance with IEEE C57.12.90, using

- combination of connections and taps that give highest average winding temperature rise.
- h. Tap Changer: External handle, for de-energized operation.
- i. Tank: Sealed, with welded-on cover. [**Designed to withstand internal pressure of not less than 7 psi (50 kPa) without permanent distortion and 15 psig (104 kPa) without rupture. Comply with IEEE C57.12.36.**]
- j. Enclosure Integrity: Comply with IEEE C57.12.28 for pad-mounted enclosures that contain energized electrical equipment in excess of 600 V that may be exposed to public.
- k. Mounting: Integral skid mounting frame, suitable to allow skidding or rolling of transformer in any direction, and with provision for anchoring frame to pad.
- l. Insulating Liquids:
 - 1) Mineral Oil: ASTM D3487, Type II, and tested for compliance with ASTM D117.
 - 2) Less-Flammable Liquids:
 - a) Edible-Seed-Oil-Based Dielectric: Listed and labeled by qualified electrical testing laboratory recognized by authorities having jurisdiction as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested in accordance with ASTM D92. Liquid must be biodegradable and nontoxic, having passed Organisation for Economic Co-operation and Development G.L.203 with zero mortality, and must be certified by U.S. Environmental Protection Agency as biodegradable, meeting Environmental Technology Verification requirements.
 - b) Biodegradable and Nontoxic Dielectric: Listed and labeled by qualified electrical testing laboratory recognized by authorities having jurisdiction as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested in accordance with ASTM D92.
- m. Sound level must comply with NEMA TR 1 requirements.
- n. Corrosion Protection:
 - 1) Transformer coating system must be factory applied, complying with requirements of [IEEE C57.12.28][IEEE C57.12.29], in manufacturer's standard color [green]<Insert color>.
 - 2) Fabricate front sill, hood, and tank base of single-compartment transformers from stainless steel in accordance with ASTM A167, Type 304 or 304L, not less than No. 13 U.S. gage, complying with requirements of [IEEE C57.12.28][IEEE C57.12.29], standard color [green]<Insert color>.
 - 3) Base and Cabinets of Two Compartment Transformers: Fabricate from stainless steel in accordance with ASTM A167, Type 304 or 304L, not less than No. 13 U.S. gage. Coat transformer with manufacturer's standard green color coating complying with requirements of [IEEE C57.12.28][IEEE C57.12.29], in manufacturer's standard color [green]<Insert color>.
- o. Compartment Construction:
 - 1) Single-Compartment Construction: Clamshell style, with provision for padlocking, hinged cover, and single-point latching.
 - 2) Double-Compartment Construction: Individual compartments for line- and load-side sections, formed by steel isolating barriers that extend full height and depth of compartments, with hinged, lift-off doors and three-point latching, with stop in open position and provision for padlocking.
- p. Primary Fusing: Designed and rated to provide thermal protection of transformer by sensing overcurrent and high liquid temperature.
 - 1) 150 kV BIL current-limiting fuses, conforming to requirements of IEEE C37.42.

- 2) Interrupting Rating: 50 000 A(rms sym) at system voltage.
 - 3) Fuse Assembly: Bayonet-type, liquid-immersed, expulsion fuses in series with liquid-immersed, partial-range, current-limiting fuses. Bayonet fuse must sense both high currents and high oil temperature to provide thermal protection to transformer.[
Connect current-limiting fuses ahead of radial-feed load-break switch.]
 - 4) Provide bayonet fuse assembly with oil retention valve and external drip shield inside housing to eliminate or minimize oil spills. Valve must close when fuse holder is removed and external drip shield is installed.
 - 5) Provide conspicuously displayed warning adjacent to bayonet fuse(s), cautioning against removing or inserting fuses unless transformer has been de-energized and tank pressure has been released.
- q. Line-Side Section: Dead-front design.
- 1) To connect primary cable, use separable insulated connectors; coordinated with and complying with requirements of Section 260513 "Medium-Voltage Cables." Bushings must be one-piece units, with ampere and BIL ratings same as connectors.
 - 2) Bushing inserts[**and feed-through inserts**]:
 - a) Conform to requirements of IEEE 386.
 - b) Rated at 200 A, with voltage class matching connectors. Provide parking stand near bushing wells.[**Parking stands must be equipped with insulated standoff bushings for parking of energized load-break elbow connectors on parking stands.**]
 - c) Provide insulated protective caps for insulating and sealing out moisture from unused bushing inserts[**and insulated standoff bushings**].
 - 3) Bushing wells configured for loop-feed application.
 - 4) Access to liquid-immersed fuses.
 - 5) Dead-front surge arresters.
 - 6) Tap-changer operator.
 - 7) Ground pad.
- r. Load-Break Switch:
- 1) Radial-feed, liquid-immersed type with voltage class and BIL matching that of separable connectors, with continuous current rating and load-break rating of **[200 A][300 A]<Insert amperage>**, and make-and-latch rating of 12 kA(rms sym).
 - 2) Loop-feed sectionalizing switches, using three two-position, liquid-immersed-type switches for closed transition loop-feed and sectionalizing operation. Voltage class and BIL must match that of separable connectors, with continuous current rating and load-break rating of **[200 A][300 A]<Insert amperage>**, and make-and-latch rating of 12 kA(rms sym). Switch operation must be as follows:
 - a) Position I: Line A connected to line B and both lines connected to transformer.
 - b) Position II: Transformer connected to line A only.
 - c) Position III: Transformer connected to line B only.
 - d) Position IV: Transformer disconnected and line A not connected to line B.
 - e) Position V: Transformer disconnected and line A connected to line B.
- s. Load-Side Section:
- 1) Bushings with spade terminals drilled for terminating number of conductors indicated on the Drawings, and lugs that comply with requirements of Section 260519 "Low-

- Voltage Electrical Power Conductors and Cables."
- 2) Metering: Coordinated with and complying with requirements of Section 262713 "Electricity Metering." **[Install][Make provision for installation by providing mounting space, brackets, and cable and conduit routing as well as]** the following:
 - a) Sensors.
 - b) BAS interface.
 - c) Kilowatt-hour meter.
 - d) Kilowatt-hour demand meter.
 - t. Capacities and Characteristics:
 - 1) Power Rating: **<Insert number>** kVA.
 - 2) Voltage Ratings: **<Insert primary voltage>** V - **[208Y/120][480Y/277]** V.
 - 3) Taps: **[Comply with IEEE C57.12.26 requirements]<Insert values>**.
 - 4) Transformer BIL (kV): **[Comply with IEEE C57.12.26 requirements]<Insert number>**.
 - 5) Minimum Tested Impedance (Percent) at 85 deg C: **[2.50][2.87][4.03][5.75]<Insert number>**.
 - 6) K-factor: **<Insert number>**.
 - 7) Comply with FM Global Class No. 3990.
 - 8) Comply with UL listing requirements for combination classification and listing for transformer and less-flammable insulating liquid.
 - u. Transformer Accessories:
 - 1) Drain and filter connection.
 - 2) Filling and top filter press connections.
 - 3) Pressure-vacuum gauge.
 - 4) Dial-type analog thermometer with alarm contacts.
 - 5) Magnetic liquid level indicator with high and low alarm contacts.
 - 6) Automatically resetting pressure-relief device. Device flow must be as recommended by manufacturer. **[With alarm contacts and manual bleeder.]**
 - 7) Stainless steel ground connection pads.
 - 8) Machine-engraved nameplate, made of anodized aluminum or stainless steel.
 - 9) Sudden pressure relay for remote alarm or trip when internal transformer pressure rises at field-set rate. Provide **[with][without]** seal-in delay.
 - v. Control Network: Support serial MS/TP and Ethernet IP communications, and able to communicate directly via TIA-485 serial networks and Ethernet 10Base-T networks as native device.
 5. Seismic and Wind Performance: Installed product must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:
 - a. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events **[and unit must be fully operational after seismic events]**.
 - b. Component Importance Factor (Ip): **[1.0][1.5]**.
 - c. Component Amplification Factor (ap): **[1.0]<Insert value>**.
 - d. Component Response Modification Factor (Rp): **[2.5]<Insert value>**.
 - e. Component Overstrength Factor (Qo): **[2.5]<Insert value>**.

PART 3 - EXECUTION**3.1 EXAMINATION**

- A. Examine areas and space conditions for compliance with requirements for pad-mounted, liquid-filled, medium-voltage transformers and other conditions affecting performance of the Work.
- B. Examine roughing-in of conduits and grounding systems to verify the following:
 - 1. Wiring entries comply with layout requirements.
 - 2. Entries are within conduit-entry tolerances specified by manufacturer, and no feeders will cross section barriers to reach load or line lugs.
- C. Examine concrete bases for suitable conditions for transformer installation.
- D. Preinstallation Checks:
 - 1. Verify removal of shipping bracing after placement.
 - 2. Remove sample of insulating liquid in accordance with ASTM D923. Insulating-liquid values must comply with NETA ATS, Table 100.4. Sample must be tested for the following:
 - a. Dielectric Breakdown Voltage: ASTM D877 or ASTM D1816.
 - b. Acid Neutralization Number: ASTM D974.
 - c. Specific Gravity: ASTM D1298.
 - d. Interfacial Tension: ASTM D971.
 - e. Color: ASTM D1500.
 - f. Visual Condition: ASTM D1524.
 - g. Water in Insulating Liquids: Comply with ASTM D1533.
 - h. Power Factor or Dissipation Factor: ASTM D924.
- E. Verify that grounding and bonding connections are in place. Ground (Earth) resistance may not exceed **[5 Ω]<Insert resistance in ohms>** at transformer location.
- F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:
 - 1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
 - 2. Electrical Maintenance: NFPA 70B.
 - 3. Electrical Safety: NFPA 70E.
 - 4. Commissioning of Electrical Systems: NECA NEIS 90.
 - 5. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
 - 6. Communications Work: BICSI N1.
 - 7. Emergency and Standby Power Work: NFPA 110, NFPA 111, and NECA NEIS 416.
 - 8. Work in Confined Spaces: NFPA 350.
 - 9. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.

10. Consult Architect for resolution of conflicting requirements.

C. Special Installation Techniques:

1. Install transformers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 260529 "Hangers and Supports for Electrical Systems."
2. Transformer must be installed level and plumb and must tilt less than 1.5 degrees while energized.
3. Maintain minimum clearances and workspace at equipment in accordance with manufacturer's published instructions and IEEE C2.

D. Grounding and Bonding:

1. For counterpoise, use tinned bare copper cable not smaller than 4/0 AWG, buried not less than **30 inch (765 mm)** below grade interconnecting grounding electrodes. Bond surge arrester and neutrals directly to transformer enclosure and then to grounding electrode system with bare copper conductors, sized as shown. Keep lead lengths as short as practicable, with no kinks or sharp bends.
2. Fence and equipment connections may not be smaller than 4 AWG. Ground fence at gate posts and corner posts and at intervals not exceeding **10 ft (3 m)**. Bond gate sections to fence posts using **1/8 by 1 inch (3 by 25 mm) [tinned]** flexible braided copper strap and clamps.
3. Make joints in grounding conductors and loops by exothermic weld or compression connector.
4. Terminate grounding and bonding conductors on common equipment grounding terminal on transformer enclosure.
5. Complete transformer tank grounding and lightning arrester connections prior to making other electrical connections.

E. Connect low-voltage wiring.

1. Maintain air clearances between energized live parts and between live parts and ground for exposed connections in accordance with manufacturer recommendations.
2. Bundle associated phase, neutral, and equipment grounding conductors together within transformer enclosure. Arrange conductors such that there is not excessive strain that could cause loose connections. Allow adequate slack for expansion and contraction of conductors.

F. Terminate medium-voltage cables in incoming section of transformers.

G. Interfaces with Other Work:

1. Identification: Provide labels for transformers and associated electrical equipment.
 - a. Identify field-installed conductors, interconnecting wiring, and components.
 - b. Label each enclosure with engraved metal or laminated-plastic nameplate.
 - c. Provide warning signs and arc-flash hazard warning labels for electrical equipment.
2. Install transformers on cast-in-place concrete equipment base(s).
3. Provide vibration isolation and seismic control devices.

3.3 FIELD QUALITY CONTROL

A. Administrator for Electrical Power Tests and Inspections:

1. **[Owner][Tenant]** will engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.

2. Engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
 4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].
- B. Acceptance Testing Preparation:
1. **<Insert requirements>**.
- C. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.
- D. Tests and Inspections:
1. General Field-Testing Requirements:
 - a. Comply with provisions of "Testing and Test Methods" Chapter in NFPA 70B.
 - b. Perform visual and mechanical inspections and electrical tests. Certify compliance with test parameters.
 - c. After installing transformer but before primary is energized, verify that grounding system at transformer is tested at specified value or less.
 - d. After installing transformer and after electrical circuitry has been energized, test for compliance with requirements.
 - e. Visual and Mechanical Inspection:
 - 1) Verify equipment nameplate data complies with the Contract Documents.
 - 2) Inspect bolted electrical connections for high resistance using one of the following two methods:
 - a) Use low-resistance ohmmeter to compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of lowest value.
 - b) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels must be in accordance with manufacturer's published data. In absence of manufacturer's published data, use NETA ATS, Table 100.12.
 2. Medium-Voltage Surge Arrester Field Tests:
 - a. Visual and Mechanical Inspection:
 - 1) Inspect physical and mechanical condition.
 - 2) Verify arresters are clean.
 - 3) Verify that ground leads on devices are individually attached to ground bus or ground electrode.
 - b. Electrical Test:
 - 1) Perform insulation-resistance test on arresters, phase terminal-to-ground. Apply voltage in accordance with manufacturer's published data. In absence of

- manufacturer's published data, comply with NETA ATS, Table 100.1. Replace units that fail to comply with recommended minimum insulation resistance listed in that table.
- 2) Perform watts-loss test. Evaluate watts-loss values by comparison with similar units and test equipment manufacturer's published data.
3. Liquid-Filled Transformer Field Tests:
- a. Visual and Mechanical Inspection:
 - 1) Test dew point of tank gases if applicable.
 - 2) Inspect anchorage, alignment, and grounding.
 - 3) Verify bushings are clean.
 - 4) Verify that alarm, control, and trip settings on temperature and level indicators are set and operate within manufacturer's recommended settings.
 - 5) Verify that liquid level in tanks is within manufacturer's published tolerances.
 - 6) Perform specific inspections and mechanical tests recommended by manufacturer.
 - 7) Verify presence of transformer surge arresters and that their ratings are as specified.
 - 8) Verify that as-left tap connections are as specified.
 - b. Electrical Tests:
 - 1) Perform insulation-resistance tests winding-to-winding and windings-to-ground. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index; value of index may not be less than 1.0.
 - 2) Perform power-factor or dissipation-factor tests on windings in accordance with test equipment manufacturer's published data. Maximum winding insulation power-factor/dissipation-factor values must be in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.3.
 - 3) Measure core insulation resistance at 500 V(dc) if core is insulated and core ground strap is removable. Core insulation-resistance values may not be less than 1 MΩ at 500 V(dc).
 - 4) Perform power-factor or dissipation-factor tip-up test on windings greater than 2.5 kV.
 - 5) Perform Optional Field Tests:
 - a) Perform turns-ratio tests at tap positions. Turns-ratio test results may not deviate by more than one-half percent from either adjacent coils or calculated ratio. If test fails, replace transformer.
 - b) Perform excitation-current test on each phase. Typical excitation-current test data pattern for three-legged core transformer is two similar current readings and one lower current reading. Investigate and correct if test shows different pattern.
 - c) Measure resistance of windings at tap connections, and record temperature-corrected winding-resistance values in Operations and Maintenance Manual.
 - d) Perform applied-voltage test on line- and load-side windings-to-ground. Comply with IEEE C57.12.91, Sections 10.2 and 10.9. This test is not required for single-phase transformers and for three-phase wye-wye-connected transformers.
 - 6) Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.
 - 7) Remove sample of insulating liquid in accordance with ASTM D923, and perform dissolved-gas analysis in accordance with IEEE C57.104 or ASTM D3612.



- E. Nonconforming Work:
 - 1. Equipment and devices will be considered defective if they do not pass tests and inspections.
 - 2. Remove and replace malfunctioning units and retest.
- F. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports. Record as-left set points of adjustable devices.
- G. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.
 - 1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.

3.4 CLOSEOUT ACTIVITIES

- A. Training:
 - 1. **[With assistance from factory-authorized service representatives, train][Train]** Owner's maintenance personnel on the following topics:
 - a. How to adjust, operate, and maintain transformer equipment.
 - 2. **[Provide video recordings of training sessions to Owner][Allow Owner to record training sessions].**

3.5 PROTECTION

- A. After installation, protect transformer from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

3.6 MAINTENANCE

- A. Voltage Monitoring and Adjusting: After Substantial Completion, if requested by Owner, but not more than six months after Final Acceptance, perform the following voltage monitoring:
 - 1. During period of normal load cycles as evaluated by Owner, perform seven days of three-phase voltage recording at outgoing section of transformers. Use voltmeters with calibration traceable to National Institute of Science and Technology standards and with chart speed of not less than **1 inch (25 mm)** per hour. Voltage unbalance greater than 1 percent between phases, or deviation of phase voltage from nominal value by more than plus or minus 5 percent during test period, is unacceptable.
 - 2. Corrective Action: If test results are unacceptable, perform the following corrective action, as appropriate:
 - a. Adjust transformer taps.
 - b. Prepare written request for voltage adjustment by electric utility.
 - 3. Retests: Repeat monitoring, after corrective action is performed, until satisfactory results are

- obtained.
4. Field Reports for Voltage Monitoring and Adjusting: Prepare written report covering monitoring performed and corrective action taken.
- B. Infrared Scanning of Transformers: Perform survey during periods of maximum possible loading. Remove necessary covers prior to inspection.
1. After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared inspection of transformer's electrical power connections. Remove covers so joints and connections are accessible to portable scanner. Take visible light photographs at same locations and orientations as infrared scans for documentation to ensure follow-on scans match same conditions for valid comparison.
 2. Instrument: Inspect distribution systems with imaging equipment capable of detecting minimum temperature difference of 1 deg C at 30 deg C. Provide documentation of device calibration.
 3. Field Reports for Infrared Scanning: Prepare certified report that identifies transformer equipment checked, testing technician, and equipment used, and that describes scanning results. Include notation of deficiencies detected, remedial actions taken, and scanning observations after remedial action. List results as follows:
 - a. Description of equipment to be tested.
 - b. Discrepancies.
 - c. Temperature difference between area of concern and reference area.
 - d. Probable cause of temperature difference.
 - e. Areas inspected. Identify inaccessible and unobservable areas and equipment.
 - f. Identify load conditions at time of inspection.
 - g. Provide photographs and thermograms of deficient area.
 4. Act on inspection results in accordance with recommendations of NETA ATS, Table 100.18. Correct possible and probable deficiencies as soon as Owner's operations permit. Retest until deficiencies are corrected.

END OF SECTION 26 12 19 00



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SECTION 26 12 19 00A - LOW-VOLTAGE SWITCHGEAR

PART 1 - GENERAL

1.1 SUMMARY

A. The Work of This Section Includes:

1. Metal-enclosed, low-voltage switchgear, with drawout power circuit breakers and metering and control accessories.
 - a. Switchgear structure.
 - b. Additional requirements for indoor switchgear.
 - c. Additional requirements for outdoor switchgear.
 - d. Circuit breakers.
 - e. Arc-flash limiting feeder circuit breakers.
 - f. Zone-selective interlocking.
 - g. Network protectors.
 - h. Surge suppression.
 - i. Control power supply, 120 V(ac).
 - j. Control power supply, 24 V(dc).
 - k. Instrumentation and control.

B. Products Furnished, but Not Installed, under This Section:

1. **<Insert products furnished, but not installed>.**

C. Products Installed, but Not Furnished, under This Section:

1. **<Insert products installed, but not furnished>.**

D. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
3. **[Section 013100 "Project Management and Coordination"]<Insert Section number and title>** for preinstallation conference procedures.
4. Section 230923.13 "Energy Meters" for electricity meters for HVAC equipment.
5. Section 262713 "Electricity Metering" for equipment to meter electricity consumption and demand for submetering.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at **[Project site]<Insert location>**.

B. Preinstallation Coordination Meeting(s): For switchgear. Conduct meeting(s) **[as videoconference][or][at Project site]<Insert location>** before **<Insert construction activity>**.

1. Attendees: Installers, fabricators, representatives of manufacturers, and administrators for field tests and inspections. Notify Architect[, **Construction Manager**][, and **Owner's Commissioning Authority**] of scheduled meeting dates.

1.3 ACTION SUBMITTALS

A. Product Data:

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

B. Shop Drawings:

1. For low-voltage switchgear.
 - a. System Power One-Line Diagrams: Depict power sources, feeders, distribution components, and major loads. Include as-built data for low-voltage power switchgear and connections as follows:
 - 1) Frame size of circuit breakers.
 - 2) Trip rating for circuit breakers.
 - 3) Conduit and wire size for feeders.
 - b. Include plans, elevations, sections, shipping splits, and mounting details.
 - c. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of field connections.
 - d. Wire Termination Diagrams and Schedules: Include diagrams for power, signal, and control wiring. Identify terminals and wiring designations and color-codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features. Differentiate between manufacturer-installed and field-installed wiring.
 - e. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices used. Describe characteristics of network and other data communication lines.
 - f. Indicate short-time and short-circuit current rating of switchgear assembly.
 - g. Include features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 - h. Include mimic-bus diagram.

C. Delegated Design Submittals: For low-voltage switchgear.

1. Comply with Section 260572 "Overcurrent Protective Device Short-Circuit Study" and Section 260573.16 "Coordination Studies."
2. For differential ground-fault protection scheme. Include wiring diagram of differential system along with test procedure recommended by UL 1558, using high-current injection equipment.

D. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

- A. Product Test Reports: Submit evidence that switchgear is compatible with connected monitoring and control devices and systems specified in [**Section 260913 "Electrical Power Monitoring"**]**<Insert Section number and title for integrated controls>**.
 - 1. Show interconnecting signal and control wiring, and interface devices to show compatibility of meters.
 - 2. For reporting and billing interfaces and adapters, list network protocols and provide statements from manufacturers that input and output devices comply with interoperability requirements of protocol.
- B. Manufacturers' Published Instructions: Record copy of official installation[**and testing**] instructions issued to Installer by manufacturer for the following:
 - 1. For unloading and inspection, clearances, torque values, insulation-resistance testing, dielectric withstand-voltage testing, breaker testing, power factor testing, grounding, ground-fault protection testing, batteries and chargers testing, and system functional testing.
- C. Source quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. System Power Riser Diagram: For switchgear, using non-fugitive ink on high-quality paper. Post on wall at switchgear location.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Spare Parts: Furnish to Owner the following spare parts for repairing switchgear that are packaged with protective covering for storage on-site and identified with labels describing contents:
 - 1. Drawout Circuit Breakers: One of each type and rating used for circuit breaker in switchgear.
 - 2. Fuses: [**One**]**<Insert number>** for every [**three**]**<Insert number>** of each type and rating, but no fewer than three of each for the following:
 - a. Potential transformers.
 - b. Control power circuits.
- B. Special Tools: Furnish to Owner proprietary equipment, keys, and software required to operate, maintain, repair, adjust, or implement future changes to switchgear, packaged with protective covering for storage on-site and identified with labels describing contents. Include the following:
 - 1. Portable test set for testing functions of circuit-breaker, solid-state trip devices without removal from switchgear.
 - 2. Relay and meter test plugs suitable for testing switchgear meters and switchgear class relays.
 - 3. Racking handle to move circuit breaker manually between connected and disconnected positions.
 - 4. Circuit-Breaker Removal Apparatus:
 - a. Floor Type: Portable, floor-supported, roller-base, elevating carriage arranged for moving circuit breakers in and out of compartments.
 - b. Overhead Type: Overhead-circuit-breaker lifting device, track mounted at top front of switchgear and complete with hoist and lifting yokes matching each size of drawout circuit breaker installed.



5. Spare-Fuse Cabinet: Identified and compartmented steel box or cabinet with lockable door.
6. Storage for Manual: Include rack or holder, near operating instructions, for copy of maintenance manual.

C. Consumable Items:

1. After completion of field quality control, startup, commissioning, adjusting, and closeout activities, replace air filters and refill fluid reservoirs.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Indoor Switchgear Storage: Store in dry, clean location, placed on level surface to prevent strain and possible distortion. During construction period, provide protection against dust, dirt, falling objects, dripping water, water, excessive moisture, and other possible causes of damage to equipment. Temporary covering may not restrict ventilation and may not be removed until equipment is ready for installation. **[Store indoor equipment within heated building.][Take special precaution to keep equipment sufficiently warm with adequate ventilation to prevent condensation during storage period. Install temporary heating if necessary.]**
- B. When provisions for temporary power connection are provided as part of switchgear assembly, provisions must be included to prevent energization of primary buses or connections by means of backfeed through fuses or control power transformers connected to primary buses or connections.
- C. If outdoor switchgear cannot be installed and energized, temporary power must be provided for operation of space heaters provided so as to prevent condensation of moisture within housing.
- D. Ventilation openings must be left open to permit proper air circulation.

PART 2 - PRODUCTS

2.1 OWNER-FURNISHED PRODUCTS

- A. Basis for Pricing: **<Insert name of manufacturer; model number or series for product that Owner intends to furnish to Contractor>.**
- B. Description: **<Insert description of product, including special features, options, and finishes for Owner-furnished product that may impact Contractor's installation>.**
- C. Accessories: **<Insert accessories that will be provided with product>.**

2.2 EXISTING PRODUCTS TO BE MODIFIED

- A. Basis for Pricing: **<Insert name of manufacturer; model number or series for existing product>.**
- B. Description: **<Insert description of existing product, including special features, options, and finishes that may impact Work>.**
- C. Accessories: **<Insert accessories included with existing product>.**

2.3 EXISTING PRODUCTS TO BE REMOVED AND RE-INSTALLED

- A. Basis for Pricing: **<Insert name of manufacturer; model number or series for existing product>.**
- B. Description: **<Insert description of existing product, including special features, options, and finishes that may impact Work>.**
- C. Accessories: **<Insert accessories included with existing product>.**

2.4 LOW-VOLTAGE SWITCHGEAR

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1. **[ABB, Electrification Business]**
 - 2. **[Eaton]**
 - 3. **[SAI Advanced Power Solutions/Switchboard Apparatus Inc.]**
 - 4. **[Siemens Industry, Inc., Energy Management Division]**
 - 5. **[Square D; Schneider Electric USA]**
 - 6. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[ABB, Electrification Business]**
 - 2. **[Eaton]**
 - 3. **[SAI Advanced Power Solutions/Switchboard Apparatus Inc.]**
 - 4. **[Siemens Industry, Inc., Energy Management Division]**
 - 5. **[Square D; Schneider Electric USA]**
 - 6. **<Insert manufacturer's name>**

2.5 SYSTEM DESCRIPTION

- A. Description: Metal-enclosed, low-voltage switchgear with drawout **[fused][fused, where indicated,]** power circuit breakers, with accessories and metering components.
 - 1. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - 2. Comply with IEEE C37.20.1.
 - 3. Listed and labeled as complying with UL 1558.
 - 4. Listed and labeled for use as service entrance equipment.

2.6 PERFORMANCE REQUIREMENTS

- A. Capacities and Characteristics:
 - 1. Nominal System Voltage: **[480 V, three][480/277 V, four][240 V, three][208/120 V, four]** wire, 60 Hz.
 - 2. Rated Maximum Voltage: **[254 V][508 V][635 V]**.
 - 3. Rated Power Frequency: 60 Hz.

4. Rated Insulation Level: Power frequency withstand must be not less than 2.2 kV(rms).
5. Rated Continuous Current:
 - a. Main-Bus Continuous: **[1600 A][2000 A][3000 A][3200 A][4000 A][5000 A]**.
 - b. Vertical Section Bus Riser: Equal to frame size of low-voltage power circuit breaker connected to that riser.
6. Rated Short-Circuit Withstand Current: **[42 000 A(sym)][65 000 A(sym)][85 000 A(sym)][100 000 A(sym)][200 000 A(sym)]**.
7. Short-Time and Short-Circuit Current: Match rating of integrated short-circuit current rating.

2.7 SWITCHGEAR STRUCTURE

- A. Bus isolation barriers must be arranged to isolate line bus from load bus at main and tie circuit breaker. Extend section barriers between main and tie circuit breakers to rear of section.
- B. Allow the following circuit-breaker functions to be performed when compartment door is closed:
 1. Operate manual charging system.
 2. Open and close circuit breaker.
 3. Examine and adjust trip unit.
 4. Read breaker nameplate.
- C. Install instrument compartments when additional space is required for metering and instrumentation. Allow for routing of instrumentation, control and communications wires, and cables.
- D. Switchgear Bus:
 1. Use bus bars to connect compartments and vertical sections. Cable connections are not permitted.
 2. Main Phase Bus: Uniform capacity entire length of assembly.
 3. Neutral Bus: **[50][100]** percent of phase-bus ampacity unless otherwise indicated. Equip bus with pressure-connector terminations for outgoing circuit neutral conductors. Include braces for neutral-bus extensions for busway feeders.
 4. Ground Bus: Uniform capacity entire length of assembly, with pressure connector terminations for feeder and branch-circuit ground conductors, minimum size **1/4 by 2 inch (6 by 50 mm)**.
 5. Vertical Section Bus Size: **[Comply with IEEE C37.20.1, including allowance for spare circuit breakers and spaces for future circuit breakers][Fully rated to system continuous current, equal to horizontal bus]**.
 6. Bus Material and Connections:
 - a. Phase- and Neutral-Bus Material:
 - 1) Hard-drawn copper of 98 percent minimum conductivity, with copper feeder circuit-breaker line connections.
 - 2) Silver- or tin-plated, high-strength, electrical-grade aluminum alloy, with copper or tin-plated aluminum circuit-breaker line connections.
 - 3) Hard-drawn copper of 98 percent minimum conductivity or tin-plated, high-strength, electrical-grade aluminum alloy.
 - b. Use silver-plated copper or tin-plated aluminum for connecting circuit-breaker line to aluminum bus.
 - c. Use copper for connecting circuit-breaker line to copper bus.
 - d. Contact Surfaces of Buses: Silver plated.

- e. Feeder Circuit-Breaker Load Terminals: Silver-plated copper bus extensions equipped with pressure connectors for outgoing circuit conductors.
- 7. Neutral Disconnect Link: Bolted, uninsulated, bus, arranged to connect neutral bus to ground bus.
- 8. Provide for future extensions from either end of main phase, neutral, and ground bus by means of predrilled bolt-holes and connecting links.
- 9. Bus-Bar Insulation: Individual bus bars wrapped with factory-applied, flame-retardant tape or spray-applied, flame-retardant insulation.
 - a. Sprayed Insulation Thickness: **3 mil (0.08 mm)**, minimum.
 - b. Bolted Bus Joints: Insulate with secure joint covers that can easily be removed and reinstalled.
- E. Circuit-Breaker Compartment:
 - 1. Drawout Features: Circuit-breaker mounting assembly equipped with racking mechanism to position circuit breaker and hold it rigidly in connected, test, disconnected, and withdrawn positions. Include the following features:
 - a. Provide circuit-breaker racking system with positive stops at connected, test, disconnected, and withdrawn positions.
 - b. Interlocks: Prevent racking of circuit breaker to or from connected position when it is closed, and prevent closure of circuit breaker unless it is in connected, test, or disconnected position.
 - c. Circuit-Breaker Positioning: Permit racking of open circuit breaker to or from connected, test, and disconnected positions only when compartment door is closed unless live parts are covered by full dead-front shield. Permit manual withdrawal of open circuit breaker to position for removal from structure. When compartment door is open, status for connection devices for different positions includes the following:
 - 1) Test Position: Primary disconnects disengaged, and secondary disconnect devices and ground contact engaged.
 - 2) Disconnected Position: Primary and secondary devices and ground contact disengaged.
 - d. Primary Disconnect: Mount on stationary part of compartment. Disconnect must consist of set of contacts extending to rear through insulating support barrier, and of corresponding moving finger contacts on power circuit-breaker studs, which engage in only connected position. Assembly must provide multiple silver-to-silver full floating, spring-loaded, high-pressure-point contacts with uniform pressure on fingers. Load studs must connect to bus extensions that terminate in solderless terminals in rear cable compartment.
 - e. Secondary Disconnect: Floating terminals mounted on stationary part of compartment that engage mating contacts at front of breaker.
 - f. Provide verification of positive ground contact between circuit breaker and its compartment when accessory cover is removed while circuit breaker is in connected, test, disconnected, and withdrawn positions.
 - g. Place 2400 A frame and larger circuit breakers at bottom of switchgear.
- F. Auxiliary Compartments: Match and align with basic switchgear assembly. Include the following:
 - 1. Utility metering compartment that complies with utility-company requirements.
 - 2. Bus transition sections.
 - 3. Incoming-line pull sections.
 - 4. Hinged front panels for access to metering, accessory, and blank compartments.
- G. Pull Boxes: Pull box on top of switchgear for extra room for pulling cable, with removable top, front, and

side covers and with ventilation provisions adequate to maintain air temperature in pull box within same limits as switchgear.

1. Set pull box back from front to clear circuit-breaker lifting mechanism.
2. Pull-Box Bottom: Insulating, fire-resistant material with separate holes for cable drops into switchgear.
3. Cable Supports: Arranged to ease cabling and adequate to support cables, including those for future installation.

2.8 ADDITIONAL REQUIREMENTS FOR INDOOR SWITCHGEAR

- A. Enclosure Rating: Indoor.
- B. Enclosure Material: Steel.
- C. Enclosure Finish: IEEE C37.20.1, manufacturer's standard gray finish over rust-inhibiting primer on phosphatizing-treated metal surfaces.
- D. Enclosure Rear Panels: Removable and hinged, to allow access to rear interior of switchgear.

2.9 ADDITIONAL REQUIREMENTS FOR OUTDOOR SWITCHGEAR

- A. Outdoor Enclosure Rating: UL 1558.
- B. Outdoor Enclosure Description: Weatherproof; integral structural-steel base frame with factory-applied asphaltic undercoating
- C. Outdoor Enclosure Material: **[Steel][12 gage, ASTM A240, Type 304 or 304L stainless steel]**.
- D. Outdoor Enclosure Finish:
 1. Factory-applied finish in manufacturer's standard color, including under surfaces treated with corrosion-resistant undercoating.
 2. Factory-applied, corrosion-resistant finish in manufacturer's standard color that withstands **[120][480]** hours of exposure to salt-spray test specified in ASTM B117, without loss of paint or release of adhesion of paint primer coat to metal surface in excess of **1/16 inch (1.6 mm)** from test mark. Scribed test mark and test evaluation must be conducted in accordance with ASTM D1654, with rating of not less than 7 in accordance with Table 1 (Procedure A). Cut edges or otherwise damaged surfaces of hot-dip galvanized sheet steel or mill-galvanized sheet steel must be coated with manufacturer's standard zinc-rich paint.
 3. Front and rear doors must be provided with stainless steel padlockable vault handles with three-point catch. Bases, frames, and channels of enclosure must be corrosion resistant, fabricated of ASTM A240 Type 304 or 304L stainless steel. Base must include part of enclosure that is within **3 inch (75 mm)** of concrete pad. Coat enclosure, including bases, must be ASTM D1535 light gray No. 61 or No. 49. Coating system must comply with IEEE C57.12.29 for stainless steel.
- E. Features:
 1. Structural design and anchorage adequate to resist seismic and wind loads specified in Section 260011 "Facility Performance Requirements for Electrical."
 2. Sloping, standing-seam type, insulated roof panels.
 3. Mount shipping group on integral base frame as complete weatherproof unit.

4. Aisle-Less Construction: Vertical sections must have the following:
 - a. Hinged front door with padlocking provisions.
 - b. Interior light with switch.
 - c. Weatherproof duplex receptacle.
 - d. With draft-stop where busway exits vertical section.
 - e. Vertical Section Space Conditioning: Provide outside-air openings with insect and rodent screens and filters; arranged to permit air circulation while excluding insects, rodents, and exterior dust. Provide thermostatically controlled space heaters operating at one-half or less of rated voltage.
5. Common Internal Aisle-Type Construction:
 - a. With aisle of sufficient width to permit protective-device withdrawal, disassembly, and servicing in aisle.
 - b. Aisle access doors with outside padlocking provisions and interior panic latches.
 - c. Vaporproof [**LED aisle lights**][**fluorescent aisle lights with low-temperature ballasts**], controlled by wall switches at entrances.
 - d. GFCI duplex receptacles, minimum of two, located in aisle.
 - e. Interior Space Conditioning:
 - 1) Forced-air aisle ventilation with thermostatically controlled vent fans, interlocked with aisle space heaters operating at one-half or less of rated voltage. Provide outside-air openings with insect and rodent screens and filters; arranged to permit air circulation while excluding insects, rodents, and exterior dust.
 - 2) Air conditioned.

2.10 CIRCUIT BREAKERS

- A. Drawout type, unfused, power operated, with electromechanical or electronic trip devices. Comply with IEEE C37.13, IEEE C37.13a, and UL 1066.
- B. Ratings: For continuous, interrupting, and short-time current ratings for circuit breakers; voltage and frequency ratings same as switchgear. Comply with IEEE C37.16.
 1. Circuit breakers must have 30-cycle short-time withstand ratings equal to their symmetrical interrupting ratings through 85 000 A, whether or not equipped with instantaneous trip protection.
- C. Operating Mechanism: Mechanically and electrically trip-free, stored-energy operating mechanism with the following features:
 1. Normal Closing Speed: Independent of both control and operator.
 2. Slow Closing Speed: Optional with operator for inspection and adjustment.
 3. Stored-Energy Mechanism: [**Manually charged**][**Electrically charged**][**Electrically charged, and operator's choice of manual charging**].
 - a. Operating Handle: One for each circuit breaker capable of manual operation.
 - b. Electric Close Button: One for each electrically operated circuit breaker.
 4. Provide interlock to discharge stored energy mechanism before circuit breaker can be withdrawn from its compartment.
 5. Operation counter.
- D. Operator Display: Located on face of circuit breaker.

1. Electrical operation buttons to open and close circuit breaker. [**Provide clear lockable cover over buttons.**]
 2. Indicating Lights: To indicate circuit breaker is open or closed, for main and bus tie circuit breakers interlocked either with each other or with external devices. Energized or hot condition must be indicated by red light. De-energized, open, and safe condition must be indicated by green light.
 3. Indicator to show position of circuit-breaker contacts, status of closing springs, and circuit-breaker position in its compartment.
 4. Provide "Charged-not OK to close" indicator when closing springs are charged but circuit breaker is not ready to close.
 5. Computer Display: One or more [touchscreen]computer displays with dedicated CPU, to display data that are generated for transmission via Ethernet connection. Display the following functions:
 - a. Circuit-breaker status and circuit-breaker controls status.
 - b. Onboard meters.
 - c. User settings for overcurrent protection and undervoltage protection.
 - d. <Insert features>.
- E. Overcurrent Protective Tripping: Microprocessor-based, programmable, time-current shaping adjustments; complete with current transformers and sensors and the following features:
1. Programmable functions independent of each other in both action and adjustment.
 - a. Long-time setting.
 - b. Long-time-delay with selectable I2T or I4T curve shaping.
 - c. Short-time setting.
 - d. Short-time-delay with flat or selectable I2T curve shaping.
 - e. Instantaneous trip.
 2. Field-adjustable, time-current characteristics.
 3. Current Adjustability: Dial settings and rating plugs on trip units, or sensors on circuit breakers, or combination of these methods.
 4. Three bands, minimum, for long-time- and short-time-delay functions; marked "minimum," "intermediate," and "maximum."
 5. Pickup Points:
 - a. Five minimum, for long-time- and short-time-trip functions. Equip short-time-trip function for switchable I2T operation.
 - b. Five minimum, for instantaneous-trip functions.
- F. Ground-Fault Protection:
1. Ground-fault protection with at least three short-time-delay settings and three trip-time-delay bands; adjustable current pickup.
 2. Trip Indication: Labeled, battery-powered lights or mechanical targets on trip device to indicate type of fault.
 3. Test Form: Provide ground-fault relays with information sheets describing system-testing instructions, and with test form; comply with UL 1558.
- G. Undervoltage Trip Devices:
1. Instantaneous, with adjustable pickup voltage.
 2. Adjustable time-delay and pickup voltage.
- H. Shunt-Trip Devices.

I. Metering:

1. Accuracy: **[0.5][1.0]** percent of reading, complying with ANSI C12.20.
2. Values must be RMS average over period of one second.
 - a. Current: Each phase, **[neutral]** and three-phase average.
 - b. Voltage: L-L for each phase, L-L three-phase average, L-N each phase, and L-N three-phase average.
 - c. Active Power (kW): **[Each phase and]** three-phase total.
 - d. Reactive Power (kVAR): **[Each phase and]** three-phase total.
 - e. Apparent Power (kVA): **[Each phase and]** three-phase total.
 - f. Power Factor: **[Each phase and]** three-phase total.
 - g. Active Energy (kWh): Three-phase total.

J. Auxiliary Contacts:

1. Contacts and switches required for normal circuit-breaker operation, sufficient for interlocking and remote indication of circuit-breaker position.
2. Spare auxiliary switches, at least two, unless otherwise indicated. Switches must consist of two Type A and two Type B contacts wired through secondary disconnect devices to terminal block in stationary circuit-breaker compartment.

K. Arc Chutes: Readily removable from associated circuit breaker when it is in disconnected position, and arranged to permit inspection of contacts without removing circuit breaker from switchgear.

L. Padlocking Provisions: For installing at least three padlocks on circuit breakers to secure its enclosure and prevent movement of drawout mechanism.

M. Mechanical Interlocking of Circuit Breakers: Uses mechanical tripping lever or equivalent design and electrical interlocks.

N. Key Interlocks: Arranged to prevent opening or closing of interlocked circuit breakers, except in specified sequence. Include mountings and hardware for future installation of key interlocks.

2.11 ARC-FLASH LIMITING FEEDER CIRCUIT BREAKERS

- A. Feeder circuit breakers must be without current-limiting fuses, listed as complying with UL 1066.
- B. Short-circuit withstand current rating must be 200 kA.
- C. Equip arc-flash limiting feeder circuit breakers with Arc-Flash Maintenance Setting switch for use as temporary arc-flash incident energy-reduction device during maintenance activities on that feeder.
 1. Provide manual switch on compartment door to switch circuit-breaker short-time tripping characteristics to instantaneous with minimum pickup setting, to reduce danger from potential arc-flash at downstream equipment.
 2. Provide lock feature for switch so that it may be locked in either off or on maintenance-mode position.
 3. Provide blue LED indicating light to indicate that switch is in maintenance mode.
 4. Provide dry relay contacts on switches for annunciation of switch position.

2.12 ZONE-SELECTIVE INTERLOCKING

- A. Trip units for indicated circuit breakers must include zone-interlocking capability for short-time delay and ground-fault delay trip functions for system coordination and arc energy reduction. Zone-interlocking system must restrain tripping of upstream circuit breaker and allow circuit breaker closest to fault to trip with no intentional time delay. In event that downstream breaker does not trip, upstream breaker must trip after preset time delay. **[Zone-interlock system must be factory wired and tested for circuit breakers within switchgear.]**

2.13 NETWORK PROTECTORS

- A. Comply with IEEE 57.12.44 and IEEE C37.20.1. Switch must comply with UL 1066.
1. Dead-front, drawout design with externally mounted fuses, using hand-cranked rail system. Include mechanical interlocks to prevent racking in and racking out when protector is closed.
 2. Locate relay and control panel on separate drawout module.
 3. Protector Operator: **[Spring-close][and][or][stored-energy]** mechanism, rated to close on **[25 000 A(rms sym)][40 000 A(rms sym)]** load.
 4. Program relay with factory-default values. Make provisions to field adjust these values using relay calibration procedures. Include antipumping program to lock protector open under abnormal conditions.
 5. Include current-limiting fuses on network side of protector for protection against switchboard bus faults.
- B. Controls must be via microprocessor-based, three-phase network relay, with the following features and functions:
1. Protector control must use positive and negative sequence-based algorithm for current and voltage.
 2. Close protector if positive sequence power flows into network. Adjustable closing range must be from 0.5 to 3.5 V in phase difference between network and transformer voltages.
 3. Trip protector if there is net, three-phase, reverse power flow through protector. Trip protectors must be adjustable from 0.05 to 5 percent of continuous-current rating of current transformers within protector.
 4. Trip protector if there is flow of reverse magnetizing current to its associated transformer.
 5. Relay parameters and W or VAR trip values must be field adjustable.
 6. Protector may not open under fault on network side of protector.
 7. Include auxiliary contacts and control wiring for use with remote pilot devices that provide remote trip and lockout functions in low-voltage switchgear. Include **[two]<Insert number>** spare auxiliary contacts and equal number of N.O. and N.C. types.
- C. Communicate the following network relay parameters:
1. Current in each phase.
 2. Phase-to-phase and phase-to-neutral voltages.
 3. Three-phase W, VAR, and VA.
 4. Frequency.
 5. Power factor.
 6. Network relay set points.

2.14 SURGE SUPPRESSION

- A. Factory Installed: Integral part of low-voltage switchgear, complying with UL 1449 SPD, Type 1, with the

following features and accessories:

1. Integral disconnect switch.
2. Internal thermal protection that disconnects SPD before damaging internal suppressor components.
3. Indicator light display for protection status.
4. Form-C contacts rated at 5 A 250 V(ac), one N.O. and one N.C., for remote monitoring of protection status. [**Contacts must reverse on failure of surge diversion module or on opening of current-limiting device. Coordinate with building power monitoring and control system.**]
5. Surge counter.

- B. Field Mounted: Complying with Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits." Include the following features and accessories:

1. Integral disconnect switch.
2. Internal thermal protection that disconnects SPD before damaging internal suppressor components.
3. Indicator light display for protection status.
4. Form-C contacts rated at 5 A 250 V(ac), one N.O. and one N.C., for remote monitoring of protection status. [**Contacts must reverse on failure of surge diversion module or on opening of current-limiting device. Coordinate with building power monitoring and control system.**]
5. Surge counter.

2.15 CONTROL POWER SUPPLY, 120 V(ac)

- A. Control Power Transformer: Supply 120 V control circuits through dry-type control power transformers, include secondary disconnect devices.

1. Place transformers larger than 3 kVA in separate compartments at bottom of vertical section, including related primary and secondary fuses.
2. Two control power transformers in separate compartments with necessary interlocking relays; transformers connected to line side of associated main circuit breaker.
 - a. Secondary windings connected through relay(s) to control bus to affect automatic transfer scheme.
 - b. Secondary windings connected through internal automatic transfer switch to switchgear control power bus.
3. Control Power Fuses: Primary and secondary fuses provide current-limiting and overload protection.

2.16 CONTROL POWER SUPPLY, 24 V(dc)

- A. System Requirements: Battery must have number of cells and ampere-hour capacity based on initial specific gravity of 1.210 at 25 deg C with electrolyte at normal level and minimum ambient temperature of 13 deg C. Cycle battery before shipment to guarantee rated capacity on installation. Arrange battery to operate ungrounded. Battery system capacity must be as recommended by switchgear manufacturer to operate circuit breakers for intended duty.
- B. Battery: [**Standard VRLA**] [**Premium VRLA**] [**Vented NiCd** ,] batteries, with battery disconnect and overcurrent protective device.

- C. Rack: Two-step rack with electrical connections between battery cells and between rows of cells; include two flexible connectors with bolted-type terminals for output leads. **[Rate battery rack, cell supports, and anchorage for seismic requirements.]**
- D. Accessories:
 - 1. Thermometers with specific-gravity correction scales.
 - 2. Hydrometer syringes.
 - 3. Set of cell numerals.
- E. Charger: Static-type silicon rectifier equipped with automatic regulation and provision for manual and automatic adjustment of charging rate. Unit must automatically maintain output voltage within 0.5 percent from no load to rated charger output current, with AC input-voltage variation of plus or minus 10 percent and input-frequency variation of plus or minus 3 Hz.
 - 1. DC ammeter.
 - 2. DC Voltmeter: Maximum error of 5 percent at full-charge voltage, with toggle switch to select between battery and charger voltages.
 - 3. Ground Indication: Two appropriately labeled lights to indicate circuit ground, connected in series between negative and positive terminals, with midpoint junction connected to ground by N.O. push-button contact.
 - 4. Capacity: Sufficient to supply steady load, float-charge battery between 2.20 and 2.25 V per cell, and equalizing charge at 2.33 V per cell.
 - 5. Charging-Rate Switch: Manually operated switch to transfer to higher charging rate. Charger operation must be automatic until manually reset.
 - 6. AC Power Supply: 120 V, 60 Hz, subject to plus or minus 10 percent variation in voltage and plus or minus 3 Hz variation in frequency. Automatic charger operation must resume after loss of AC power supply for interval.
 - 7. Charging Regulator: Protect charger from damage due to overload, including short circuit on output terminals. Device must regulate charging current but may not disconnect charger from either battery or AC supply.
 - 8. Charger's Audible Noise: Less than 26 dB(A-weighted).

2.17 INSTRUMENTATION AND CONTROL

- A. Power Distribution Equipment must be web enabled, direct connected to Local Area Network (LAN) or Intranet.
- B. Ethernet Connectivity:
 - 1. Install multipoint, TIA-485 MODBUS serial communications network within switchgear to interconnect breaker trip units, protective relays, drives, and metering devices equipped with communications.
 - 2. Serial communications network must be wired to Ethernet gateway in switchgear. Gateway must be web enabled, with integral network port and embedded web server with factory-configured firmware and HTML-formatted web pages for viewing of power monitoring and equipment status information from switchgear devices equipped with digital communication ports.
 - 3. LAN must consist of multipoint, TIA-485 MODBUS serial communication network to interconnect breaker trip units, protective relays, drives, and metering devices equipped with communications. Serial communication network must be connected to Ethernet server that functions as gateway and server, providing data access via **[10 Base-T][100 Base-T][100 Base-TX][100 Base FX]** LAN.
 - 4. Server Configuration:

- a. Initial network parameters set using standard web browser. Connect via local operator interface, or TIA-1096 Type 8P8C jack accessible from front of equipment.
 - b. Network server must be factory programmed with embedded HTML-formatted web pages that are user configurable and that provide detailed communication diagnostic information for serial and Ethernet ports as status of TIA-485 network; with internal memory management information pages for viewing using standard web browser.
 - c. Password-protected login, with password administration accessible from LAN using standard web browser.
 - d. Operating Software: Suitable for local access; firewall protected.
 5. All serial communications devices within equipment must be addressed at factory and tested.
- C. Instrument Transformers: Comply with IEEE C57.13. Instrument transformers may not be used to power space conditioning equipment associated with outdoor switchgear, or for power to convenience receptacles and lighting.
 1. Potential Transformers: Secondary voltage rating of 120 V and NEMA C12.11 Accuracy class of 0.3 with burdens of W, X, and Y.
 2. Current Transformers: Burden and Accuracy class suitable for connected relays, meters, and instruments.
- D. Analog Instruments: Rectangular, **4-1/2 inch (115 mm)** square, 1 percent accuracy, semiflush mounting, with antiparallax 250-degree scale and external zero adjustment.
 1. Voltmeters: Cover expanded scale range of normal voltage plus 10 percent.
 2. Voltmeter Selector Switch: Rotary type with off position to provide readings of phase-to-phase[**and phase-to-neutral**] voltages.
 3. Ammeters: Cover expanded scale range of bus rating plus 10 percent.
 4. Ammeter Selector Switch: Permits current reading in each phase and keeps current-transformer secondary circuits closed in off position.
 5. Locate meter and selector switch on circuit-breaker compartment door for indicated feeder circuits only.
 6. Watt-Hour Meters: Flush- or semiflush-mounting type, 5 A, 120 V, three phase, three wire; with three elements, 15-minute indicating demand register, and provision for testing and adding pulse initiation.
 7. Recording Demand Meter: Usable as totalizing relay or indicating and recording maximum demand meter with 15-minute interval.
 - a. Operation: Counts and records succession of pulses entering two channels.
 - b. Housing: Drawout, back-connected case arranged for semiflush mounting.
- E. Power Monitoring: Separately mounted, modular, permanently installed, solid-state, digital I/O multifunction metering instrument for power and energy metering and monitoring, complying with UL 61010-1.
 1. Capable of metering four-wire wye, three-wire wye, three-wire delta, and single-phase power systems.
 2. Equipped with security lock to protect revenue-related metering from unauthorized and accidental changes.
 3. Comply with IEC 60529 degree of protection code of IP65 for front of meter, and code of IP30 for body.
 4. Overvoltage: Comply with UL 61010-1 overvoltage withstand rating for CAT III.
 5. Accuracy:
 - a. Comply with ANSI C12.20, Class 0.5.
 - b. Neutral Current Measurement: Not more than 0.65 percent.

- c. Power Factor: 1.0 percent.
 - d. Frequency: 0.1 percent.
 - e. THD: 1.0 percent.
 - f. Waveform Sampling: 64 per cycle.
6. Data Link: Ethernet connectivity specified in this article.
7. Meter Physical Characteristics:
- a. Display: Backlit LCD with antiglare and scratch-resistant lens.
 - b. Display of Metered Values: One screen to show at least **[three]<Insert number>** user-selected values displayed at same time. Selections available to display must include the following:
 - 1) All meters.
 - 2) Measurements.
 - 3) THD.
 - 4) Energy.
 - 5) Demand.
 - 6) Minimum and maximum values.
 - 7) Power demand.
8. Sampling Rate: Continuously sample and record voltage and current at rate not less than **[64]<Insert number>** samples per cycle, simultaneously on voltage and current channels of meter.
9. Meters:
- a. Instantaneous, RMS:
 - 1) Current: Each phase, **[neutral]** and three-phase average.
 - 2) Voltage: L-L for each phase, L-L three-phase average, L-N each phase, and L-N three-phase average.
 - 3) Active Power (kW): **[Each phase and]** three-phase total.
 - 4) Reactive Power (kVAR): **[Each phase and]** three-phase total.
 - 5) Apparent Power (kVA): **[Each phase and]** three-phase total.
 - 6) Power Factor: **[Each phase and]** three-phase total.
 - b. Energy:
 - 1) Active Energy (kWh): Three-phase total.
 - c. Demand, Derived from Instantaneous RMS Meters:
 - 1) Current: Present and maximum.
 - 2) Active: Present and maximum.
 - 3) Reactive: Present and maximum.
 - 4) Apparent: Present and maximum/
 - d. Power Quality Measurements:
 - 1) THD: Current and voltage from measurements simultaneously from same cycle, as can be calculated from specified sampling rate.
10. I/O: Two optically isolated digital outputs for KYZ pulsing or control. Output signal characteristics must be 150 mA at 200 V.

- a. KYZ Pulse: Generate standard KYZ pulses for user-defined increment of metered active energy as follows:
 - 1) User-defined pulse output, associated with kWh.
 - 2) User-defined pulse output, associated with kVARh.
 - b. <Insert control function>.
11. Capacities and Characteristics:
- a. Circuit Connections:
 - 1) Voltage: Measurement autoranging, 60 to 400 V(ac rms) L-N. [**Connect directly to low-voltage (600 V and less) without using voltage transformers.**] [**Connect to instrument-grade potential transformers secondary at 120 V.**] Meter impedance must be 2 MΩ L-L or greater.
 - 2) Overload Tolerance: 1500 V(ac rms) continuously.
 - 3) Current: Connect to instrument-grade current transformer with metering range of 5 mA to 6 A. Overcurrent tolerance of instrument must be 10 A continuous, 50 A for 10 seconds once per hour, and 120 A for one second per hour.
 - 4) Frequency: 45 to 65 Hz.
 - 5) Time: Input from GPS receiver to synchronize internal clock of instrument and to time-synchronize this instrument with network to deviation of not greater than 1 ms.

2.18 POWER TRANSFER CONFIGURATIONS

- A. Factory-installed and -tested controls of circuit breakers to accomplish automatic transfer controls for switchgear having two power sources.
- B. Relays: Comply with IEEE C37.90, types and settings as indicated; with test blocks and plugs.
- C. Control Wiring:
 - 1. Factory installed, complete with bundling, lacing, and protection.
 - 2. Provide flexible conductors for 8 AWG and smaller, for conductors across hinges and for conductors for interconnections between shipping units.
 - 3. Install plugs in control wiring at shipping splits.
- D. Two-Breaker Transfer Control:
 - 1. Two-breaker transfer control must provide for switchgear assembly with common load bus and two normally energized medium-voltage power sources, designated "normal" and "standby," connected to load bus. Circuit breakers connecting two power sources to load bus must be controlled by microprocessor-based automatic transfer control. Power for transfer control must be from voltage sensing transformers.
 - 2. In automatic mode, load bus is connected to normal power source. When normal source fails, control must automatically open normal power source and close standby source circuit breaker.
 - 3. Sequence of Operation:
 - a. Default operation must be with normal source main breaker closed and standby main breaker open. On detection of undervoltage to line side of normal main breaker and after field-adjustable time delay, that main breaker must open and after additional field-adjustable time delay, standby breaker must close restoring power to facility.
 - b. On restoration of voltage to line side of normal main breaker and after field-adjustable time delay, standby main breaker must open and after field-adjustable time delay, normal main

breaker must close.

4. Field-Adjustable Transfer Parameters:
 - a. Delay transfer from normal power source to standby power source and from standby power source to normal source. Time delay is to allow load voltage to decay before reconnecting to another power source. Delay range: zero seconds to 30 minutes.
 - b. Delay initiation of transfer sequence. Time delay is recommended to override momentary power outage or voltage fluctuation. Delay range: zero seconds to 120 seconds.
 - c. Delay transfer from standby power source to normal power source. Delay range: zero seconds to 30 minutes.
 - d. A relay with contact that changes state when power is available on normal source and relay with contact that changes state when power is available on standby source.
5. Controls and Indicators: Besides delay setting controls, provide the following:
 - a. Interlocks or relay control to prevent transfer when either of two controlled circuit breakers are tripped due to overcurrent or ground fault.
 - b. Three-position selector switch to select normal source: Source 1, Source 2, or none.
 - c. Transfer-control automatic and manual selector.
 - 1) Interlock must prevent paralleling of two power sources in manual mode.
 - d. Open-close control switch for manual electrical operation of controlled circuit breakers.
 - e. Selector to place control into programming mode.
 - f. Circuit-breaker control switch for normal and standby source breakers, providing open and close operation.
 - g. Push-button to initiate manual retransfer to normal source when transfer controller is in automatic mode.
 - h. Meters and display to show the following:
 - 1) Voltage and frequency of both sources.
 - 2) A multiline display showing the following:
 - a) Set points of timers, and voltage pickup and dropout set points.
 - b) Date, time, and reason for at least last 10 transfers. Display may show information for one transfer at time using scrolling control, with others held in memory.
 - c) When control system is in transferring process, display must show delay countdown in seconds.
 - i. LED indicator lights to show the following:
 - 1) Normal source available.
 - 2) Standby source available.
 - 3) Normal source connected.
 - 4) Standby source connected.
 - 5) Load bus energized.
6. Voltage Transformers: Primary and secondary protection and disconnecting means for sensing functions and control power.
7. Voltage Sensing Relays: Microprocessor-based ANSI No. 27/47 voltage detection relays for three-phase undervoltage protection and negative sequence voltage protection.

E. Three-Breaker Transfer Control:

1. Switchgear assembly, with two normally energized, medium-voltage power sources designated "Main 1" and "Main 2" connected to load bus. N.O. bus tie circuit breaker can tie two load buses. Three circuit breakers must be controlled by microprocessor-based automatic-transfer control. Power for transfer control must be from voltage sensing transformers.
2. In automatic mode, on loss of voltage to line side of source, that main breaker must open and then bus tie must close. On restoration of power to previously failed main breaker, bus tie must open and open main must close.
3. Sequence of Operation:
 - a. Default operation must be with main breakers closed and bus tie breaker open. On detection of undervoltage to line side of main breaker and after field-adjustable time delay, that main breaker must open and after additional field-adjustable time delay, bus tie breaker must close, restoring power to failed bus.
 - b. On restoration of voltage to line side of previously failed main breaker and after field-adjustable time delay, tie breaker must open and after field-adjustable time delay, previously failed main breaker must close.
4. Field-Adjustable Transfer Parameters:
 - a. Delay opening of failed main and closing of bus tie. Time delay is to allow load voltage to decay before reconnecting to another power source. Delay range: zero seconds to 30 minutes.
 - b. Delay initiation of transfer sequence. Time delay is recommended to override momentary power outage or voltage fluctuation. Delay range: zero to 120 seconds.
 - c. Delay opening of bus tie and closing of previously failed main. Time delay is to allow bus voltage to decay before reconnecting to another power source. Delay range: zero seconds to 30 minutes.
5. Controls and indicators must include the following in addition to delay setting controls:
 - a. Interlocks or relay control to prevent transfer when any of three controlled circuit breakers trip due to overcurrent or ground fault.
 - b. Transfer control automatic and manual selector.
 - 1) Interlock that prevents paralleling of two mains in manual or automatic mode.
 - c. Open-close control switch for manual electrical operation of controlled circuit breakers.
 - d. Selector must place control into programming mode.
 - e. A relay with contact that changes state when power is available on both mains and relay with contact that changes state to indicate open main and when bus tie is closed.
 - f. Push-button to initiate manual retransfer to previously failed source when transfer controller is in automatic mode.
 - g. Meters and display must show the following:
 - 1) Voltage and frequency at line side of both mains.
 - 2) A multiline display must show following:
 - a) Set points of timers, and voltage pickup and dropout set points.
 - b) Date, time, and reason for at least last 10 transfers. Display may show information for one transfer at time using scrolling control, with others held in memory.
 - c) When control system is in transferring process, display must show delay countdown in seconds.
 - h. LED indicator lights must show the following:

- 1) Main source available.
 - 2) Main source unavailable.
 - 3) Main closed.
 - 4) Main open.
 - 5) Bus tie open or closed.
6. Voltage transformers must have primary and secondary protection and disconnecting means for sensing functions and control power.
 7. Voltage Sensing Relays: Microprocessor-based ANSI No. 27/47 voltage detection relays for three-phase undervoltage protection and negative-sequence voltage protection.

2.19 DIFFERENTIAL GROUND-FAULT PROTECTION

- A. Description: Ground-fault protection system for three-phase, four-wire switchgear having multiple sources must be devised by manufacturer to insure that proper main or tie breaker(s) operate properly in normal and emergency conditions. Switchgear must include additional current transformers, ground-fault relays, interlocks, wiring, and accessories to avoid nuisance tripping of circuit breakers connected to main bus of switchgear. Ensure that the following occurs on main bus:
 1. A ground fault at location in switchgear must trip system.
 2. Combination of normal current flow and ground-fault current flow must trip system.
 3. Circulating currents through neutral due to multiple grounds and sources external to immediate low-voltage power sources may not trip system.
 4. System may not trip if there is no ground fault, during normal current flow.
 5. System may not trip due to large single-phase currents.
- B. Relays: Comply with IEEE C37.90, with test blocks and plugs.
- C. Control Wiring:
 1. Factory installed, complete with bundling, lacing, and protection.
 2. Provide flexible conductors for 8 AWG and smaller, for conductors across hinges and for conductors for interconnections between shipping units.
 3. Install plugs in control wiring at shipping splits.

2.20 SOURCE QUALITY CONTROL

- A. Owner will witness required factory tests. Notify Architect at least 14 days before date of tests and indicate their approximate duration.
- B. Testing Administrator: **[Owner will engage][Engage]** qualified testing agency to evaluate low-voltage switchgear.
- C. Factory Tests and Inspections: Test and inspect low-voltage switchgear, by, or under supervision of, qualified electrical testing laboratory recognized by authorities having jurisdiction, in accordance with IEEE C37.20.1 before delivering to site. Affix label with name and date of **[manufacturer's][qualified electrical testing laboratory's]** certification of system compliance on control units. Drawout circuit breakers need not be tested in assembly if they are tested separately.
 1. Dielectric Tests: Perform power-frequency withstand tests to demonstrate ability of insulation system to withstand voltages listed in IEEE C37.20.1. Voltage must be increased gradually from zero to required test value within 5 to 10 seconds and must be held at that value for one minute.
 2. Perform mechanical operation tests to ensure proper functioning of operating mechanism,

- mechanical interlocks, and interchangeability of removable elements that are designed to be interchangeable.
- 3. Test effectiveness of grounding of metal-case instrument transformer frame or case.
- 4. Verify that control wiring is correct by verifying continuity. Perform electrical operation of component devices to ensure that they function properly and in intended sequence.
- 5. Perform control wiring insulation tests.
- 6. Verify correct polarity of connections between instrument transformers and meters and relays.
- D. Serial communications devices within equipment must be addressed at factory and tested to verify reliable communications to equipment's Ethernet gateway.
- E. Nonconforming Work:
 - 1. Low-voltage switchgear assembly will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and space conditions for compliance with requirements for secondary unit substations and other conditions affecting performance of the Work.
- B. Examine roughing-in of conduits and grounding systems to verify the following:
 - 1. Wiring entries comply with layout requirements.
 - 2. Entries are within conduit-entry tolerances specified by manufacturer, and no feeders will have to cross section barriers to reach load or line lugs.
- C. Examine walls, floors, roofs, and concrete bases for suitable conditions where switchgear will be installed.
- D. Verify that ground connections are in place and that requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance must be [5 Ω]<Insert Ω> at switchgear location.
- E. On delivery of switchgear and prior to unloading, inspect equipment for damage.
 - 1. Verify that tie rods and chains are undamaged and tight, and that blocking and bracing are tight.
 - 2. Verify that there is no evidence of load shifting in transit, and that readings from transportation shock recorders, if equipped, are within manufacturer's published instructions.
 - 3. Examine switchgear for external damage, including dents or scratches in doors and sill, and termination provisions.
 - 4. Compare switchgear and accessories received with bill of materials to verify that shipment is complete. Verify that switchgear and accessories comply with manufacturer's published instructions and Shop Drawings. If shipment is incomplete or does not comply with Project requirements, notify manufacturer in writing immediately.
 - 5. Unload switchgear, observing packing label warnings and handling instructions.
 - 6. Open compartment doors and inspect components for damage or displaced parts, loose or broken connections, cracked or chipped insulators, bent mounting flanges, dirt or foreign material, and water or moisture.

- F. Handling:
1. Handle switchgear, in accordance with manufacturer's published instructions; avoid damage to enclosure, termination compartments, base, frame, tank, and internal components. Do not subject switchgear to impact, jolting, jarring, or rough handling.
 2. Protect switchgear compartments against entrance of dust, rain, and snow.
 3. Transport switchgear upright, to avoid internal stresses on equipment mounting assemblies. Do not tilt or tip switchgear.
 4. Use spreaders or lifting beam to obtain vertical lift and to protect switchgear from straps bearing against enclosure. Lifting cable pull angles may not be greater than 15 degrees from vertical.
 5. Do not damage structure when handling switchgear.
- G. Proceed with installation only after examinations are complete and unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install switchgear on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 260529 "Hangers and Supports for Electrical Systems."
- B. Comply with requirements for vibration isolation and seismic-control devices specified in Section 260529 "Hangers and Supports for Electrical Systems" and **[Section 260548 "Vibration and Seismic Controls for Electrical Systems."][Section 260548.16 "Seismic Controls for Electrical Systems."]**
- C. Maintain minimum clearances and workspace at equipment in accordance with manufacturer's published instructions and NFPA 70.

3.3 CONNECTIONS

- A. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Grounding Connections at Exterior Locations:
1. Install tinned bare copper conductors not smaller than 4/0 AWG, for ground conductors buried not less than **30 inch (765 mm)** below grade interconnecting grounding electrodes.
 2. Bond surge arrester and neutrals directly to switchgear enclosure and then to grounding electrode system with bare copper conductors, sized as indicated.
 3. Keep lead lengths as short as practicable with no kinks or sharp bends.
 4. Make joints in grounding conductors and loops by exothermic weld or compression connector.
 5. Fence and equipment connections may not be smaller than 4 AWG.
 6. Ground fence at gate posts and corner posts and at intervals not exceeding **10 ft (3 m)**.
 7. Bond gate sections to fence posts using **1/8 by 1 inch (3 by 25 mm) [tinned,]flexible braided copper strap and clamps.**
- C. Terminate grounding and bonding conductors on common equipment grounding terminal on switchgear enclosure. Install supplemental terminal bars, lugs, and bonding jumpers as required to accommodate number of conductors for termination.
- D. Complete switchgear grounding and surge-protector connections prior to making other electrical connections.

3.4 IDENTIFICATION

- A. Comply with installation requirements for labels and signs specified in Section 260553 "Identification for Electrical Systems."
- B. Install warning signs as required to comply with OSHA 29 CFR 1910.269.
- C. Compartment Nameplates: **[Engraved, laminated-acrylic][Engraved, melamine plastic][Preprinted aluminum signs]**, as described in Section 260553 "Identification for Electrical Systems," for compartments, mounted with corrosion-resistant screws.
- D. Mimic Bus: Continuous mimic bus, arranged in single-line diagram format, using symbols and lettered designations consistent with approved mimic-bus diagram.
 - 1. Mimic-bus segments coordinated with devices in switchgear sections to which applied, to produce concise visual presentation of principal switchgear components and connections.
 - 2. Medium: Painted graphics, as selected by Architect.
 - 3. Color: Contrasting with factory-finish background; as selected by Architect from manufacturer's full range.
- E. Arc-Flash Warning Labels:
 - 1. Comply with requirements in Section 260573.19 "Arc-Flash Hazard Analysis." Produce **3.5 by 5 inch (76 by 127 mm)** self-adhesive equipment label for work locations included in analysis.
 - 2. Comply with requirements in Section 260553 "Identification for Electrical Systems." Produce **3.5 by 5 inch (76 by 127 mm)** self-adhesive equipment label for work locations included in analysis. Labels must be machine printed, with no field-applied markings.
 - a. Label must have orange header with wording, "WARNING, ARC-FLASH HAZARD," and must include the following information taken directly from arc-flash hazard analysis:
 - 1) Location designation.
 - 2) Nominal voltage.
 - 3) Flash protection boundary.
 - 4) Hazard risk category.
 - 5) Incident energy.
 - 6) Working distance.
 - 7) Engineering report number, revision number, and issue date.
 - b. Labels must be machine printed, with no field-applied markings.

3.5 FIELD QUALITY CONTROL

- A. Acceptance Testing Preparation:
 - 1. **<Insert requirements>**.
- B. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.
- C. Tests and Inspections:
 - 1. Comply with provisions of "Testing and Test Methods" Chapter in NFPA 70B and NETA ATS.
 - 2. After installing switchgear and after electrical circuitry has been energized, test for compliance

- with requirements.
3. Perform visual and mechanical inspections and electrical tests stated in NETA ATS. Certify compliance with test parameters.
 4. Visual and Mechanical Inspection:
 - a. Verify that fuse and circuit-breaker sizes and types correspond to Drawings and coordination study[, **as well as to circuit breaker's address in control network**].
 - b. Verify that current and voltage transformer ratios correspond to Drawings.
 - c. Inspect bolted electrical connections for high resistance using one of the following two methods:
 - 1) Use low-resistance ohmmeter to compare bolted-connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of lowest value.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels must be in accordance with manufacturer's published data. In absence of manufacturer's published data, use NETA ATS, Table 100.12.
 - d. Confirm correct operation and sequencing of electrical and mechanical interlock systems.
 - 1) Attempt closure on locked-open devices. Attempt to open locked-closed devices.
 - 2) Make key exchange with devices operated in off-normal positions.
 - e. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
 - f. Inspect insulators for evidence of physical damage or contaminated surfaces.
 - g. Verify correct barrier and shutter installation and operation.
 - h. Exercise active components.
 - i. Inspect mechanical indicating devices for correct operation.
 - j. Verify that filters are in place and that vents are clear.
 - k. Perform visual and mechanical inspection of instrument transformers in accordance with "Instrument Transformer Field Tests" Paragraph.
 - l. Inspect control power transformers.
 - 1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
 - 2) Verify that primary and secondary fuse or circuit-breaker ratings match Drawings.
 - 3) Verify correct functioning of drawout disconnecting and grounding contacts and interlocks.
 5. Electrical Tests:
 - a. Perform DC voltage insulation-resistance tests on bus sections, phase-to-phase and phase-to-ground, for one minute. If bus temperature is other than plus or minus 20 deg C, adjust resulting resistance as provided in NETA ATS, Table 100.11.
 - 1) Insulation-resistance values of bus insulation must be in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's published instructions or NETA ATS, Table 100.1.
 - 2) Do not proceed to dielectric withstand voltage tests until insulation-resistance levels are raised above minimum values.

- b. Perform dielectric withstand voltage test on bus sections, phase-to-ground with phases not under test grounded, in accordance with manufacturer's published data. If manufacturer has no recommendation for this test, it must be conducted in accordance with NETA ATS, Table 100.2. Apply test voltage for one minute.
 - 1) If no evidence of distress or insulation failure is observed by end of total time of voltage application during dielectric withstand test, test specimen is considered to have passed test.
 - c. Perform insulation-resistance tests on control wiring for ground. Applied potential must be 500 V(dc) for 300 V rated cable and 1000 V(dc) for 600 V rated cable. Test duration must be one minute. For units with solid-state components or control devices that cannot tolerate applied voltage, follow manufacturer's published instruction.
 - 1) Minimum insulation-resistance values of control wiring may not be less than 2 MΩ.
 - d. Control Power Transformers:
 - 1) Perform insulation-resistance tests. Perform measurements from winding-to-winding and windings-to-ground. Insulation-resistance values of winding insulation must be in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's published instructions or NETA ATS, Table 100.1.
 - 2) Perform secondary wiring integrity test. Disconnect transformer at secondary terminals and connect secondary wiring to rated secondary voltage source. Verify correct potential at devices.
 - 3) Verify correct secondary voltage by energizing primary winding with system voltage. Measure secondary voltage with secondary wiring disconnected.
 - 4) Verify correct function of control transfer relays located in switchgear with multiple control power sources.
 - e. Voltage Transformers:
 - 1) Perform secondary wiring integrity test. Verify correct potential at devices.
 - 2) Verify secondary voltages by energizing primary winding with system voltage.
 - f. Perform current-injection tests on entire current circuit in switchgear sections.
 - 1) Perform current tests by secondary injection with magnitudes such that minimum 1.0 A current flows in secondary circuit. Verify correct magnitude of current at devices in circuit.
 - 2) Perform current tests by primary injection with magnitudes such that minimum 1.0 A current flows in secondary circuit. Verify correct magnitude of current at devices in circuit.
 - g. Perform system function tests in accordance with "System Function Tests" Paragraph.
 - h. Verify operation of space heaters.
 - i. Perform phasing checks on double-ended or dual-source switchgear to ensure correct bus phasing from sources.
- D. Circuit-Breaker Field Tests:
- 1. Visual and Mechanical Inspection:
 - a. Inspect physical and mechanical condition.

- b. Inspect anchorage, alignment, and grounding.
 - c. Verify that maintenance devices are available for servicing and operating breaker.
 - d. Verify unit is clean.
 - e. Verify that arc chutes are intact.
 - f. Inspect moving and stationary contacts for condition and alignment.
 - g. Verify that primary and secondary contact wipe and other dimensions vital to satisfactory operation of breaker are correct.
 - h. Perform mechanical operator and contact alignment tests on both breaker and its operating mechanism in accordance with manufacturer's published data.
 - i. Verify cell fit and element alignment.
 - j. Verify racking mechanism operation.
 - k. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
 - l. Perform adjustments for final protective-device settings in accordance with coordination study provided by Owner.
 - m. Record as-found and as-left operation counter readings.
2. Electrical Tests:
- a. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to ground with switch closed, and across open poles. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, use NETA ATS, Table 100.1. Insulation-resistance values must be in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Values of insulation resistance less than Table 100.1 or manufacturer's published instructions must be investigated.
 - b. Measure contact resistance across power contacts of circuit breakers. Drop values for $\mu\Omega$ or mV(dc) may not exceed high levels of normal range as indicated in manufacturer's published data. In absence of manufacturer's published data, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of lowest value.
 - c. Determine long-time pickup and delay by primary current injection. Long-time pickup values must be as specified, and trip characteristic may not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors. If manufacturer's curves are unavailable, trip times may not exceed value shown in NETA ATS, Table 100.7.
 - d. Determine short-time pickup and delay by primary current injection. Short-time pickup values must be as specified, and trip characteristic may not exceed manufacturer's published time-current tolerance band.
 - e. Determine ground-fault pickup and delay by primary current injection. Ground-fault pickup values must be as specified, and trip characteristic may not exceed manufacturer's published time-current tolerance band.
 - f. Determine instantaneous pickup value by primary current injection. Instantaneous pickup values must be as specified and within manufacturer's published tolerances. In absence of manufacturer's published data, comply with NETA ATS, Table 100.8.
 - g. Test functions of trip unit by means of secondary injection. Pickup values and trip characteristic must be as specified and within manufacturer's published tolerances.
 - h. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data. Minimum pickup voltage of shunt trip and close coils must comply with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.20.
 - i. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.
 - j. Verify correct operation of auxiliary features, such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free operation, antipump function, and trip-unit battery condition. Reset trip logs and indicators. Auxiliary features must operate in

- accordance with manufacturer's published data.
- k. Verify operation of charging mechanism. Charging mechanism must operate in accordance with manufacturer's published data.

E. Instrument Transformer Field Tests:

1. Visual and Mechanical Inspection:

- a. Verify that equipment nameplate data complies with Contract Documents.
- b. Inspect physical and mechanical condition.
- c. Verify correct connection of transformers with system requirements.
- d. Verify that adequate clearances exist between primary and secondary circuit wiring.
- e. Verify that unit is clean.
- f. Inspect bolted electrical connections for high resistance using one of the following two methods:
 - 1) Use low-resistance ohmmeter to compare bolted-connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of lowest value.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels must be in accordance with manufacturer's published data. In absence of manufacturer's published data, use NETA ATS, Table 100.12.
- g. Verify that required grounding and shorting connections provide contact.
- h. Verify correct operation of transformer withdrawal mechanism and grounding operation.
- i. Verify correct primary and secondary fuse sizes for voltage transformers.
- j. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

2. Electrical Tests of Current Transformers:

- a. Perform insulation-resistance test of current transformers and secondary wiring for ground at 1000 V(dc) for one minute. For units with solid-state components that cannot tolerate applied voltage, follow manufacturer's published instructions. Investigate and correct values of insulation resistance less than manufacturer's published instructions or NETA ATS, Table 100.5.
- b. Perform polarity test on current transformers in accordance with IEEE C57.13.1. Polarity results must agree with transformer markings.
- c. Perform ratio-verification test using voltage or current method in accordance with IEEE C57.13.1. Ratio errors must be in accordance with IEEE C57.13.
- d. Perform excitation test on transformers used for relaying applications in accordance with IEEE C57.13.1. Excitation results must match curve supplied by manufacturer or be in accordance with IEEE C57.13.1.
- e. Measure current circuit burdens at transformer terminals in accordance with IEEE C57.13.1. Measured burdens must be compared to, and must match, instrument transformer ratings.
- f. Perform insulation-resistance tests on primary winding with secondary grounded. Test voltages must be in accordance with NETA ATS, Table 100.5.
- g. Perform dielectric withstand tests on primary winding with secondary grounded. Test voltages must be in accordance with NETA ATS, Table 100.9.
- h. Perform power-factor or dissipation-factor tests in accordance with test equipment manufacturer's published data.
- i. Verify that current transformer secondary circuits are grounded and have only one grounding point in accordance with IEEE C57.13.3. That grounding point should be located

as specified by Engineer in Project Drawings.

3. Electrical Tests of Voltage Transformers:

- a. Perform insulation-resistance tests, winding-to-winding and windings-to-ground. Test voltages must be applied for one minute in accordance with NETA ATS Table 100.5. For units with solid-state components that cannot tolerate applied voltage, follow manufacturer's published instructions. Investigate and correct values of insulation resistance less than manufacturer's published instructions or NETA ATS, Table 100.5.
- b. Perform polarity test on transformers to verify polarity marks or H1-X1 relationship as applicable. Polarity results must agree with transformer markings.
- c. Perform turns-ratio test on tap positions. Ratio errors must be in accordance with IEEE C57.13.
- d. Measure voltage circuit burdens at transformer terminals. Measured burdens must be compared to, and must match, instrument transformer ratings.
- e. Perform dielectric withstand test on primary windings with secondary windings connected to ground. Dielectric voltage must be in accordance with NETA ATS, Table 100.9. Test voltage must be applied for one minute. If no evidence of distress or insulation failure is observed by end of total time of voltage application during dielectric withstand test, primary windings are considered to have passed test.
- f. Perform power-factor or dissipation-factor tests in accordance with test equipment manufacturer's published data. Power-factor or dissipation-factor values must be in accordance with manufacturer's published data. In absence of manufacturer's published data, use test equipment manufacturer's published data.
- g. Verify that voltage transformer secondary circuits are grounded and have only one grounding point in accordance with IEEE C57.13.3. Test results must indicate that circuits are grounded at only one point.

F. Ground-Resistance Test:

1. Visual and Mechanical Inspection:

- a. Verify that ground system complies with Contract Documents and with Article 250, "Grounding and Bonding," in NFPA 70.
- b. Inspect physical and mechanical condition. Grounding system electrical and mechanical connections must be free of corrosion.
- c. Inspect bolted electrical connections for high resistance using one of the following two methods:
 - 1) Use low-resistance ohmmeter to compare bolted-connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of lowest value.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels must be in accordance with manufacturer's published data. In absence of manufacturer's published data, use NETA ATS, Table 100.12.
- d. Inspect anchorage.

2. Electrical Tests:

- a. Perform fall-of-potential or alternative test in accordance with IEEE 81 on main grounding electrode or system. Resistance between main grounding electrode and ground must be no more than **[5 Ω][maximum ground-resistance value specified in "Examination"**

Article].

- b. Perform point-to-point tests to determine resistance between main grounding system and major electrical equipment frames, system neutral, and derived neutral points. Investigate point-to-point resistance values that exceed 0.5 Ω . Compare equipment nameplate data with the Contract Documents.
- c. Inspect physical and mechanical condition.
- d. Inspect bolted electrical connections for high resistance using one of the following two methods:
 - 1) Use low-resistance ohmmeter to compare bolted-connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of lowest value.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels must be in accordance with manufacturer's published data. In absence of manufacturer's published data, use NETA ATS, Table 100.12.

G. Metering Devices Field Tests:

1. Visual and Mechanical Inspection:

- a. Inspect physical and mechanical condition.
- b. Inspect bolted electrical connections for high resistance using one of the following two methods:
 - 1) Use low-resistance ohmmeter to compare bolted-connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of lowest value.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels must be in accordance with manufacturer's published data. In absence of manufacturer's published data, use NETA ATS, Table 100.12.
- c. Inspect cover gasket, cover glass, condition of spiral spring, disk clearance, contacts, and case shorting contacts, as applicable.
- d. Verify that unit is clean.
- e. Verify freedom of movement, end play, and alignment of rotating disk(s).

2. Electrical Tests:

- a. Verify accuracy of meters at cardinal points. Meter accuracy must be in accordance with manufacturer's published data.
- b. Calibrate meters in accordance with manufacturer's published data. Calibration results must be within manufacturer's published tolerances.
- c. Verify instrument multipliers. Instrument multipliers must be in accordance with system design specifications.
- d. Verify that current transformer and voltage transformer secondary circuits are intact. Test results must confirm integrity of secondary circuits of current and voltage transformers.

H. Microprocessor-Based Protective Relay Field Tests:

1. Visual and Mechanical Inspection:

- a. Record model number, style number, serial number, firmware revision, software revision,

- and rated control voltage.
- b. Verify operation of LEDs, display, and targets.
- c. Record passwords for each access level.
- d. Clean front panel and remove foreign material from case.
- e. Check tightness of connections.
- f. Verify that frame is grounded in accordance with manufacturer's published instructions.
- g. Set relay in accordance with results in Section 260573.16 "Coordination Studies" and in Section 260573.19 "Arc-Flash Hazard Analysis."
- h. Download settings from relay. Print copy of settings for report and compare settings to those specified in coordination study.

2. Electrical Tests:

- a. Perform insulation-resistance tests from circuits to grounded frame in accordance with manufacturer's published data.
- b. Apply voltage or current to analog inputs, and verify correct registration of relay meter functions.
- c. Check functional operation of elements used in protection scheme as follows:
 - 1) ANSI No. 2/62, Timing Relay:
 - a) Determine time delay.
 - b) Verify operation of instantaneous contacts.
 - 2) ANSI No. 24, Volts/Hertz Relay:
 - a) Determine pickup frequency at rated voltage.
 - b) Determine pickup frequency at second voltage level.
 - c) Determine time delay.
 - 3) ANSI No. 25, Sync Check Relay:
 - a) Determine closing zone at rated voltage.
 - b) Determine maximum voltage differential that permits closing at zero degrees.
 - c) Determine set points of live line, live bus, dead line, and dead bus.
 - d) Determine time delay.
 - e) Verify control functions of dead bus/live line, dead line/live bus, and dead bus/dead line.
 - 4) ANSI No. 27, Undervoltage Relay:
 - a) Determine dropout voltage.
 - b) Determine time delay.
 - c) Determine time delay at second point on timing curve for inverse time relays.
 - 5) ANSI No. 32, Directional Power Relay:
 - a) Determine minimum pickup at maximum torque angle.
 - b) Determine closing zone.
 - c) Determine maximum torque angle.
 - d) Determine time delay.
 - e) Verify time delay at second point on timing curve for inverse time relays.
 - f) Plot operating characteristic.
 - 6) ANSI No. 46, Current Balance Relay:

- a) Determine pickup of unit.
 - b) Determine percent slope.
 - c) Determine time delay.
- 7) ANSI No. 46N, Negative Sequence Current Relay:
- a) Determine negative sequence alarm level.
 - b) Determine negative sequence minimum trip level.
 - c) Determine maximum time delay.
 - d) Verify two points on I²T curve.
- 8) ANSI No. 47, Phase Sequence or Phase Balance Voltage Relay:
- a) Determine positive sequence voltage to close N.O. contact.
 - b) Determine positive sequence voltage to open N.C. contact (undervoltage trip).
 - c) Verify negative sequence trip.
 - d) Determine time delay to close N.O. contact with sudden application of 120 percent of pickup.
 - e) Determine time delay to close N.C. contact on removal of voltage when previously set to rated system voltage.
- 9) ANSI No. 50, Instantaneous Overcurrent Relay:
- a) Determine pickup.
 - b) Determine dropout.
 - c) Determine time delay.
- 10) ANSI No. 51, Time Overcurrent:
- a) Determine minimum pickup.
 - b) Determine time delay at two points on time current curve.
- 11) ANSI No. 64, Ground Detector Relay:
- a) Determine maximum impedance to ground causing relay pickup.
- 12) ANSI No. 67, Directional Overcurrent Relay:
- a) Determine directional unit minimum pickup at maximum torque angle.
 - b) Determine closing zone.
 - c) Determine maximum torque angle.
 - d) Plot operating characteristics.
 - e) Determine overcurrent unit pickup.
 - f) Determine overcurrent unit time delay at two points on time current curve.
- 13) ANSI No. 87, Differential Relay:
- a) Determine operating unit pickup.
 - b) Determine operation of restraint unit.
 - c) Determine slope.
 - d) Determine harmonic restraint.
 - e) Determine instantaneous pickup.
 - f) Plot operating characteristics for restraint.

d. Control Verification:



- 1) Functional Tests:
 - a) Check operation of active digital inputs.
 - b) Check output contacts or SCRs, preferably by operating controlled device, such as circuit breaker, auxiliary relay, or alarm.
 - c) Check internal logic functions used in protection scheme.
 - d) On completion of testing, reset minimum/maximum recorders, communications statistics, fault counters, sequence-of-events recorder, and event records.
 - 2) In-Service Monitoring: After equipment is initially energized, measure magnitude and phase angle of inputs and verify expected values.
- I. Ground-Fault Protection Field Tests: Evaluate interconnected system in accordance with switchgear manufacturer's published instructions.
1. Determine proper location of sensors around bus of circuit to be protected. This determination may be done visually, with knowledge of which bus is involved.
 2. Verify grounding points of system to determine that ground paths do not exist that would bypass sensors. Use high-voltage testers and resistance bridges.
 3. Test installed system for correct response by application of full-scale current into equipment to duplicate ground-fault condition, or by equivalent means such as by simulated fault current generated by the following:
 - a. A coil around sensors.
 - b. A separate test winding in sensors.
 4. Record test results on test form provided with instructions provided by manufacturer.
- J. DC System VRLA Batteries Field Test:
1. Visual and Mechanical Inspection:
 - a. Verify that batteries are adequately located.
 - b. Verify that battery area ventilation system is operable.
 - c. Verify existence of suitable eyewash equipment.
 - d. Verify that equipment nameplate data complies with the Contract Documents.
 - e. Inspect physical and mechanical condition.
 - f. Verify adequacy of battery support racks, mounting, anchorage, alignment, grounding, and clearances.
 - g. Verify that units are clean.
 - h. Inspect spill containment installation.
 - i. Verify application of oxide inhibitor on battery terminal connections.
 2. Electrical Tests:
 - a. Measure charger float and equalizing voltage levels. Adjust to battery manufacturer's recommended levels.
 - b. Verify charger functions and verify that alarms comply with system manufacturer's published instructions.
 - c. Measure negative post temperature. This temperature must comply with manufacturer's published data or IEEE 1188.
 - d. Measure charger float and equalizing voltage levels. These levels must be in accordance with battery manufacturer's published data.
 - e. Measure monoblock/cell voltage and total battery voltage with charger energized and in

float mode of operation. Monoblock/cell voltages must be in accordance with manufacturer's published data.

- f. Measure intercell connection resistances.
- g. Perform internal ohmic measurement tests. Cell internal ohmic values (resistance, impedance, or conductance) may not vary by more than 25 percent between identical cells that are in fully charged state. Monoblock/cell internal ohmic values (resistance, impedance, or conductance) may not vary by more than 25 percent between identical monoblocks/cells in fully charged state.
- h. Perform load test in accordance with manufacturer's published data or IEEE 1188. Replace units that fail to pass test.
- i. Measure battery system voltage from positive-to-ground and negative-to-ground. Voltage measured from positive-to-ground must be equal in magnitude to voltage measured from negative-to-ground.

K. DC System Vented NiCd Batteries Field Test:

1. Visual and Mechanical Inspection:

- a. Verify that batteries are adequately located.
- b. Verify that battery area ventilation system is operable.
- c. Verify existence of suitable eyewash equipment.
- d. Verify that equipment nameplate data complies with the Contract Documents.
- e. Inspect physical and mechanical condition.
- f. Verify adequacy of battery support racks, mounting, anchorage, alignment, grounding, and clearances.
- g. Verify electrolyte level. Measure pilot-cell electrolyte temperature, and correct as recommended by manufacturer's maintenance procedures to bring temperature and electrolyte level to within normal limits.
- h. Verify that units are clean.
- i. Inspect spill containment installation.
- j. Verify application of oxide inhibitor on battery terminal connections.

2. Electrical Tests:

- a. Measure charger float and equalizing voltage levels. Adjust to battery manufacturer's recommended levels.
- b. Verify charger functions and verify that alarms comply with system manufacturer's published instructions.
- c. Measure cell voltage and total battery voltage with charger energized and in float mode of operation. Cell voltages must be within 0.05 V of each other or in accordance with manufacturer's published data.
- d. Measure intercell connection resistances.
- e. Perform internal ohmic measurement tests. Cell internal ohmic values (resistance, impedance, or conductance) may not vary by more than 25 percent between identical cells that are in fully charged state.
- f. Perform load test in accordance with manufacturer's published data or IEEE 1106. Replace units that fail to pass test.
- g. Measure battery system voltage from positive-to-ground and negative-to-ground. Voltage measured from positive-to-ground must be equal in magnitude to voltage measured from negative-to-ground.

L. System Function Tests: Perform system function tests after other field quality-control tests have been completed and components have passed specified tests. Verify correct interaction of sensing, processing, and action devices.

- 1. Develop test parameters and perform tests for purpose of evaluating performance of integral

components and their functioning as complete unit within design requirements and manufacturer's published data.

2. Verify correct operation of interlock safety devices for fail-safe functions in addition to design function.
3. Verify correct operation of sensing devices, alarms, and indicating devices.

M. Nonconforming Work:

1. Switchgear components will be considered defective if they do not pass tests and inspections.
2. Remove and replace defective units and retest.

N. Collect, assemble, and submit test and inspection reports. Record as-left set points of adjustable devices.

O. Manufacturer Services:

1. Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.

3.6 MAINTENANCE

A. Voltage Monitoring and Adjusting: After Substantial Completion, but not more than six months after Final Acceptance, and if requested by Owner, perform the following voltage monitoring:

1. During period of normal load cycles as evaluated by Owner, perform seven days of three-phase voltage recording at switchgear outgoing sections. Use voltmeters with calibration traceable to NIST standards and with chart speed of not less than **1 inch (25 mm)** per hour. Voltage unbalance greater than 1 percent between phases, or deviation of phase voltage from nominal value by more than plus or minus 5 percent during test period, is unacceptable.
2. Corrective Action: If test results are unacceptable, perform the following corrective action, as appropriate:
 - a. Adjust switchgear taps.
 - b. Prepare published request for voltage adjustment by electric utility.
3. Retests: Repeat monitoring, after corrective action has been performed, until specified results are obtained.
4. Report:
 - a. Prepare published report covering monitoring performed and corrective action taken.

B. Infrared Inspection: Perform survey during periods of maximum possible loading. Remove covers prior to inspection.

1. After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared inspection of electrical power connections of switchgear.
2. Instrument: Inspect distribution systems with imaging equipment capable of detecting minimum temperature difference of 1 deg C at 30 deg C.
3. Record of Infrared Inspection: Prepare certified report that identifies testing technician and equipment used and that lists results as follows:
 - a. Description of equipment to be tested.
 - b. Discrepancies.
 - c. Temperature difference between area of concern and reference area.

- d. Probable cause of temperature difference.
 - e. Areas inspected. Identify inaccessible and unobservable areas and equipment.
 - f. Identify load conditions at time of inspection.
 - g. Provide photographs and thermograms of deficient area.
 - 4. Act on inspection results in accordance with recommendations in NETA ATS, Table 100.18. Correct possible and probable deficiencies as soon as Owner's operations permit. Retest until deficiencies are corrected.
 - 5. **[Follow-up Infrared Scanning: Perform additional follow-up infrared scan of switches 11 months after date of Substantial Completion.]**
- C. Software and Firmware Service Agreement:
- 1. Technical Support: Beginning at Substantial Completion, verify that software and firmware service agreement includes software support for **[two]<Insert number>** years.
 - 2. Upgrade Service: At Substantial Completion, update software and firmware to latest version. Install and program software upgrades that become available within **[two]<Insert number>** years from date of Substantial Completion. Verify that upgrading software includes operating system and new or revised licenses for using software.
 - a. Upgrade Notice: No fewer than **[30]<Insert number>** days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.
 - 3. Upgrade Reports: Prepare report after each update, documenting upgrades installed.

END OF SECTION 26 12 19 00A



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Task	Specification	Specification Description
26 12 19 00	26 12 13 00	Liquid-Filled, Medium-Voltage Transformers
26 12 19 00	26 22 13 00	Low-Voltage Distribution Transformers



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SECTION 26 13 29 00 - MEDIUM-VOLTAGE COMPARTMENTALIZED SWITCHGEAR

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes dead-front, remotely controlled insulated vacuum load and fault interrupting switchgear.
- B. Related Requirements:
 - 1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
 - 2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.2 DEFINITIONS

- A. Bushing: An insulating structure including a central conductor, or providing a central passage for a conductor, with provision for mounting on a barrier, conducting or otherwise, for insulating the conductor from the barrier and conducting current from one side of the barrier to the other.
- B. Bushing Elbow: An insulated device used to connect insulated conductors to separable insulated connectors on dead-front, pad-mounted switchgear and to provide a fully insulated connection. Also called an "elbow connector."
- C. Bushing Insert: That component of a separable insulated connector that is inserted into a bushing well to complete a dead-front, load break or non-load break, separable insulated connector (bushing).
- D. Bushing Well: A component of a separable insulated connector, either permanently welded or clamped to an enclosure wall or barrier, having a cavity that receives a replaceable component (bushing insert) to complete the separable insulated connector (bushing).
- E. Fault Interrupter: A self-controlled mechanical switching device capable of making, carrying, and automatically interrupting an alternating current. It includes an assembly of control elements to detect overcurrents and control the fault interrupter. A fault interrupter always consists of a switching device, a control unit, and sensors for current and/or voltage sensing.
- F. Hotstick: An insulated stick, usually made of fiberglass, that is used to work energized overhead conductors and operate electrical equipment that is overhead, underground, and compartmentalized.
- G. NETA ATS: InterNational Electrical Testing Association, Acceptance Testing Specification.
- H. Way: A three-phase or single-phase circuit connection to the bus that may contain combinations of switches and protective devices or may be a solid bus.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, and furnished specialties and accessories.
2. Time-current characteristic curves for overcurrent protective devices.

B. Shop Drawings: For pad-mounted switchgear.

1. Include a tabulation of installed devices with features and ratings.
2. Include dimensioned plans and elevations, showing dimensions, shipping sections, and weights of each assembled section. Elevations must show major components and features, and they will mimic bus diagram.
3. Include a plan view and cross section of equipment base showing clearances, manufacturer's recommended work space, and locations of penetrations for grounding and conduits. Show location of anchor bolts[**and leveling channels**].
4. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, and location and size of each field connection.
5. Include list of materials.
6. Locate accessory and spare equipment storage.
7. Include single-line diagram.
8. Include control power wiring diagrams.
9. Include battery, charger, and transfer switch ratings.
10. Include copy of nameplate.
11. Switchgear Ratings:
 - a. Voltage.
 - b. Continuous current.
 - c. Short-circuit rating.
 - d. BIL.
12. Design Calculations: Signed and sealed by a qualified professional structural engineer. Calculate requirements for selecting seismic restraints.
13. Relay settings.
14. Interface data with monitoring or control network.
15. Wiring Diagrams: For each switchgear assembly, include the following:
 - a. Power, signal, and control wiring.
 - b. Three-line diagrams of current and future secondary circuits, showing device terminal numbers and internal diagrams.
 - c. Schematic control diagrams.
 - d. Diagrams showing connections of component devices and equipment.
 - e. Schematic diagrams showing connections to remote devices[**including SCADA remote terminal unit**].

1.4 INFORMATIONAL SUBMITTALS

A. Product Certificates: For pad-mounted switchgear.

1. Switch ratings as listed in IEEE C37.74.
2. Interrupter ratings as listed in IEEE C37.60.
3. Coating system compliance with the IEEE standard listed in "Switchgear Enclosure" Article.

B. Source quality-control reports.

C. Field quality-control reports.

1.5 WARRANTY

- A. Special Battery Warranties: Manufacturer and Installer agree to repair or replace the switchgear control system storage batteries that fail in materials or workmanship within specified warranty period.
1. Warranted Cycle Life for VRLA Batteries: Equal to or greater than that represented in manufacturer's published table, including figures corresponding to the following, based on annual average battery temperature of **77 deg F (25 deg C)**:
 - a. For discharge rate not faster than eight hours, discharge duration not longer than eight hours, and voltage at end of discharge not less than 1.67 V, warranted life must be not fewer than six discharge cycles.
 - b. For discharge rate not faster than 30 minutes, discharge duration not longer than 30 minutes, and voltage at end of discharge not less than 1.67 V, warranted life must be not fewer than 20 discharge cycles.
 - c. For discharge rate not faster than 15 minutes, discharge duration not longer than 45 seconds, and voltage at end of discharge not less than 1.67 V, warranted life must be not fewer than 120 discharge cycles.
 2. Warranted Cycle Life for Premium VRLA Batteries: Equal to or greater than that represented in manufacturer's published table, including figures corresponding to the following, based on annual average battery temperature of **77 deg F (25 deg C)**:
 - a. For discharge rate not faster than eight hours, discharge duration not longer than eight hours, and voltage at end of discharge not less than 1.67 V, warranted life must be not fewer than 40 discharge cycles.
 - b. For discharge rate not faster than 30 minutes, discharge duration not longer than 30 minutes, and voltage at end of discharge not less than 1.67 V, warranted life must be not fewer than 20 discharge cycles.
 - c. For discharge rate not faster than 15 minutes, discharge duration not longer than 1.5 minutes, and voltage at end of discharge not less than 1.67 V, warranted life must be not fewer than 750 discharge cycles.

PART 2 - PRODUCTS

2.1 MEDIUM-VOLTAGE COMPARTMENTALIZED SWITCHGEAR

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[ABB, Electrification Business]**
 2. **[Eaton]**
 3. **[S&C Electric Company]**
 4. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[ABB, Electrification Business]**
 2. **[Eaton]**
 3. **[S&C Electric Company]**
 4. **<Insert manufacturer's name>**

2.2 SYSTEM DESCRIPTION

- A. Manufactured Unit: Pad-mounted switchgear, designed for application in **[solidly grounded neutral][ungrounded][impedance-grounded]** underground distribution systems.
- B. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory, and marked for intended location and application.
- C. Comply with IEEE C2.
- D. Comply with IEEE C37.74.

2.3 RATINGS

- A. Switchgear is applied to a nominal **[4.16][13.2][13.8][23][24.94][34.5]<Insert voltage>** kV (L-L) medium-voltage electrical power system. Minimum ratings of the switchgear must be as follows:
 - 1. Rated Maximum Voltage and Rated BIL: **[15.5 kV and 95 kV BIL][27 kV and 125 kV BIL][38 kV and 150 kV BIL]<Insert voltage>**.
 - 2. Continuous and Load Interrupting Current: 600 A.
 - 3. Short-Time and Short-Circuit Interrupting Current: **[12.5 kA SYM RMS][16 kA SYM RMS][20 kA SYM RMS][25 kA SYM RMS]**.

2.4 SWITCHGEAR ENCLOSURE

- A. Weatherproof enclosure with an integral skid mounting frame, designed for mounting on a concrete pad, suitable to allow skidding or rolling of the switchgear in any direction, and with provision for anchoring the frame to the pad.
- B. Enclosure Integrity: Comply with IEEE C57.12.28 for compartmentalized enclosures that contain energized electrical equipment in excess of 600 V that may be exposed to the public.
 - 1. Each vertical section must have the following features:
 - a. Structural design and anchorage adequate to resist loads imposed by **[125 mph (200 km/h)]<Insert wind speed>** wind.
 - b. Space heater operating at one-half or less of rated voltage, sized to prevent condensation, controlled by thermostats to maintain temperature of each section above expected dew point.
 - c. Louvers equipped with insect and rodent screens and filters, and arranged to permit air circulation while excluding rodents and exterior dust.
 - d. Weatherproof ground-fault circuit interrupter duplex receptacles.
 - e. Power for heaters and receptacles must be provided **[by control power transformer][as indicated]**.
 - f. Skid Mounted: Mount each shipping group on an integral base frame as a complete weatherproof unit.
- C. Corrosion Protection:
 - 1. Enclosure coating system must be factory applied, meeting the requirements of **[IEEE C57.12.28][IEEE C57.12.29]**, in manufacturer's standard color **[green]<Insert color>**.
 - 2. Fabricate the support frame, enclosure base, and the enclosure from stainless steel, ASTM A167,

Type 304 or 304L. Enclosure coating system must be factory applied, meeting the requirements of [IEEE C57.12.28][IEEE C57.12.29], standard color [green]<Insert color>.

2.5 SWITCHGEAR CONSTRUCTION

- A. Dead-front, front and rear access switchgear.
- B. Each disconnect switch in switched ways must be in a sealed, dielectric filled [stainless]steel tank, factory-filled with [SF6 gas][mineral oil][or][less-flammable, high-firepoint fluid].
 - 1. SF6 Gas: Comply with ASTM D2472. Provide enclosure with pressure gauge and self-sealing fill valve.
 - 2. Mineral Oil: Comply with ASTM D3487, Type II, and tested for compliance with ASTM D117. Provide enclosure with level gauge to monitor the dielectric level; automatic pressure relief valve; and fill, drain, and sampling valves.
 - 3. Less-flammable, high-firepoint fluid must comply with ASTM D6871 and IEC 61099. The temperature rating of the fluid must be satisfactory for ambient air temperatures of **minus 22 and plus 104 deg F (minus 30 and plus 40 deg C)**. Provide enclosure with level gage to monitor the dielectric level; automatic pressure relief valve; and fill, drain, and sampling valves.
- C. Construct switchgear assembly with switched ways that have front-accessible terminations for cables entering from below and with manual operating provisions with a lineman's hotstick.
- D. Trapped Key Interlocks: Kirk key interlock system using a dowel pin design having no openings. Brass housing and 316 stainless steel key and lock bolts.
- E. Viewing Windows: For each switch, located adjacent to manual operating devices, and positioned to show switch contact position.
- F. Grounding: Provision to make grounding cable and wire connections at each way.

2.6 SWITCHED WAYS

- A. Source Switch Ways: Non-fused, hotstick operated, ganged vacuum load interrupter switches[, **in series with a visible-break disconnect switch**].
 - 1. Rated Continuous Current and Load Switching Current: 600 A.
 - 2. Vacuum Load Interrupter:
 - a. With 24 V(dc) motor operators to open or close the load interrupter.
 - b. Trip-free switch mechanism. Closing the switch must be independent of the speed of the operating handle.
 - 3. Visible-Break Disconnect Switch: [**Three positions, with open, closed, and ground positions**][**Two positions, with open and closed positions**]. The switch must be mechanically interlocked so that the vacuum interrupter opens and closes first.
 - a. Switch position indicator, clearly labeled.
 - b. Padlocking and tagging provisions.
- B. Fault Interrupting Switched Ways: Non-fused, hotstick-operated, ganged vacuum fault interrupter switches[, **in series with a visible-break disconnect**]. With internally mounted current transformers and electronic overcurrent sensing for [**single-phase or**]three-phase ganged tripping of the interrupter.

Comply with IEEE C37.60.

1. Rated Continuous Current and Load Switching Current: 600 A.
2. Vacuum Fault Interrupter:
 - a. Operated by a motor-charged stored energy mechanism, with provision to manually charge the mechanism. Charging motors must operate at 24 V(ac).
 - b. Auxiliary Switches: Provide two auxiliary switches, each with field-selectable NC or NO switch position, for connection of remote indication of the position of the switched way. The switches must be rated at 15 A, 120 V(ac), and 1 A, 120 V(dc).
 - c. Trip-free switch mechanism when manually operated. Closing the switch must be independent of the speed of the operating handle.
 - d. Single operating handle and a clearly labeled switch position indicator; open, closed, tripped.
 - e. Operations Counters: Mechanical type, linked to the operating handle of each switched way.
 - f. Padlocking and tagging provisions.
3. Visible-Break Disconnect Switch: **[Three positions, with open, closed, and ground positions][Two positions, with open and closed positions]**. The switch must be mechanically interlocked so that the switch cannot be operated unless the vacuum fault interrupter is open.
 - a. Switch position indicator, clearly labeled.
 - b. Padlocking and tagging provisions.

C. Controls:

1. Motor Actuators: "Open," "close," and "stop" push buttons.
2. Switch Status LEDs: "Open" and "closed" lights. Show status of disconnect switch using its auxiliary contact.
3. Motor Actuator Process LEDs: "Opening" and "closing" lights indicating that the selected motor is operating the switch.
4. Power Switch: "On" and "off" toggle switch and circuit protector, to disconnect the dc supply to its motor and provide overload and short-circuit protection.
5. 120 V(ac) LED to display battery system power level.
6. Battery voltage meter to show battery condition.
7. Local and Remote Selector: In the "local" position remote operation of the switches is disabled and is possible only under the control of switchgear-mounted push buttons.

D. Overcurrent[**and Control**] Relays: Field-adjustable microprocessor electronic relays in each phase at indicated locations. Provide for current adjustment from 0 to 600 A.

1. Device Functions: **[51/50, 51N/50N, or 51G/50G in accordance with IEEE C37.2]<Insert values>**.

2.7 POWER SUPPLY

- A. The power supply for instrumentation, communications, and switch operations must be for connection to two 120 V(ac) power sources, controlled by an automatic transfer switch to connect to the alternate supply when the primary supply has failed.
- B. The power supply for instrumentation, communications, and switch operations must be from a potential transformer installed as part of the switchgear.

- C. Control Power Supply: Dedicated **[48 V(dc)][120 V(dc)][240 V(dc)]** battery system.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[C&D Technologies, Inc.]**
 - b. **[EnerSys]**
 - c. **[Trojan Battery Company]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[C&D Technologies, Inc.]**
 - b. **[EnerSys]**
 - c. **[Trojan Battery Company]**
 - d. **<Insert manufacturer's name>**
 3. System Requirements: Battery must have number of cells and ampere-hour capacity based on an initial specific gravity of 1.210 at **77 deg F (25 deg C)** with electrolyte at normal level and minimum ambient temperature of **55 deg F (13 deg C)**. Cycle battery before shipment to guarantee rated capacity on installation. Arrange to operate ungrounded. Battery system capacity must be as recommended by switchgear manufacturer to operate the circuit breakers for intended duty.
 4. Battery:
 - a. **[Standard VRLA][Premium VRLA]<Insert type>** batteries, with system disconnect and overcurrent protective device.
 - b. Rack: **[Two]<Insert number>**-step rack with electrical connections between battery cells and between rows of cells; include two flexible connectors with bolted-type terminals for output leads. **[Rate battery rack, cell supports, and anchorage for seismic requirements.]**
 - c. Accessories:
 - 1) Set of cell numerals.
 - 2) Monitoring system.
 - d. Charger: Static-type silicon rectifier equipped with automatic regulation and provision for manual and automatic adjustment of charging rate. Unit must automatically maintain output voltage within 0.5 percent from no load to rated charger output current, with ac input-voltage variation of plus or minus 10 percent and input-frequency variation of plus or minus 3 Hz.
 - 1) DC ammeter.
 - 2) DC Voltmeter: Maximum error of 5 percent at full-charge voltage, with toggle switch to select between battery and charger voltages.
 - 3) Ground Indication: Two appropriately labeled lights to indicate circuit ground, connected in series between negative and positive terminals, with midpoint junction connected to ground by NO push-button contact.
 - 4) Capacity: Sufficient to supply steady load, float-charge battery between 2.20 and 2.25 V per cell and equalizing charge at 2.33 V per cell.
 - 5) Charging-Rate Switch: Manually operated switch to transfer to higher charging rate. Charger operation must be automatic until manually reset.

- 6) AC Power Supply: 120 V, 60 Hz, subject to plus or minus 10 percent variation in voltage and plus or minus 3 Hz variation in frequency. Automatic charger operation must resume after loss of ac power supply for any interval.
 - 7) Charging Regulator: Protect charger from damage due to overload, including short circuit on output terminals. The device must regulate charging current but must not disconnect charger from either battery or ac supply.
 - 8) Charger's Audible Noise: Less than 26 dB.
5. Battery Ground-Fault Detector: Initiates alarm when resistance to ground of positive or negative bus of battery is less than 5000 ohms.
 6. Control Wiring: Factory installed, complete with bundling, lacing, and protection.
 - a. Conductors across Hinges and for Interconnections between Shipping Units: Flexible conductors for No. 8 AWG and smaller.
 - b. Conductors: Sized in accordance with NFPA 70 for duty required.
 7. An automatic transfer switch to connect the alternate power supply when the primary power supply has failed.

2.8 AUTOMATIC SOURCE TRANSFER CONTROLS

- A. An automatic switch control system must execute manual, automatic source-transfer, and SCADA operation of the source and fault interrupting switch ways. The source-transfer controls must open an incoming switch way where voltage is lost and close the other incoming switch way if voltage is present. The controls must include an overcurrent lockout that prevents the closing of a switch way into a system fault.
- B. The automatic switch control system must execute remote commands received from a SCADA master station and transmit switchgear operation information to a SCADA master station using DNP3 communications protocol. Execution of remote commands must include enabling of the source-transfer controls and transfer of switch ways to "close," "open," and "ground" positions. Transmission of switchgear information must include switch way positions and DC supply system status. Additional switchgear information that must be transmitted follows:
 1. Voltage.
 2. Current in load ways.
 3. <Insert text>.
- C. The control must have communication port provisions for connection to a multi-mode serial fiber link.

2.9 CONTROL NETWORK

- A. Compliance with ASHRAE 135: Controllers must support serial MS/TP and Ethernet IP communications and must be able to communicate directly via TIA-485 serial networks and Ethernet 10Base-T networks as a native device.
- B. Support DNP3 protocol remote control commands received from the SCADA master stations that control switch operations. Comply with the requirements of IEEE 1815.

2.10 BUSHINGS

- A. Separable insulated connectors must be used to connect primary cable. Comply with requirements in Section 260513 "Medium-Voltage Cables."
 - 1. Bushings: One-piece, 600 A, BIL ratings the same as the connectors. Comply with IEEE 386.
 - 2. Supply a standoff bracket or parking stand for each bushing, mounted horizontally adjacent to each bushing.

2.11 SURGE ARRESTERS

- A. Distribution class; metal-oxide-varistor type, fully shielded, separable elbow type, suitable for plugging into the inserts. Comply with IEEE C62.11 and IEEE 386.
 - 1. Nominal System Line-to-Line Voltage: <Insert number> kV RMS.
 - 2. Maximum Continuous Operating Voltage: <Insert number> kV RMS.
 - 3. Duty-Cycle Voltage: <Insert number> kV RMS.

2.12 WARNING LABELS AND SIGNS

- A. Comply with requirements in Section 260553 "Identification for Electrical Systems" for labels and signs.
 - 1. High-Voltage Warning Label: Self-adhesive labels on the outside of the high-voltage compartment door(s). Legend must be "DANGER HIGH VOLTAGE" printed in two lines of minimum 2 inch (50 mm) high letters. The word "DANGER" must be in white letters on a red background and the words "HIGH VOLTAGE" must be in black letters on a white background.
 - 2. Arc-Flash Warning Label: Self-adhesive labels on the outside of the high-voltage compartment door(s), warning of potential electrical arc-flash hazards and appropriate personal protective equipment required.

2.13 SOURCE QUALITY CONTROL

- A. Factory Tests: Comply with requirements in IEEE C37.60 and IEEE C37.74 for testing procedures.
 - 1. Circuit Resistance Test: Verify that switchgear contacts have been properly aligned and current transfer points have been properly assembled.
 - 2. Power-frequency dry withstand voltage test.
 - 3. Dielectric withstand test; one-minute dry power-frequency.
 - 4. Calibrate overcurrent devices for conformance to published time-current characteristic curves.
 - 5. Sealed Tank Leak Test:
 - a. Comply with IEC 62271-1 for test procedure for switchgear using SF6.
 - b. The test procedure for vacuum switchgear must be as follows:
 - 1) Each vacuum tube must be identified by its serial number. Its vacuum pressure level must be tested by the manufacturer of the vacuum interrupter. Document the test results.
 - 2) After assembly of the switchgear way, test the vacuum pressure level of the vacuum tubes by the routine dielectric test across the open contacts. The test voltage must be stated by the manufacturer. The dielectric test must be carried out after the mechanical routine test.

6. Operating tests must verify the following:
 - a. Switch position indicators and contacts are in the correct position for both the open and closed positions.
 - b. Insulating medium quantity indicator (if provided) is functioning properly.
 - c. Circuit configuration is shown correctly.
 - d. Mechanical interlocks are in place and operative.
 - e. Position and polarity of current transformers meets requirements.
 - f. Control, secondary wiring, and accessory devices are connected correctly.
 - g. Devices and relays actually operate as intended. Circuits for which operation is not feasible must be checked for continuity.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Upon delivery of switchgear and prior to unloading, inspect equipment for damage.
 1. Examine tie rods and chains to verify they are undamaged and tight and that blocking and bracing are tight.
 2. Verify that there is no evidence of load shifting in transit and that readings from transportation shock recorders, if equipped, are within manufacturer's recommendations.
 3. Examine switchgear for external damage, including dents or scratches in doors and sill, and termination provisions.
 4. Compare switchgear and accessories received with the bill of materials to verify that the shipment is complete. Verify that switchgear and accessories conform to the manufacturer's quotation and Shop Drawings. If the shipment is not complete or does not comply with project requirements, notify the manufacturer in writing immediately.
 5. Unload switchgear, observing packing label warnings and handling instructions.
 6. Open compartment doors and inspect components for damage or displaced parts, loose or broken connections, cracked or chipped insulators, bent mounting flanges, dirt or foreign material, and water or moisture.
- B. Handling:
 1. Handle switchgear, in accordance with manufacturer's recommendations; avoid damage to the enclosure, termination compartments, base, frame, and internal components. Do not subject switchgear to impact, jolting, jarring, or rough handling.
 2. Transport switchgear upright to avoid internal stresses on equipment mounting assemblies. Do not tilt or tip switchgear.
 3. Use spreaders or a lifting beam to obtain a vertical lift and to protect switchgear from straps bearing against the enclosure. Lifting cable pull angles may not be greater than 15 degrees from vertical.
 4. Do not damage structure when handling switchgear.
- C. Storage:
 1. Switchgear may be stored outdoors. If possible, store switchgear at final installation locations on concrete pads. If dry concrete surfaces are not available, use pallets of adequate strength to protect switchgear from direct contact with the ground. Ensure switchgear is level.
 2. Protect switchgear from physical damage. Do not store switchgear in the presence of corrosive or explosive gases.
 3. Store switchgear with compartment doors closed.

- D. Examine roughing-in of conduits and grounding systems to verify the following:
 - 1. Wiring entries comply with layout requirements.
 - 2. Entries are within conduit-entry tolerances specified by manufacturer and no feeders have to cross section barriers to reach load or line lugs.
- E. Pre-Installation Checks:
 - 1. Verify removal of shipping bracing after placement.
- F. Verify that ground connections are in place and that requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance must be **[5 ohms]<Insert value>** at switchgear location.
- G. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 SWITCHGEAR INSTALLATION

- A. Equipment Mounting:
 - 1. Install switchgear on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 2. Comply with requirements for vibration isolation and seismic control devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- B. Install level and plumb, tilting less than 1.5 degrees when energized.
- C. Maintain minimum clearances and workspace at equipment in accordance with manufacturer's instructions and NFPA 70.
- D. Maintain minimum clearances and workspace at equipment in accordance with manufacturer's instructions and IEEE C2.

3.3 CONNECTIONS

- A. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
 - 1. For counterpoise, use tinned bare copper cable not smaller than No. 4/0 AWG, buried not less than **30 inch (765 mm)** below grade interconnecting the grounding electrodes. Bond surge arrester and neutrals directly to the switchgear enclosure and then to the grounding electrode system with bare copper conductors, sized as shown. Keep lead lengths as short as practicable with no kinks or sharp bends.
 - 2. Fence and equipment connections must not be smaller than No. 4 AWG. Ground fence at each gate post and corner post and at intervals not exceeding **10 ft. (3 m)**. Bond each gate section to the fence post using **1/8 by 1 inch (3 by 25 mm) [tinned]** flexible braided copper strap and clamps.
 - 3. Make joints in grounding conductors and loops by exothermic weld or compression connector.
 - 4. Terminate grounding and bonding conductors on a common equipment grounding terminal on the switchgear enclosure.
 - 5. Complete the switchgear grounding and surge protector connections prior to making other electrical connections.
- B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and

Cables."

1. Maintain air clearances between energized live parts and between live parts and ground for exposed connections in accordance with manufacturer recommendations.
2. Bundle associated phase, neutral, and equipment grounding conductors together within the switchgear enclosure. Arrange conductors such that there is not excessive strain on the connections that could cause loose connections. Allow adequate slack for expansion and contraction of conductors.

- C. Terminate medium-voltage cables in incoming section of switchgear in accordance with Section 260513 "Medium-Voltage Cables."

3.4 SIGNS AND LABELS

- A. Comply with the installation requirements for labels and signs specified in Section 260553 "Identification for Electrical Systems."
- B. Install warning signs as required to comply with OSHA 29 CFR 1910.269.

3.5 FIELD QUALITY CONTROL

- A. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.
- B. General Field Testing Requirements:
 1. Comply with the provisions of NFPA 70B, "Testing and Test Methods" chapter.
 2. Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.
 3. After installing switchgear but before primary is energized, verify that grounding system at the switchgear is tested at the specified value or less.
 4. After installing switchgear and after electrical circuitry has been energized, test for compliance with requirements.
- C. Medium-Voltage Switchgear Field Tests:
 1. Visual and Mechanical Inspection:
 - a. Verify that current and voltage transformer ratios correspond to Drawings.
 - b. Inspect bolted electrical connections using calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - c. Confirm correct operation and sequencing of electrical and mechanical interlock systems.
 - 1) Attempt closure on locked-open devices. Attempt to open locked-closed devices.
 - 2) Make key exchange with devices operated in off-normal positions.
 - d. Inspect control power transformers.
 - 1) Inspect for physical damage, cracked insulation, broken leads, tightness of

- connections, defective wiring, and overall general condition.
- 2) Verify that primary and secondary fuse or circuit breaker ratings match Drawings.

2. Electrical Tests:

- a. Inspect bolted electrical connections using a low-resistance ohmmeter to compare bolted resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
- b. Perform dc voltage insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground, for one minute. If the temperature of the bus is other than plus or minus 20 deg C, adjust the resulting resistance as provided in NETA ATS, Table 100.11.
 - 1) Insulation-resistance values of bus insulation must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.1.
 - 2) Do not proceed to the dielectric withstand voltage tests until insulation-resistance levels are raised above minimum values.
- c. Perform a dielectric withstand voltage test on each bus section, each phase-to-ground with phases not under test grounded, in accordance with manufacturer's published data. If manufacturer has no recommendation for this test, it must be conducted in accordance with NETA ATS, Table 100.2. Apply the test voltage for one minute.
 - 1) If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.
- d. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential must be 500 V(dc) for 300 V rated cable and 1000 V(dc) for 600 V rated cable. Test duration must be one minute. For units with solid-state components or control devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.
 - 1) Minimum insulation-resistance values of control wiring must not be less than 2 megohms.
- e. Voltage Transformers:
 - 1) Perform secondary wiring integrity test. Verify correct potential at devices.
 - 2) Verify secondary voltages by energizing the primary winding with system voltage.
- f. Perform current-injection tests on the entire current circuit in each section of switchgear.
 - 1) Perform current tests by secondary injection with magnitudes such that a minimum current of 1.0 A flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.
 - 2) Perform current tests by primary injection with magnitudes such that a minimum of 1.0 A flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.
- g. Perform system function tests in accordance with "System Function Tests" Article.
- h. Verify operation of space heaters.
- i. Perform phasing checks on double-ended or dual-source switchgear to ensure correct bus phasing from each source.

D. Medium-Voltage Vacuum Interrupter Field Tests:

1. Visual and Mechanical Inspection:
 - a. Inspect physical and mechanical condition.
 - b. Inspect anchorage, alignment, grounding, and required clearances.
 - c. Verify that maintenance devices such as special tools and gages specified by the manufacturer are available for servicing and operating the breaker.
 - d. Verify the unit is clean.
 - e. Perform mechanical operation tests on operating mechanism in accordance with manufacturer's published data.
 - f. Measure critical distances on operating mechanism as recommended by the manufacturer. Critical distances of the operating mechanism must be in accordance with manufacturer's published data.
 - g. Verify cell fit and element alignment.
 - h. Verify racking mechanism operation.
 - i. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
 - j. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
 - k. Perform time-travel analysis. Travel and velocity values must be in accordance with manufacturer's published data.
 - l. Record as-found and as-left operation counter reading. Operation counter must advance one digit per close-open cycle.
2. Electrical Tests:
 - a. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Insulation-resistance values must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than this table or manufacturer's recommendations. Dielectric-withstand-voltage tests must not proceed until insulation-resistance levels are raised above minimum values.
 - b. Perform a contact/pole-resistance test. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value. Microhm or dc millivolt drop values must not exceed the high levels of the normal range in accordance with manufacturer's published data. If manufacturer's published data is not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
 - c. Perform minimum pickup voltage tests on trip and close coils in accordance with manufacturer's published data. Minimum pickup voltage of the trip and close coils must comply with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.20.
 - d. Verify correct operation of auxiliary features, such as electrical close and trip operation, trip-free operation, and anti-pump function. Auxiliary features must operate in accordance with manufacturer's published data.
 - e. Trip circuit breaker by operation of each protective device. Reset trip logs and indicators.
 - f. Perform power-factor or dissipation-factor tests on each pole with the breaker open and each phase with the breaker closed. Power-factor or dissipation-factor values must comply with manufacturer's published data.
 - g. Perform vacuum bottle integrity (dielectric-withstand-voltage) test across each vacuum bottle, with the contacts in the "open" position in accordance with manufacturer's published data. If no evidence of distress or insulation failure is observed by the end of the total time

of voltage application during the vacuum bottle integrity test, the specimen is considered to have passed the test.

- h. Perform a dielectric-withstand-voltage test in accordance with manufacturer's published data. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric-withstand-voltage test, the specimen is considered to have passed the test.

E. Microprocessor-Based Protective Relay Field Tests:

1. Visual and Mechanical Inspection:

- a. Record model number, style number, serial number, firmware revision, software revision, and rated control voltage.
- b. Verify operation of light-emitting diodes, display, and targets.
- c. Record passwords for each access level.
- d. Clean the front panel and remove foreign material from the case.
- e. Check tightness of connections.
- f. Verify that the frame is grounded in accordance with manufacturer's instructions.
- g. Set the relay in accordance with results in Section 260573.16 "Coordination Studies" and in Section 260573.19 "Arc-Flash Hazard Analysis."
- h. Download settings from the relay. Print a copy of the settings for the report and compare the settings to those specified in the coordination study.

2. Electrical Tests:

- a. Perform insulation-resistance tests from each circuit to the grounded frame in accordance with manufacturer's published data.
- b. Apply voltage or current to analog inputs, and verify correct registration of the relay meter functions.
- c. Functional Operation: Check functional operation of each element used in the protection scheme.
- d. Control Verification:

1) Functional Tests:

- a) Check operation of active digital inputs.
- b) Check output contacts or silicone-controlled rectifiers, preferably by operating the controlled device, such as circuit breaker, auxiliary relay, or alarm.
- c) Check internal logic functions used in protection scheme.
- d) Upon completion of testing, reset min/max recorders, communications statistics, fault counters, sequence-of-events recorder, and event records.

- 2) In-Service Monitoring: After the equipment is initially energized, measure magnitude and phase angle of inputs and verify expected values.

F. Ground Resistance Test:

1. Visual and Mechanical Inspection:

- a. Verify ground system complies with the Contract Documents and NFPA 70 "Grounding and Bonding" Article.
- b. Inspect physical and mechanical condition. Grounding system electrical and mechanical connections must be free of corrosion.
- c. Inspect bolted electrical connections using a calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels must be in accordance with manufacturer's published data. In the absence of

manufacturer's published data, use NETA ATS, Table 100.12. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

- d. Inspect anchorage.

2. Electrical Tests:

- a. Perform fall-of-potential or alternative test in accordance with IEEE 81 on the main grounding electrode or system. The resistance between the main grounding electrode and ground must be no more than **[5 ohms][maximum ground resistance value specified in the "Examination" Article]**.
- b. Perform point-to-point tests to determine the resistance between the main grounding system and major electrical equipment frames, system neutral, and derived neutral points. Investigate point-to-point resistance values that exceed 0.5 ohms. Compare equipment nameplate data with Contract Documents.
- c. Inspect bolted electrical connections for high resistance using a low-resistance ohmmeter to compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
- d. Inspect physical and mechanical condition.
- e. Inspect anchorage.

G. Nonconforming Work:

- 1. Switchgear will be considered defective if it does not pass tests and inspections.
- 2. Remove and replace defective units and retest.

H. Prepare test and inspection reports.

3.6 SYSTEM FUNCTION TESTS

- A. System function tests must prove the correct interaction of sensing, processing, and action devices. Perform system function tests after "Field Quality Control" tests have been completed and components have passed specified tests.
 - 1. Develop test parameters and perform tests for evaluating performance of integral components and their functioning as a complete unit within design requirements and manufacturer's published data.
 - 2. Verify the correct operation of interlock safety devices for fail-safe functions in addition to design function.
 - 3. Verify the correct operation of sensing devices, alarms, and indicating devices.

3.7 MAINTENANCE

- A. Infrared Inspection: Perform the survey during periods of maximum possible loading. Remove necessary covers prior to the inspection.
 - 1. After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared inspection of the electrical power connections of the switchgear.
 - 2. Instrument: Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1 deg C at **86 deg F (30 deg C)**.
 - 3. Record of Infrared Inspection: Prepare a certified report that identifies the testing technician and equipment used, and lists the results as follows:

- a. Description of equipment to be tested.
 - b. Discrepancies.
 - c. Temperature difference between the area of concern and the reference area.
 - d. Probable cause of temperature difference.
 - e. Areas inspected. Identify inaccessible and unobservable areas and equipment.
 - f. Identify load conditions at time of inspection.
 - g. Provide photographs and thermograms of the deficient area.
4. Act on inspection results in accordance with the recommendations of NETA ATS, Table 100.18. Correct possible and probable deficiencies as soon as Owner's operations permit. Retest until deficiencies are corrected.

END OF SECTION 26 13 29 00



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Task	Specification	Specification Description
26 13 29 00	26 11 16 11	Secondary Unit Substations with Switchgear Secondary
26 18 36 00	26 11 16 11	Secondary Unit Substations with Switchgear Secondary
26 19 18 00	26 05 00 00	Sleeves and Sleeve Seals for Electrical Raceways and Cabling
26 19 80 60	26 05 00 00	Sleeves and Sleeve Seals for Electrical Raceways and Cabling
26 21 13 00	26 05 13 00	Medium-Voltage Cables
26 21 13 00	26 05 19 00	Low-Voltage Electrical Power Conductors and Cables



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SECTION 26 21 16 00 - PARALLELING LOW-VOLTAGE SWITCHGEAR

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Multiple-generator paralleling monitoring and control system.
2. Single-generator paralleling monitoring and control system.
3. Metal-enclosed, circuit-breaker switchgear (600 V and less).

B. Products Furnished, but Not Installed, under This Section:

1. **<Insert products furnished, but not installed>.**

C. Products Installed, but Not Furnished, under This Section:

1. **<Insert products installed, but not furnished>.**

D. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
3. **[Section 013100 "Project Management and Coordination"]<Insert Section number and title>** for preinstallation conference procedures.
4. Section 260913 "Electrical Power Monitoring" for interfacing communication and metering requirements.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at **[Project site]<Insert location>**.

B. Preinstallation Coordination Meeting(s): For {Insert system or product}. Conduct meeting(s) **[as videoconference][or][at Project site]<Insert location>** before **<Insert construction activity>**.

1. Attendees: Installers, fabricators, representatives of manufacturers, and administrators for field tests and inspections. Notify Architect[, **Construction Manager**][, and **Owner's Commissioning Authority**] of scheduled meeting dates.

1.3 ACTION SUBMITTALS

A. Product Data:

1. For each type of paralleling low-voltage switchgear.
 - a. Include technical data on features, performance, electrical characteristics, ratings, and

finishes for programmable logic controllers, instrumentation, control devices, monitoring devices, **[SCADA interface devices,][Ethernet interface,]** and display components.

- b. Include rated capacities, operating characteristics, furnished specialties, factory settings, and accessories for individual circuit breakers.
- c. Include time-current characteristic curves for overcurrent protective devices.

B. Shop Drawings:

1. For each type of paralleling low-voltage switchgear.

- a. Include dimensioned plans, elevations, sections, details, shipping sections, weights of assembled sections, and required clearances and service space around equipment.
- b. Include tabulation of installed devices with features and ratings.
- c. Include enclosure types and details.
- d. Detail locations for anchor bolts **[and leveling channels]**.
- e. Show bus configuration with current rating, size, and number of conductors in bus run, including phase, neutral, and ground conductors of main and branch buses.
- f. Indicate short-time and short-circuit current rating of switchgear assembly.
- g. Include features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
- h. Detail nameplate legends.
- i. Include mimic-bus diagram.
- j. Include three-line power wiring diagrams for paralleling low-voltage switchgear, generators, and related equipment showing device terminal numbers.
- k. Include point-to-point schematic control, monitoring, and alarm wiring diagrams showing internal component terminal numbers.
- l. Include point-to-point schematic control, monitoring, and alarm wiring diagrams for external components indicating terminal numbers for the following:
 - 1) Engine generators.
 - 2) Transfer switches.
 - 3) Other load-control devices.
 - 4) Elevator controller in elevator bank.
 - 5) DDC system for HVAC controller.
 - 6) SCADA remote terminal unit.

2. Sequence of Operation: Description of sequence of operation for paralleling controls in automatic, manual, system test, and peak-shaving modes.

- a. Include the following in description of automatic-mode sequence of operation:
 - 1) Programmed sequence of initial generator starting and connection of generators to isolated paralleling bus, including description of how proposed design complies with requirements for redundancy.
 - 2) Programmed sequence of transferring loads to isolated paralleling bus based on operator-adjustable preset priorities and preset loads. Include initial load settings.
 - 3) Programmed sequence of starting and stopping generators based on actual real-time measured loads.
 - 4) Programmed sequence of sending load-shed signal to transfer switches **[, and to other devices]** when generator frequency does not return to normal frequency within adjustable time period.
 - 5) Programmed sequence of stopping generators based on no transfer switch or other device sending start signal.
- b. Include the following in description of system testing mode sequence of operation:

- 1) Load.
- 2) No load.

- c. Include in description, peak-shaving-mode sequence of operation.
- d. Include in description, manual-mode sequence of operation showing that manual mode fulfills requirement to permit operator at paralleling low-voltage switchgear to accomplish automatic, system test, and peak-shaving functions.
- e. Paralleling Low-Voltage Switchgear Redundancy: Identify single points of failure.

C. Samples:

1. Representative portion of mimic bus with specified finish. Manufacturer's color charts showing colors available for mimic bus.

D. Delegated Design Submittal: For seismic restraints for switchgear and wind-loading for outdoor enclosures, include analysis data signed and sealed by qualified structural professional engineer responsible for their preparation.

E. Field Quality-Control Submittals:

1. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

- A. Source quality-control reports.
- B. Sample Warranty: For manufacturer's special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Record Documentation: Include updated mimic bus diagram reflecting field changes after final switchgear load connections have been made, for record.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Spare Parts: Furnish to Owner the following spare parts for repairing paralleling switchgear that are packaged with protective covering for storage on-site and identified with labels describing contents:
 1. Control Power Fuses: **[Six]<Insert number>** of each type and rating used. Include spares for the following:
 - a. Potential transformers.
 - b. Control power circuits.
 2. Indicating Lights: **[Six]<Insert number>** of each type installed.
 3. Draw-out Circuit Breakers: One of each type and rating used for circuit breaker in paralleling low-voltage switchgear.
- B. Special Tools: Furnish to Owner proprietary equipment, keys, and software required to operate, maintain, repair, adjust, or implement future changes to switchgear, packaged with protective covering for storage on-site and identified with labels describing contents. Include the following:

1. Racking handle to move circuit breaker manually between connected and disconnected positions.
2. Tools for circuit-breaker and switchgear tests, inspections, maintenance, and operation.
3. Portable test set for testing functions of circuit-breaker, solid-state trip devices without removal from switchgear.
4. Relay and meter test plugs suitable for testing switchgear meters and switchgear class relays.
5. Portable, floor-supported, roller-base, elevating carriage arranged for moving circuit breakers in and out of compartments.
6. Overhead-circuit-breaker lifting device, track mounted at top front of switchgear and complete with hoist and lifting yokes matching each size of draw-out circuit breaker installed.
7. Spare-Fuse Cabinet: Identified and compartmented steel box or cabinet with lockable door.
8. Storage for Manual: Rack or holder, near operating instructions, for copy of maintenance manual.

C. Consumable Items:

1. After completion of field quality control, startup, commissioning, adjusting, and closeout activities, replace air filters and refill fluid reservoirs.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver paralleling low-voltage switchgear in sections of lengths that can be moved past obstructions in delivery path.
- B. Store paralleling low-voltage switchgear indoors in clean dry space with uniform temperature to prevent condensation.

1.8 WARRANTY

- A. Special Installer Extended Warranty: Installer warrants that fabricated and installed paralleling switchgear perform in accordance with specified requirements and agrees to repair or replace components that fail to perform as specified within extended-warranty period.
 1. Extended-Warranty Period: **[Two][Three][Four]<Insert number>** years from date of Substantial Completion; full coverage for labor, materials, and equipment.
- B. Special Manufacturer Extended Warranty: Manufacturer warrants that components of paralleling switchgear perform in accordance with specified requirements and agrees to provide repair or replacement of components that fail to perform as specified within extended-warranty period.
 1. **[Initial]**Extended-Warranty Period: **[Three][Four][Five]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for labor, materials, and equipment.
 2. Follow-On Extended-Warranty Period: **[Eight]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for materials **[that failed because of transient voltage surges]** only, free on board **[origin][destination]**, freight prepaid.

PART 2 - PRODUCTS

2.1 OWNER-FURNISHED PRODUCTS

- A. Basis for Pricing: **<Insert name of manufacturer; model number or series for product that Owner intends to furnish to Contractor>**.

- B. Description: **<Insert description of product, including special features, options, and finishes for Owner-furnished product that may impact Contractor's installation>.**
- C. Accessories: **<Insert accessories that will be provided with product>.**

2.2 EXISTING PRODUCTS[**TO BE MODIFIED**][**TO BE REMOVED AND RE-INSTALLED**]

- A. Basis for Pricing: **<Insert name of manufacturer; model number or series for existing product>.**
- B. Description: **<Insert description of existing product, including special features, options, and finishes that may impact Work>.**
- C. Accessories: **<Insert accessories included with existing product>.**

2.3 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- B. Multiple-generator paralleling monitoring and control panel in paralleling low-voltage switchgear must monitor and control the following standby power system components:
 - 1. Paralleling low-voltage switchgear.
 - 2. Single-generator monitoring and control system.
 - 3. Single-generator paralleling monitoring and control systems that are **[part of paralleling low-voltage switchgear][located at individual engine generator]**.
 - 4. Engine generators.
 - 5. Transfer switches.
 - 6. Circuit breakers downstream of transfer switches.
 - 7. Other load-control devices.
 - 8. Distribution circuit breakers in paralleling low-voltage switchgear.
- C. Redundant Standby Power System:
 - 1. Single generator with associated single-generator paralleling monitoring and control system.
 - 2. Black-start controller with no single point of failure.
 - 3. Black-start controller with backup control in multiple-generator paralleling monitoring and control system.
 - 4. Multiple-generator paralleling monitoring and control system must automatically be performed by backup system without degradation in the event that primary system fails to function (such as component failure or off-line maintenance).
 - 5. Multiple-generator paralleling monitoring and control system must automatically be performed by backup system without degradation in the event that primary system fails to function (such as component failure or off-line maintenance), except for the following manually operated functions:
 - a. Load management.
 - b. Peak shaving.
 - c. **<Insert exceptions>.**
- D. Sequence of Operation for Normal Conditions:
 - 1. Paralleling low-voltage switchgear, including controlled generators[, **controlled circuit breakers,**][, **other controlled devices,**] and transfer switches, must be in automatic position and

- ready to operate on loss of power or other designated initiation conditions.
2. Single-generator monitoring and control system has not received "start" signal from the following:
 - a. Transfer switch.
 - b. Multiple-generator paralleling monitoring and control system.
 - c. **<Insert device>**.

E. Sequence of Operation for Loss of Normal Power Conditions:

1. Single-generator monitoring and control system must receive start signal from redundant system.
 - a. Start signal may come from transfer switch[**or other device**] directly wired to start engine generator.
 - b. Start signal may come from multiple-generator paralleling monitoring and control system that monitors loss of normal source availability from one or more transfer switches[**or other device**].
2. On receiving start signal, single-generator monitoring and control system must start engine generators and achieve rated voltage and frequency.
3. If engine generator fails to start, after expiration of overcrank time delay, engine generator shuts down and alarm is initiated.
4. Transfer Inhibit Control: Multiple-generator paralleling monitoring and control system receives loss of normal source availability signal from transfer switch(es)[**or other device**] and sends transfer inhibit signals.
 - a. Transfer switch(es) serving emergency loads may not be sent transfer-inhibit signal.
 - b. Transfer switch(es) serving other than emergency loads that must transfer within required time must have transfer-inhibit signal end at such time as will permit transfer switch to operate within required time.
 - c. Transfer switch(es) serving other than emergency loads that are not required to transfer within required time must be sent transfer-inhibit signal.
 - d. Transfer switch(es) serving loads that are to be disconnected after detecting loss of normal source availability must signal associated circuit breakers and other load devices to de-energize these predetermined loads.
 - e. Transfer switch(es) serving HVAC loads that need to operate at lower load by modifying HVAC sequence of operation after detecting loss of normal source availability must signal DDC system for HVAC to change to HVAC load-shed sequence of operation for associated equipment.
 - f. Transfer switch(es) serving elevator loads after detecting loss of normal source availability must signal associated elevator controllers that elevators are connected to generator power and must initiate sequence of operation in elevator control system to protect elevators and to reduce elevator load demand.
 - g. Distribution circuit breakers in paralleling low-voltage switchgear, which are indicated in priority-load schedule to transfer load by opening and closing circuit breaker, receive inhibit closing signal.
5. Black-Start Control: Prevent out-of-phase paralleling. After selecting first generator to achieve 90 percent rated voltage and frequency, inhibit connection of generator-controlled circuit breakers to isolated paralleling bus, then close circuit breaker connecting first generator to isolated paralleling bus.
 - a. Comply with requirements in applicable engine generator Section for selection of first engine generator to connect to isolated paralleling bus.
 - b. Redundant System: Multiple-generator paralleling monitoring and control system selects first engine generator to connect to isolated paralleling bus.

6. Single-generator paralleling monitoring and control system synchronizes its associated engine generator and allows closure of respective generator paralleling low-voltage circuit breakers to isolated paralleling bus. On closure to isolated paralleling bus, engine generator assumes its proportional share of total load.
7. Failure of Engine Generator to Synchronize: If engine generator fails to synchronize, sound alarm after preset time delay, but continue to attempt to synchronize engine generator until signaled to stop by manual operation.

F. Priority Controller Sequence of Operation:

1. Programming from Human-Machine Interface for Priority Controller:
 - a. Set priority blocks of load that indicate priority number and scheduled size of load from Priority-Load Schedule. Set generator blocks of capacity that indicate individual engine generators and their capacity.
 - b. Signal to transfer loads to engine generator source may be accomplished by one of the following:
 - 1) Signaling to transfer-inhibit enable transfer switch associated with priority load to transfer load.
 - 2) Signaling load-add relay at transfer switch to transfer priority load.
 - 3) Closing distribution-feeder circuit breaker associated with priority load.
 - 4) Enabling another device.
2. When generator has transferred Priority 1 emergency load, send signal to transfer loads that must be transferred within specific time in accordance with Priority-Load Schedule.
3. When generator capacity is adequate to support next priority load, send signal to transfer next priority load to generator source until priority loads have been transferred.

G. Overload Sequence of Operation:

1. Signal to shed loads from generator source may be accomplished by one of the following:
 - a. Signaling load-shed relay in transfer switch associated with priority load.
 - b. Opening distribution-feeder circuit breaker associated with priority load.
 - c. Disabling another device.
2. Overload sequence of operation sends signal to shed lowest connected load priority when isolated paralleling bus frequency does not return to normal frequency within its adjustable time period.
3. If isolated paralleling bus does not return to normal frequency after shedding lowest connected priority load within adjustable time period, additional load continues to be shed by signaling to load shed in reverse priority until isolated paralleling bus returns to normal frequency.
4. Loads shed can be reconnected to isolated paralleling bus only by manual reset at human-machine interface.

H. Load-Demand Sequence of Operation:

1. With load-demand sequence of operation activated, controller continuously monitors total isolated paralleling bus load.
2. If isolated paralleling bus load is below preset limits and after preset time delay, demand controller shuts down engine generators in predetermined order until minimum number of sets are operating. Set preset limits, predetermined order, and preset time delay, as well as choose manual operation, from human-machine interface.
3. On sensing available isolated paralleling bus capacity diminished to set point, controller starts and closes engine generators to isolated paralleling bus to accommodate load.

- I. Individual Transfer Switch Return to Normal Condition Sequence of Operation: Enable individual transfer switches to return to normal power when normal power is available at transfer switch.
- J. Feeder Circuit Breakers in Paralleling Low-Voltage Switchgear Return to Normal Condition Sequence of Operation: When normal power is available at transfer switches served by feeder circuit breaker, open circuit breaker.
- K. Individual Circuit Breaker or Other Load Device for Loads Controlled Downstream from Transfer Switch Sequence of Operation: Return circuit breaker or other load device to closed position when transfer switch serving circuit breaker has returned to normal power.
- L. Return to Normal Condition Sequence of Operation:
 - 1. Process starts on removal of start signals from system.
 - 2. When no load remains on isolated paralleling bus, generator breakers open, go through cool-down period, and shut down.
 - 3. If start signal is received during cool-down period, one engine generator is reconnected to isolated paralleling bus, and system operation follows that of "loss of normal power."
- M. System Test Sequence of Operation:
 - 1. Configure tests to comply with NFPA 110, Level 1 testing requirements for generator. Automatically generate NFPA 110, Level 1 reports.
 - 2. Single-generator test.
 - 3. Multiple-generator test.
 - 4. Start generators manually, by generator exerciser on user-defined schedule, or by remote contact from **[DDC system for HVAC][SCADA system]**.
 - 5. Engine generator(s) start and achieve rated voltage and frequency.
 - 6. Failure of Engine Generator to Start: After expiration of overcrank time delay, engine generator shuts down and alarm is initiated.
 - 7. Black-Start Control: Prevent out-of-phase paralleling. After selecting first generator to achieve 90 percent rated voltage and frequency, inhibit connection of generator-controlled circuit breakers to isolated paralleling bus, then close circuit breaker connecting first generator to isolated paralleling bus. Single-generator paralleling monitoring and control system synchronizes its associated engine generator and allows closure of respective generator paralleling low-voltage circuit breakers to isolated paralleling bus. On closure to isolated paralleling bus, engine generator assumes its proportional share of total load.
 - 8. Failure of Engine Generator to Synchronize: If engine generator fails to synchronize, sound alarm after preset time delay, but continue to attempt to synchronize engine generator until signaled to stop by manual operation.
 - 9. Manually select or automatically preselect whether test is load or no-load test. If test is load test, manually select or automatically preselect loads to be transferred in accordance with schedule or by adjustable time delays at transfer switches. After generators are connected to isolated paralleling bus, transfer loads by sending signal to load-add relay that is connected to input for "remote transfer to generator source" of transfer switch controller or to other devices. **[If test is load-bank test, automatically operate load-bank breaker to connect load bank for testing generators based on number and configuration of generators.]**
 - 10. After adjustable period of time system, allow engine generators to optimize down to only required number to be online to avoid wet stacking. Set stopping and starting sequences through human-machine interface panel device and allow settings based on manual priorities or by engine run time.
 - 11. On sensing available bus capacity diminished to set point, controller starts and closes engine generators to isolated paralleling bus to accommodate load.
 - 12. After system test is completed, transfer loads back to normal power with transfer switches. Shut down system using sequence in automatic mode.

13. If there is outage during this mode of operation, automatically change to requirements specified in "Sequence of Operation for Loss of Normal Power Conditions" Paragraph, send load-shed signals to lower-priority loads until load is below generator capacity, signal engine generator that is not currently operating to start, and cancel system test.
- N. Peak-Shaving Sequence of Operation:
1. Start engine generators manually through human-machine interface or by remote contact initiated from peak-shaving command from **[DDC system for HVAC][SCADA system]**.
 2. Engine generator(s) start and achieve rated voltage and frequency.
 3. Failure of Engine Generator to Start: After expiration of overcrank time delay, engine generator shuts down and alarm is initiated.
 4. Black-Start Control: Prevent out-of-phase paralleling. After selecting first generator to achieve 90 percent rated voltage and frequency, inhibit connection of generator-controlled circuit breakers to isolated paralleling bus, then close circuit breaker connecting first generator to isolated paralleling bus.
 5. Single-generator paralleling monitoring and control system synchronizes its associated engine generator and allows closure of respective generator paralleling low-voltage circuit breakers to isolated paralleling bus. On closure to isolated paralleling bus, engine generator assumes its proportional share of total load.
 6. Failure of Engine Generator to Synchronize: If generator set fails to synchronize, sound alarm after preset time delay, but continue to attempt to synchronize engine generator until signaled to stop by manual operation.
 7. Through human-machine interface manually select or on closure of contact from peak-shaving command preselected loads to be automatically transferred to isolated paralleling bus. After engine generators are connected to isolated paralleling bus, transfer loads by sending signal to corresponding load-add relays that are connected to remote transfer to generator source control input at transfer switch or similar control devices. Add loads until contact closure from **[DDC system for HVAC][SCADA system]** opens.
 8. After adjustable period of time, allow engine generators to optimize down to only required number to be online to avoid wet stacking. Set stopping and starting sequences through human-machine interface panel device and allow settings based on manual priorities or by engine run time.
 9. If isolated paralleling bus load is below preset limits and after preset time delay, demand controller shuts down engine generators in predetermined order until minimum number of sets are operating. Set preset limits, predetermined order, and preset time delay, as well as choose manual operation, from human-machine interface.
 10. On sensing available isolated paralleling bus capacity diminished to set point, controller starts and closes engine generators to isolated paralleling bus to accommodate load.
 11. After peak shaving is completed, transfer loads back to normal power. Shut down system using sequence in automatic mode.
 12. If there is outage during this mode of operation, automatically change to requirements specified in "Sequence of Operation for Loss of Normal Power Conditions" Paragraph, send, send load-shed signals to lower-priority loads until load is below engine generator capacity, signal generators that are not currently operating to start, and cancel system peak-shaving operation.
 13. Manual Sequence of Operation: Include functions indicated for automatic mode, except that operator must be able to monitor parameters and manually perform operations.
- O. Comply with NFPA 110 for the following:
1. Legally Required Standby Systems: EPSS Level 1, Type 10.
 2. Optional Standby Systems: EPSS **[Level 1][Level 2]**, **[Type 10][Type 60][Type 120][Manual]**.
- P. Comply with NFPA 99 for healthcare applications.

2.4 MULTIPLE-GENERATOR PARALLELING MONITORING AND CONTROL SYSTEM

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[ABB, Electrification Business]**
 2. **[ASCO Power Technologies]**
 3. **[Caterpillar, Inc.; Electric Power Division]**
 4. **[Cummins Power Generation]**
 5. **[Russelectric, Inc]**
 6. **[SAI Advanced Power Solutions/Switchboard Apparatus Inc.]**
 7. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[ABB, Electrification Business]**
 2. **[ASCO Power Technologies]**
 3. **[Caterpillar, Inc.; Electric Power Division]**
 4. **[Cummins Power Generation]**
 5. **[Russelectric, Inc]**
 6. **[SAI Advanced Power Solutions/Switchboard Apparatus Inc.]**
 7. **<Insert manufacturer's name>**
- C. Source Limitations: Obtain paralleling low-voltage switchgear from same manufacturer as required for **[engine generator][transfer switches][transfer switches and engine generators]**.
- D. Components and Devices: Factory mounted in **[metal-enclosed, paralleling low-voltage switchgear][separate switchboard]**.
1. Paralleling Low-Voltage Switchgear Door-Mounted Control Devices: Industrial, oil-type devices.
 2. Indicator Lamps: High-intensity digital display.
- E. Control Power for Multiple-Generator Monitoring and Control System: Supplied from 24 V(dc) starting batteries of engine generators.
1. Isolate battery bank to prevent failure of one battery from disabling entire system.
 2. Include, if necessary, separate control power battery system rated 24 V(dc) for equipment unable to accept voltage drop that occurs during engine cranking.
- F. Redundant Multiple-Generator Monitoring and Control System Controller:
1. Fully equip with hot swappable programmable logic controller, power supplies, and I/O points.
 2. Black-start control equipment specified in applicable engine generator Section.
- G. Multiple-generator monitoring and control system auto/manual selector switch.
- H. Control switch for circuit breaker that serves load bank.
- I. Full-Color, Touch-Screen, Human-Machine Interface Device:
1. Minimum viewing area of **[60 sq. inch (387 sq. cm)][100 sq. inch (645 sq. cm)]** must be configurable in either U.S. Standard or SI (metric) units.
 2. Main Menu: Include date, time, and system status messages. Configure screens so that no

- screen is more than three touches from other screen.
- a. Individual engine generator data must be accessed at paralleling low-voltage switchgear from **[main menu][main menu and single-generator paralleling monitoring and control system]**.
3. One-Line Diagram: Depicting system configuration and system status by screen animation, screen colors, text messages, or pop-up indicators.
- a. Conditions for Engine Generators, Buses, and Paralleling Circuit Breakers: Energized or de-energized.
 - b. Engine Generator Modes:
 - 1) Auto.
 - 2) Lockout.
 - 3) Reset.
 - 4) Off.
 - 5) Cool down.
 - 6) Test off line.
 - 7) Test on load.
 - c. Engine Generator Status: Normal, warning, shutdown, or load-demand stop.
 - d. Paralleling Circuit-Breaker Status: Open, closed, or tripped.
 - e. Bus Conditions: Energized or de-energized.
 - f. Percent load.
4. AC metering screen for isolated paralleling bus must display the following:
- a. Phase, volts, and amperes.
 - b. Kilowatts.
 - c. Kilovolt amperes.
 - d. Kilovolt-ampere rating.
 - e. Power factor.
 - f. Frequency.
 - g. Kilowatt hour.
 - h. Kilowatt demand.
 - i. Real-time trend chart for system kilowatts and volts updated on not less than one-second intervals.
 - j. A minimum of one historical trend chart for total system loads with intervals no shorter than five minutes and minimum duration of four hours.
 - k. Percent of available capacity of engine generators that are operating in parallel on bus.
5. Engine Generator Monitoring and Control Screen:
- a. Control:
 - 1) Engine generator manual start/stop control (functional only when paralleling low-voltage switchgear mounted control switch is in "Auto" position).
 - 2) Engine generator alarm reset.
 - 3) Manual paralleling and circuit-breaker enable/inhibit controls.
 - 4) Engine function and timer settings.
 - 5) System function, testing, and timer settings.
 - 6) Engine generator optimization settings: automatically determine priority of engine generators based on engine run time and number of engine starts or manually assign engine priorities.



- b. Status and Alarms:
 - 1) Power Metering: Watts, volt-ampere reactive, power factor, frequency, amperes, and voltage.
 - 2) Engine run hours.
 - 3) Engine status.
 - 4) Number of generator circuit-breaker operations.
 - 5) Replicate status and alarms from single-generator paralleling monitoring and control panel.
6. Dual, Three-Phase, Metering Screen: Graphical analog (270 electrical degree) metering representation with digital display. Display two generators at same time or one generator and isolated paralleling bus at same time. Display graphical synchroscope when one generator and isolated paralleling bus are selected.
 - a. True RMS, three-phase voltage, amperes, kilowatts, kilovolt amperes, kilovolt-ampere reactive, power factor, and frequency parameters.
 - b. Engine battery voltage display.
7. Password-Protected System Control Screen:
 - a. System Test Modes: Test with load/test without load/normal/retransfer time-delay override.
 - b. Test with Load: Starts and synchronizes engine generators on isolated paralleling bus; loads are transferred to isolated paralleling bus.
 - c. Test without Load: Starts and synchronizes engine generators on isolated paralleling bus but does not transfer loads to isolated paralleling bus.
 - d. Time adjustments for retransfer time delay, transfer time delay, system time delay on stopping, and system time delay on starting.
8. Password-Protected, Peak-Shaving Control Screen:
 - a. Peak-Shaving Modes: Manual start and transfer of loads; automatic start and transfer of loads by DDC system for HVAC peak-shaving relay closure.
 - b. For automatic mode, set load priorities for peak-shaving function.
 - c. Time adjustments for retransfer time delay, transfer time delay, system time delay on stopping, and system time delay on starting.
9. Load-Demand Control Screen: Monitors total load on isolated paralleling bus and controls number of engine generators running so that capacity tracks load demand.
 - a. Load-Demand Control: Enable/disable.
 - b. Set engine generator shutdown sequence.
 - c. Load-Demand Pickup Set Point: Adjustable from 90 to 40 percent in 5 percent increments.
 - d. Load-Demand Dropout Set Point: Adjustable from 20 to 70 percent in 5 percent increments.
10. Manual Load Control Screen: Allows operator to manually add or delete engine generators from paralleled system in response to system load parameters.
 - a. Indication of system available in kilowatts and amperes.
 - b. Control functions allow manual addition/removal of engine generators on system, and activation of load-shed/load-restore functions.
11. Load-Add/Load-Shed Sequence Screen: Password protected and with the following minimum functions:

- a. Display sequence.
 - b. Assigns "load-add sequence priority" to load-control relay with designation for relay operation after set number of engine generators are online.
 - c. Assigns "load-shed sequence priority" to load-control relay with designation for relay operation depending on number of engine generators online.
12. Alarm Summary and Run Report Screen:
- a. Lists most recent alarm conditions and status changes.
 - b. Lists minimum of most recent 32 alarm conditions by name and time/date; acknowledges alarm conditions with time/date.
 - c. For start signal, lists start time and date, stop time and date, maximum kilowatt and ampere load on system during run time, and start and stop times of individual engine generators.
 - d. Lists generator circuit position and status.
 - e. Access to trend monitored automatic transfer switches.
 - f. **[16-gigabyte]<Insert value>** hard-disk space for storing database file for multiple-generator paralleling monitoring and control panel trending and event logging. Trend and log data at resolution of one second. If hard drive is full, overwrite in first-in-first-out procedure.
 - 1) Trend up to eight monitored points simultaneously.
13. Load Status and Control Screen: Displays status of automatic transfer switches connected to system for **[32][64]** transfer switches, and other controlled devices.
- a. Automatic transfer switch connected to normal.
 - b. Automatic transfer switch connected to emergency.
 - c. Controlled circuit breakers downstream from automatic transfer switch device enabled or disabled.
 - d. Engine start indication.
 - e. Load-shed indication.
 - f. Load-add indication.
 - g. Inhibit to emergency source.
 - h. Inhibit to normal source.
 - i. Transfer Switch Power Metering Function: Total kilowatt, three-phase current, and three-phase voltage.
 - j. Automatic Transfer Switch Load Priority: Ability to change priorities of automatic transfer switches (password protected).
 - k. Display name, status, and priority of load block (whether on or off) and total load of that block.
 - l. Allow for manually adding or shedding loads.
14. Automated email messages must be transmitted when shutdowns occur and must include time and date of alarm.
15. Based on either number operations or time since last maintenance, suggest maintenance period for generator (run hours), controlled circuit breaker (number of operations), and transfer switches (number of transfers).
16. Status and Alarm Screen:
- a. Visual alarm status indicator and alarm horn with silence and acknowledge push-button.
 - b. Status, Light Only:
 - 1) "SYSTEM NOT IN AUTO" (red).
 - 2) Running Status: Display engine generator number and running-status light (green).
 - 3) Load-demand mode (green).

- 4) Priority Load Status: Display load number with "LOAD ADD" (green) and "LOAD SHED" (red).
- 5) System test (green).
- 6) Remote system start (red).
- 7) Monitoring of Transfer Switch:
 - a) Normal source available (green).
 - b) Connected to normal (green).
 - c) Generator source available (green).
 - d) Connected to generator source (green).

c. Status Light and Alarm:

- 1) Isolated paralleling bus under frequency (red).
- 2) Isolated paralleling bus over frequency (red).
- 3) Auxiliary power failure (red).
- 4) Emergency start signal power failure (red).
- 5) Load-Shed Level Status: Displays load number and red load-shed, status light.
- 6) Generator Alarm Status: Displays generator number and red "Check Generator" status light.
- 7) Controller malfunction (red).
- 8) Check station battery (red).
- 9) Isolated paralleling bus overload (red).
- 10) System not in auto (red).
- 11) Main tank, low fuel (amber)
- 12) Main tank, high fuel (amber).
- 13) Main tank, fuel leak (red).

J. Remote Monitoring: Replicate human-machine interface monitoring functions **[at SCADA][at remote computer terminal][via communication bus]**.

K. Remote Monitoring of Status and Alarms: Replicate human-machine interface status and alarms at DDC system for HVAC via isolated contacts.

2.5 SINGLE-GENERATOR PARALLELING MONITORING AND CONTROL SYSTEM

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

1. **[ABB, Electrification Business]**
2. **[ASCO Power Technologies]**
3. **[Caterpillar, Inc.; Electric Power Division]**
4. **[Cummins Power Generation]**
5. **[Russelectric, Inc]**
6. **<Insert manufacturer's name>**

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

1. **[ABB, Electrification Business]**
2. **[ASCO Power Technologies]**
3. **[Caterpillar, Inc.; Electric Power Division]**
4. **[Cummins Power Generation]**

5. [Russelectric, Inc]
 6. <Insert manufacturer's name>
- C. Source Limitations: Obtain paralleling low-voltage switchgear from same manufacturer as required for [engine generator][transfer switches][transfer switches and engine generators].
- D. Components and Devices: Factory mount in single-generator section of metal-enclosed, paralleling low-voltage switchgear.
1. Paralleling low-voltage switchgear door-mounted control devices must be industrial oil-type devices. Indicator lamps must be high-intensity digital display.
- E. Control Power: Supply control power from 24 V(dc) starting batteries from controlled generator. Include separate control power battery system rated 24 V(dc) for equipment unable to accept voltage drop that occurs during engine cranking.
- F. Programmable Logic Controller: Factory-mounted controller, separate from multiple-generator paralleling monitoring and control system in single-generator paralleling monitoring and control module of metal-enclosed, paralleling low-voltage switchgear.
- G. Single-Generator Paralleling Low-Voltage Switchgear Circuit Breaker:
1. Factory mount circuit-breaker control switch.
 2. Paralleling Circuit-Breaker Monitor and Control:
 - a. Monitors circuit-breaker auxiliary contacts.
 - b. Initiates fault signal if circuit breaker fails to close within adjustable time-delay period (0.5 to 15 seconds).
 - c. Trips open and locks out paralleling circuit breaker on paralleling circuit breaker failure to close, until manually reset.
- H. Generator Mode Selector Switch: Factory mounted in single-generator paralleling monitoring and control system module of metal-enclosed, paralleling low-voltage switchgear.
1. "Lockout/Reset" mode prevents generator from starting or immediately shuts down generator if running.
 2. "Off/Cool-Down" mode stops engine after cool-down period.
 3. "Auto" mode allows generator to start on receipt of remote start signal. If generator is already running and there is not start signal, then "Auto" mode allows engine to run for predetermined cool-down period before stopping.
 4. "Test Off-Line" allows engine to start and run as if start signal were received, except it does not allow generator to connect to isolated paralleling bus unless start signal is received.
 5. "Test Online" allows engine to start, run, and connect to isolated paralleling bus as if start signal were received.
- I. Engine Generator Controller: Woodward compatible.
1. Factory mount governor (speed control and load sharing) supplied in applicable engine generator Section in single-generator monitoring and control module.
 2. Loading control interface to governor system.
 3. Automatic synchronizer.
- J. Automatic Synchronizer:
1. Include sync mode selector switch with RUN-OFF-CHECK-PERMISSIVE positions. In RUN mode, enable active synchronization and sync-check function. In CHECK mode, perform sync-

check function. In PERMISSIVE mode, annunciate when generator and bus are synchronized but do not allow breaker closure.

- a. Include discrete inputs in synchronizer to switch to each mode.
2. Bias generator speed and voltage to match paralleling isolated bus.
 3. If automatic synchronizer receives permissive signal to allow closure to paralleling isolated bus and generator is within synchronizing limits, send close signal to single-generator paralleling circuit breaker.
- K. Sync-switch, removable, keyed T-handle.
- L. "Engine Generator Synchronized" Indication: Indicator lamp or digital-display indication of synchronization.
- M. Voltage and Frequency Raise and Lower Switches: Allow plus or minus 5 percent adjustment when engine generator is operating but is not connected to isolated paralleling bus.
- N. Control and Reset Push-Button: Have flashing lamp to indicate generator is locked out due to fault condition.
- O. Lamp Test Push-Button: Simultaneously tests lamps on panel.
- P. Control Panel Illumination: DC lamps illuminate panel when lighting from surrounding environment is unavailable.
- Q. Emergency Stop Push-Button: Red mushroom-head switch maintains its position until manually reset.
- R. Alarm and Status Indicating Display:
1. Status and Alarm Indications:
 - a. Status, Light Only (Nonlatching):
 - 1) Generator mode selector switch not in auto (red).
 - 2) Generator mode selector switch in auto (green).
 - 3) Start signal received (green).
 - 4) Emergency stop activated (red).
 - 5) Demand mode standby (green).
 - 6) Timing for start (green).
 - 7) Timing for shutdown (green).
 - 8) Generator circuit breaker closed (red).
 - 9) Generator circuit breaker open (green).
 - a) Generator circuit breaker locked out (white).
 - b) Generator circuit breaker racked out (white)
 - 10) Remote generator breaker is open (red).
 - 11) Engine stopped (green).
 - 12) Time-delay start (green).
 - 13) Engine running (red).
 - 14) Engine cool-down (green).
 - b. Pre-Alarm, Light and Horn (Nonlatching):

- 1) Pre-high coolant temperature (amber).
- 2) Pre-low oil pressure (amber).
- 3) Low coolant temperature (amber).
- 4) Engine low battery (amber).
- 5) Battery charger failure (amber).
- 6) Auxiliary power failure (amber).
- 7) Low fuel-day tank (amber).
- 8) Paralleling low-voltage switchgear generator breaker failed to close (amber).
- 9) Paralleling low-voltage switchgear generator breaker failed to open (amber).
- 10) Overcurrent alarm (amber).
- 11) Day tank low-fuel alarm (amber).
- 12) Ground-fault alarm (amber).

c. Shutdown Alarm, Light and Horn (Latching):

- 1) Engine overcrank (red).
- 2) Engine overspeed (red).
- 3) Engine low oil pressure (red).
- 4) Engine high coolant temperature (red).
- 5) Engine low coolant level (red).
- 6) Engine remote emergency shutdown (red).
- 7) Generator fail to synchronize shutdown (red).
- 8) Generator circuit breaker tripped (red).
- 9) Generator circuit breaker failure (red).
- 10) Generator not in auto (red).
- 11) Generator loss of field (red).
- 12) Generator reverse power (red).
- 13) Generator undervoltage (red).
- 14) Generator overvoltage (red).
- 15) Generator underfrequency (red).
- 16) Generator overfrequency (red).
- 17) Phase rotation (red).
- 18) Generator short circuit (red).
- 19) Day tank low-fuel shutdown (red).
- 20) Air damper activated, shutdown (red).

S. Paralleling Controls and Protection:

1. Engine Generator Governor (Speed Control and Load Sharing): Comply with requirements in applicable engine generator Section. Components must be Woodward compatible.
2. Kilowatt Load Sharing Control and Interface:
 - a. Operates engine generator governors during synchronizing and provides isochronous load sharing when paralleled.
 - b. Allows engine generator to ramp up to kilowatt load level[**signaled by multiple-generator monitoring and control controller**].
3. Load-Demand Governing Control:
 - a. Causes engine generator to ramp down at operator-adjustable rate to zero load when signaled to shut down in load-demand mode.
 - b. Causes engine generator to ramp up at operator-adjustable rate to proportional share of total isolated paralleling bus load when signaled to restart.
4. Kilovolt-Ampere-Reactive Load Sharing Control:

- a. Operates alternator excitation system while engine generator is paralleled.
 - b. Causes sharing of reactive load among engine generators to within 1 percent of equal levels without voltage drop.
5. Paralleling Monitor and Control:
- a. Monitors and verifies that engine generator has reached 90 percent of nominal voltage and frequency before closing to isolated paralleling bus.
 - b. Prevents accidental closure of breaker with engine generator out of phase with bus.
 - c. Prevents out-of-phase closure to isolated paralleling bus due to errant manual or automatic operation of synchronizer.
 - d. System of diagnostic digital displays to assist in analyzing synchronization.
6. Synchronizer Control:
- a. Adjusts engine governor to match voltage, frequency, and phase angle of isolated paralleling bus.
 - b. Maintains engine generator voltage within 1 percent of isolated paralleling bus voltage, and phase angle within 20 electrical degrees of isolated paralleling bus for 0.5 seconds before circuit-breaker closing.
 - c. Provides "fail-to-synchronize time delay" adjustable from 10 to 120 seconds; with field selectivity to either initiate alarm or shut down engine generator on failure condition.
7. Reverse Power Monitor and Control:
- a. Prevents sustained reverse power flow in engine generator.
 - b. Trips generator paralleling circuit breaker and initiates engine generator shutdown when reverse power condition exceeds 10 percent of engine generator kilowatt for three seconds.
 - c. Trips generator paralleling circuit breaker and initiates engine generator shutdown when reverse kilovolt-ampere conditions exceeds 20 percent of generator kilovolt-ampere rating.
8. Phase Rotation Monitor and Control: Verifies engine generator and isolated paralleling bus phase rotation match prior to closing paralleling circuit breaker.
9. Electronic Alternator Overcurrent Alarm and Shutdown Control:
- a. Monitors current flow at engine generator output terminals.
 - b. Initiates alarm when load current on engine generator is more than 110 percent of rated current for more than 60 seconds.
 - c. Overcurrent shutdown function matched to thermal damage curve of alternator.
10. Electronic Alternator Short-Circuit Protection: Shuts down generator, without instantaneous-trip function, when load current is more than 175 percent of rated current and combined time/current approaches thermal damage curve of alternator.
11. Loss of Excitation Monitor: Displays alarm on single-generator paralleling monitoring and control panel when generator controls sense loss of excitation to alternator while paralleled to isolated paralleling bus.
12. Cool-Down, Time-Delay Control: Adjustable, zero to 600 seconds.
13. Start Time-Delay Control: Adjustable, zero to 300 seconds.
14. Frequency Control: Initiate alarm condition when engine generator is below 90 percent of rated frequency for more than 20 seconds or is over frequency.
15. Under- and Overvoltage Control: Initiate alarm condition when engine generator is at 90 percent voltage for more than 20 seconds or is over voltage.

2.6 METAL-ENCLOSED, CIRCUIT-BREAKER SWITCHGEAR (600 V AND LESS)

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[ABB, Electrification Business]**
 - 2. **[Eaton]**
 - 3. **[Siemens Industry, Inc., Energy Management Division]**
 - 4. **[Square D; Schneider Electric USA]**
 - 5. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[ABB, Electrification Business]**
 - 2. **[Eaton]**
 - 3. **[Siemens Industry, Inc., Energy Management Division]**
 - 4. **[Square D; Schneider Electric USA]**
 - 5. **<Insert manufacturer's name>**
- C. Source Limitations: Obtain paralleling low-voltage switchgear from same manufacturer as required for **[engine generator][transfer switches][transfer switches and engine generators]**.
- D. Description: Factory assembled and tested, and complying with IEEE C37.20.1 and UL 1558.
- E. Ratings: Suitable for application in three-phase, 60 Hz, solidly grounded neutral system.
- F. Nominal System Voltage: **[480 V, three][480/277 V, four][240 V, three][208/120 V, four]** wire, 60 Hz.
- G. Isolated Paralleling Bus: **[5000 A][4000 A][3200 A][2000 A][1600 A]<Insert amperes>**.
 - 1. Phase-, Neutral-, and Ground-Bus Materials:
 - a. Phase**[and Neutral]** Bus: **[Copper, silver plated at connection points][Copper, tin plated][Aluminum, tin plated]**.
 - b. Ground Bus: Copper**[, silver][, tin]** plated; minimum size **1/4 by 2 inch (6 by 50 mm)**.
 - 2. Bus bars connect between vertical sections and between compartments. Cable connections are not permitted.
 - a. Uniform capacity for horizontal and vertical bus.
 - b. Neutral Bus: **[50][100]** percent of phase-bus ampacity, except as indicated. **[Equip bus with pressure-connector terminations for outgoing neutral conductors][Include braces for neutral-bus extensions for busway feeders]**.
 - c. Supports and Bracing for Buses: Adequate strength for indicated short-circuit currents.
- H. Short-Circuit Current: Match rating of highest-rated circuit breaker in switchgear assembly.
- I. Switchgear Fabrication:
 - 1. Bus isolation barriers must be arranged to isolate line bus from load bus at main and tie circuit breaker.
 - 2. Circuit-breaker compartments must be equipped to house drawout-type circuit breakers and must be fitted with hinged outer doors.
 - 3. Auxiliary Compartments: Match and align with basic switchgear assembly.

- a. Bus transition sections.
 - b. Pull sections.
 - c. Hinged front panels for access to accessory and blank compartments.
 - d. Pull box on top of switchgear for extra room for pulling cable, with removable top, front, and side covers; and ventilation provisions adequate to maintain air temperature in pull box within same limits as switchgear.
 - 1) Set pull box back from front to clear circuit-breaker lifting mechanism.
 - 2) Bottom: Insulating, fire-resistive material with separate holes for cable drops into switchgear.
 - 3) Cable Supports: Arranged to ease cabling and adequate to support cables indicated, including those for future installation.
 - e. Neutral Disconnect Link: Bolted, uninsulated, **1/4 by 2 inch (6 by 50 mm)** copper bus, arranged to connect neutral bus to ground bus.
 - f. Provide for future extensions from either end of main phase, neutral, and ground bus by means of predrilled bolt-holes and connecting links.
 - g. Bus-Bar Insulation: Individual bus bars wrapped with factory-applied, flame-retardant tape or spray-applied, flame-retardant insulation.
 - 1) Sprayed Insulation Thickness: **3 mil (0.08 mm)**, minimum.
 - 2) Bolted Bus Joints: Insulate with secure joint covers that can easily be removed and reinstalled.
4. Circuit-Breaker Terminals for Cable Connections: Silver-plated copper bus extensions equipped with pressure connectors for conductors.
- J. Circuit Breakers: Comply with IEEE C37.13, IEEE C37.16, and IEEE C37.17.
1. Ratings: As indicated for continuous, interrupting, and short-time current ratings for circuit breaker; voltage and frequency ratings same as switchgear.
 2. Operating Mechanism: Mechanically and electrically trip-free, stored-energy operating mechanism with the following features:
 - a. Normal Closing Speed: Independent of both control and operator.
 - b. Slow Closing Speed: Optional with operator for inspection and adjustment.
 3. Stored-Energy Mechanism: Electrically charged, with optional manual charging[**and operation counter**].
 4. Trip Devices:
 - a. Solid-state, overcurrent trip-device system consisting of one or two current transformers or sensors per phase, and release mechanism.
 - b. Functions: Long-time-delay, short-time-delay, and instantaneous-trip functions, independent of each other in both action and adjustment.
 - c. Temperature Compensation: Ensures accuracy and calibration stability from minus 5 to plus 40 deg C.
 - d. Time-Current Characteristics: Field adjustable.
 - e. Current Adjustability: Dial settings and rating plugs on trip units or sensors on circuit breakers, or combination of these methods.
 - f. Long-Time- and Short-Time-Delay Functions: Three bands, minimum; marked "minimum," "intermediate," and "maximum."
 - g. Pickup Points:
 - 1) Five minimum, for long-time- and short-time-trip functions. Equip short-time-trip

- function for switchable I-squared-t operation.
 - 2) Five minimum, for instantaneous-trip functions.
 - h. Ground-fault protection[**alarm**] with at least three short-time-delay settings and three trip-time-delay bands; adjustable current pickup. Arrange to provide protection for the following:
 - 1) Three-wire circuit or system.
 - 2) Four-wire circuit or system.
 - 3) Four-wire, double-ended substation.
 - i. Trip Indication: Labeled, battery-powered lights or mechanical targets on trip device to indicate type of fault.
- 5. Auxiliary Contacts: For interlocking or remote indication of circuit-breaker position, with spare auxiliary switches and other auxiliary switches required for normal circuit-breaker operation, quantity as indicated, consisting of two Type "a" and two Type "b" stages (contacts) wired through secondary disconnect devices to terminal block in stationary housing.
- 6. Drawout Features: Circuit-breaker mounting assembly equipped with racking mechanism to position circuit breaker and hold it rigidly in connected, test, and disconnected positions.
 - a. Interlocks: Prevent movement of circuit breaker to or from connected position when it is closed.
 - b. Circuit-Breaker Positioning:
 - 1) An open circuit breaker may be racked to or from connected, test, and disconnected positions only with associated compartment door closed, unless live parts are covered by full dead-front shield.
 - 2) An open circuit breaker may be manually withdrawn to position for removal from structure with door open.
 - 3) Status for connection devices for different positions includes the following:
 - a) Test Position: Primary disconnect devices disengaged, and secondary disconnect devices and ground contact engaged.
 - b) Disconnected Position: Primary and secondary devices and ground contact disengaged.
- 7. Arc Chutes: Readily removable from associated circuit breaker when it is in disconnected position; arranged to permit inspection of contacts without removing circuit breaker from switchgear.
- 8. Padlocking Provisions: For installing at least three padlocks on circuit breaker to secure its enclosure and prevent movement of drawout mechanism.
- 9. Operating Handle: One for each circuit breaker capable of manual operation.
 - a. Generator Paralleling Circuit Breakers: Interlocked with system control so that circuit breaker does not close unless mode selector switch is in "Auto" position and engine generator is synchronized with isolated paralleling bus.
- 10. Electric Close Button: One for each electrically operated circuit breaker.
 - a. Generator Paralleling Circuit Breakers: Interlocked with system control so that circuit breaker does not close unless mode selector switch is in "Auto" position and engine generator is synchronized with isolated paralleling bus.
- 11. Mechanical Interlocking of Circuit Breakers: Uses mechanical tripping lever or equivalent design and electrical interlocks.
- 12. Key Interlocks: Arranged so keys are attached at devices indicated. Mountings and hardware are

- included where future installation of key-interlock devices is indicated.
13. Undervoltage Trip Devices:

- a. Instantaneous, with adjustable pickup voltage.
- b. Adjustable time-delay and pickup voltage.

14. Shunt-Trip Devices:

- a. 24 V(dc) for generator paralleling circuit breakers and for distribution paralleling switchgear circuit breakers.
- b. Where indicated.

15. Indicating Lights: To indicate circuit breaker is open or closed, for main and bus tie circuit breakers interlocked either with each other or with external devices.

K. Metering:

1. Type and Locations:

- a. Isolated Paralleling Bus: **[Multifunction digital-metering monitor;][Analog metering for voltage, amperage, frequency, watt-hour, and recording demand;]** on door of separate metering compartment.
- b. Generator Circuit Breakers: **[Multifunction digital-metering monitor;][Analog metering for voltage, amperage, frequency, watt-hour, and recording demand;]** on circuit-breaker door.
- c. Distribution Circuit Breakers: **[Multifunction digital-metering monitor;][Analog metering for voltage, amperage, frequency, watt-hour, and recording demand;]** on circuit-breaker door.

2. Instrument Transformers:

- a. Comply with IEEE C57.13.
- b. Potential Transformers: Secondary-voltage rating of 120 V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.
- c. Current Transformers:
 - 1) Burden and accuracy class suitable for connected relays, meters, and instruments.
 - 2) Size for maximum momentary current amperage based on calculation or momentary rating of circuit breaker protecting conductor.
 - 3) Include shorting-type terminal blocks.

3. Multifunction Digital-Metering Monitor:

- a. Microprocessor-based unit suitable for three- or four-wire systems.
- b. Inputs from sensors or 5 A current-transformer secondaries, and potential terminals rated to 600 V.
- c. Switch-selectable digital display with the following features:
 - 1) Phase Currents, Each Phase: Plus or minus 1 percent.
 - 2) Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
 - 3) Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
 - 4) Three-Phase Real Power: Plus or minus 2 percent.
 - 5) Three-Phase Reactive Power: Plus or minus 2 percent.
 - 6) Power Factor: Plus or minus 2 percent.
 - 7) Frequency: Plus or minus 0.5 percent.

- 8) Integrated Demand, with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
- 9) Accumulated energy, in **MWh (MJ)**, plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.
- d. Communications module suitable for remote monitoring of meter quantities and functions. Interface communication and metering requirements in accordance with Section 260913 "Electrical Power Monitoring."
- e. Mounting: Display and control unit that is flush or semirecessed mounted in instrument compartment door.
- 4. Analog Instruments: Rectangular, **4-1/2 inch (115 mm)** square, accurate within 1 percent of full scale range; semirecessed mounting, with antiparallax 250-degree scale and external adjustment.
 - a. Voltmeters: Cover expanded scale range of normal voltage plus 10 percent.
 - b. Voltmeter Selector Switch: Rotary type with off position; provides readings of phase-to-phase[**and phase-to-neutral**] voltages.
 - c. Ammeters: Cover expanded scale range of bus rating plus 10 percent.
 - d. Ammeter Selector Switch: Permits current reading in each phase and keeps current-transformer secondary circuits closed in off position.
 - e. Watt-Hour Meters: Flush- or semirecessed-mounting type, **[5 A, 120 V, three phase, three wire; with three elements]<Insert characteristics>, [15-minute]<Insert value>** indicating demand register, and provision for testing and adding pulse initiation.
 - f. Recording Demand Meter: Usable as totalizing relay or indicating and recording maximum demand meter with **[15-minute]<Insert value>** interval.
 - 1) Operation: Counts and records succession of pulses entering two channels.
 - 2) Housing: Drawout type, back-connected case arranged for semirecessed mounting.
- L. Relays: Comply with IEEE C37.90, integrated digital type; with test blocks and plugs.
 - 1. Functions: **<Insert functions>**.
 - 2. Characteristics: **<Insert characteristics>**.
- M. Door-Mounted Control Components: Industrial-type oiltight devices and digital-display indicator lamps.
- N. Control Power Supply:
 - 1. Control power transformer must supply 120 V(ac) control circuits from generator source through secondary disconnect devices.
 - 2. Include control power transformer for generator paralleling switchgear circuit breaker connected to generator side of circuit breaker.
 - 3. Include control power transformer for distribution paralleling switchgear circuit breaker.
 - 4. Dry-type transformers must be in separate compartments for units larger than 3 kVA, including primary and secondary fuses.
 - 5. Two control power transformers in separate compartments with necessary interlocking relays; transformer must be connected to line side of associated main circuit breaker.
 - a. Secondary windings must be connected through relay(s) to control bus to effect automatic transfer scheme.
 - b. Secondary windings must be connected through internal automatic transfer switch to paralleling switchgear control power bus.
 - 6. Control Power Fuses: Primary and secondary fuses must provide current-limiting and overload protection.

- O. Control Wiring:
1. Factory installed, complete with bundling, lacing, and protection.
 2. Provide flexible conductors for 8 AWG and smaller, for conductors across hinges and for conductors for interconnections between shipping units.
 3. Conductors must be sized in accordance with NFPA 70 for duty required.
- P. Provision for Future Devices: Equip compartments with rails, mounting brackets, supports, necessary appurtenances, and bus connections.
- Q. Identification: Comply with requirements in Section 260553 "Identification for Electrical Systems" for electrical identification devices and installation.
1. Identify units, devices, controls, and wiring.
 2. Mimic Bus: Continuous mimic bus, applied to front of paralleling low-voltage switchgear, arranged in one-line diagram format, using symbols and lettered designations consistent with approved mimic-bus diagram.
 - a. Mimic-bus segments coordinated with devices in paralleling low-voltage switchgear sections to which applied, to produce concise visual presentation of principal paralleling switchgear components and connections.
 - b. Medium: Painted graphics, as selected by Architect.
 - c. Color: Contrasting with factory-finish background; as selected by Architect from manufacturer's full range.
- R. Indoor Enclosure Material: Steel.
- S. Outdoor Enclosure Fabrication Requirements: Galvanized steel, weatherproof; integral structural-steel base frame with factory-applied asphaltic undercoating.
1. Features for Compartment or Group of Compartments:
 - a. Thermostatically controlled air-conditioning units sized to prevent temperatures exceeding **[80 deg F (27 deg C)]<Insert temperature>**.
 - b. Space heater operating at one-half or less of rated voltage, sized to prevent condensation.
 - c. Louvers equipped with insect and rodent screen and filter; arranged to permit air circulation while excluding insects, rodents, and exterior dust.
 - d. Hinged front door with locking provisions.
 - e. Interior light with switch.
 - f. Weatherproof ground-fault circuit-interrupter duplex receptacle.
 - g. Power for air conditioning, heaters, lights, and receptacles to be provided from control power transformer.
 2. Features for Weatherproof Internal Aisle Construction:
 - a. Common internal aisle of sufficient width to permit protective-device withdrawal, disassembly, and servicing in aisle.
 - b. Aisle access doors with exterior padlocking provisions and interior panic latches.
 - c. Thermostatically controlled aisle space heaters operating at one-half or less of rated voltage.
 - d. Thermostatically controlled, aisle air-conditioning units sized to prevent temperatures exceeding **104 deg F (40 deg C)**.
 - e. Vaporproof, fluorescent aisle lights with low-temperature ballasts, controlled by wall switch at entrance.
 - f. At least two duplex, ground-fault circuit-interrupter receptacles, located in aisle.

- g. Aisle ventilation louvers arranged with makeup air near floor level and exhaust air near roof level.
 - 1) Louvers must have insect and rodent screen and filter, arranged to permit air circulation while excluding insects, rodents, and exterior dust.
 - 2) Exhaust fans.
- T. Access: Fabricate enclosure with hinged, rear cover panels to allow access to rear interior of paralleling low-voltage switchgear.
- U. Finish: Manufacturer's standard gray finish over rust-inhibiting primer on phosphatizing-treated metal surfaces.

2.7 SOURCE QUALITY CONTROL

- A. Owner will witness required factory tests. Notify Architect at least 14 days before date of tests and indicate their approximate duration.
 - 1. Perform successfully tests prior to witness test.
- B. Testing Administrant: **[Owner will engage][Engage]** qualified electrical testing agency to evaluate paralleling switchgear.
- C. **[Factory]**Tests and Inspections: Test and inspect paralleling low-voltage switchgear, with **[generators][generators and transfer switches]**, by, or under supervision of, qualified electrical testing laboratory recognized by authorities having jurisdiction, in accordance with {Insert standards} before delivering to site. Affix label with name and date of **[manufacturer's][qualified electrical testing laboratory's]** certification of system compliance on control units.
 - 1. Paralleling Low-Voltage Switchgear:
 - a. NETA ATS, 7.6.1.2, "Circuit Breaker, Air, Low-Voltage Power Switchgear."
 - b. Factory test with simulated inputs. Test control and relay functions for proper operation.
 - 2. Engine Generator:
 - a. NETA ATS, 7.22.1, "Emergency Systems, Engine Generator."
 - b. NETA ATS, 7.15.1, "Rotating Machinery, AC Motors & Generator."
 - 3. Automatic Transfer Switches:
 - a. NETA ATS, 7.22.3, "Emergency System, Automatic Transfer Switches."
- D. Verification of Performance: Rate paralleling low-voltage switchgear, with **[generators][generators and transfer switches]**, in accordance with operation of functions and features specified.
- E. Nonconforming Work:
 - 1. Paralleling low-voltage switchgear, with **[generators][generators and transfer switches]**, will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, where paralleling low-voltage switchgear will be installed for compliance with installation tolerances, required clearances, and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 SELECTION OF SWITCHGEAR COMPONENTS

- A. Product Selection for Restricted Space: Drawings indicate maximum dimensions for paralleling low-voltage switchgear, including clearances between paralleling switchgear and adjacent surfaces and other items. Comply with indicated maximum dimensions.

3.3 INSTALLATION

- A. Comply with applicable portions in NECA 400.
- B. Equipment Mounting:
 - 1. Install paralleling low-voltage switchgear on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 260529 "Hangers and Supports for Electrical Systems."
 - 2. Comply with requirements for seismic control devices specified in **[Section 260548 "Vibration and Seismic Controls for Electrical Systems."][Section 260548.16 "Seismic Controls for Electrical Systems."]**
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, brackets, and temporary blocking of moving parts from paralleling low-voltage switchgear units and components.

3.4 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Section 260553 "Identification for Electrical Systems."
- B. Diagrams and Instructions:
 - 1. Frame and mount under clear acrylic plastic on front of paralleling low-voltage switchgear.
 - a. Operating Instructions: Printed basic instructions for paralleling low-voltage switchgear, including control and key-interlock sequences and emergency procedures.
 - b. System Power Riser Diagrams: Depict power sources, feeders, distribution components, and major loads.
 - 2. Storage for Maintenance: Include rack or holder, near operating instructions, for copy of maintenance manual.
- C. Compartment Nameplates: **[Engraved, laminated acrylic][Engraved, melamine plastic][Preprinted**

aluminum], as described in Section 260553 "Identification for Electrical Systems," for compartment, mounted with corrosion-resistant screws.

- D. Mimic Bus: Continuous mimic bus, arranged in single-line diagram format, using symbols and lettered designations consistent with approved mimic-bus diagram.
1. Mimic-bus segments coordinated with devices in switchgear sections to which applied, to produce concise visual presentation of principal switchgear components and connections.
 2. Medium: Painted graphics, as selected by Architect.
 3. Color: Contrasting with factory-finish background; as selected by Architect from manufacturer's full range.
- E. Arc-Flash Warning Labels:
1. Comply with requirements in Section 260573.19 "Arc-Flash Hazard Analysis." Produce **3.5-by-5-inch (76-by-127-mm)** self-adhesive equipment label for each work location included in analysis.
 2. Comply with requirements in Section 260553 "Identification for Electrical Systems." Produce **3.5-by-5-inch (76-by-127-mm)** self-adhesive equipment label for each work location included in analysis. Labels must be machine printed, with no field-applied markings.
 - a. Label must have orange header with wording, "WARNING, ARC-FLASH HAZARD," and must include the following information taken directly from arc-flash hazard analysis:
 - 1) Location designation.
 - 2) Nominal voltage.
 - 3) Flash protection boundary.
 - 4) Hazard risk category.
 - 5) Incident energy.
 - 6) Working distance.
 - 7) Engineering report number, revision number, and issue date.
 - b. Labels must be machine printed, with no field-applied markings.

3.5 CONNECTIONS

- A. Comply with grounding and bonding requirements in Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Comply with wire and cable requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.6 FIELD QUALITY CONTROL

- A. **[Acceptance]**Testing Preparation: Prepare for acceptance tests as follows:
1. Test insulation resistance for switchgear bus, component, connecting supply, feeder, and control circuit.
 2. Test continuity of circuit.
 3. Inspect paralleling switchgear installation, including wiring, components, connections, and equipment. **[Test and adjust components and equipment.]**
 4. Verify that electrical control wiring installation complies with manufacturer's submittal by means of point-to-point continuity testing.
 5. Complete installation and startup checks in accordance with manufacturer's written instructions.

- B. Field tests must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.
- C. Tests and Inspections:
 - 1. Perform visual and mechanical inspections and electrical tests stated in NETA ATS. Certify compliance with test parameters. Perform NETA tests and inspections for the following NETA categories:
 - a. AC generators and emergency systems.
 - b. Switchgear.
 - c. Circuit breakers.
 - d. Instrument transformers.
 - e. Metering and instrumentation.
 - f. Ground-fault systems.
 - g. Battery systems.
 - h. Surge arresters.
 - i. Capacitors.
 - 2. Perform NFPA 110 tests for Type 1 essential power systems.
 - 3. Test sequence of operation step by step for each mode.
- D. Nonconforming Work:
 - 1. Paralleling low-voltage switchgear will be considered defective if it does not pass tests and inspections.
- E. Collect, assemble, and submit test and inspection reports.
- F. Manufacturer Services:
 - 1. Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.

3.7 ADJUSTING

- A. Set field-adjustable, electronic circuit-breaker trip characteristics in accordance with results specified in Section 260573.16 "Coordination Studies."
- B. Set field-adjustable, electronic circuit-breaker trip characteristics.

3.8 CLEANING

- A. On completion of installation, inspect interior and exterior of paralleling low-voltage switchgear. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair damaged finishes.

3.9 PROTECTION

- A. Temporary Heating: Apply temporary heat to paralleling low-voltage switchgear, in accordance with manufacturer's written instructions, throughout periods when paralleling switchgear environment is not controlled for temperature and humidity within manufacturer's stipulated service conditions.

3.10 MAINTENANCE

- A. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared scan of switchgear. Remove front and rear panels so joints and connections are accessible to portable scanner.
 - 1. Follow-up Infrared Scanning: Perform additional follow-up infrared scan of switchgear 11 months after date of Substantial Completion.
 - 2. Instrument: Use infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - 3. Record of Infrared Scanning: Prepare certified report that identifies switchgear checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

END OF SECTION 26 21 16 00



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Task	Specification	Specification Description
26 21 16 00	26 05 13 00	Medium-Voltage Cables
26 21 16 00	26 05 19 00	Low-Voltage Electrical Power Conductors and Cables
26 22 00 00	26 12 19 00a	Low-Voltage Switchgear



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SECTION 26 22 13 00 - LOW-VOLTAGE DISTRIBUTION TRANSFORMERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Distribution, dry-type transformers with nominal primary and secondary rating of 600 V and less, with capacities up to 1500 kVA.

B. Products Furnished, but Not Installed, under This Section:

1. **<Insert products furnished, but not installed>.**

C. Products Installed, but Not Furnished, under This Section:

1. **<Insert products installed, but not furnished>.**

D. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.2 ACTION SUBMITTALS

A. Product Data:

1. For each type of product.
 - a. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type and size of transformer.
 - b. Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer.

B. Shop Drawings:

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of field connections.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
3. Include diagrams for power, signal, and control wiring.

C. Field Quality-Control Submittals:

1. Field quality-control reports.

1.3 INFORMATIONAL SUBMITTALS

- A. Manufacturers' Published Instructions: Record copy of official installation[**and testing**] instructions issued to Installer by manufacturer for the following:
 - 1. Transformer temporary heating, working clearances, anchoring, torque values, and insulation-resistance testing.
- B. Source quality-control reports.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Inspection: On receipt, inspect for and note shipping damage to packaging and transformer.
 - 1. If manufacturer packaging is removed for inspection, and transformer will be stored after inspection, re-package transformer using original or new packaging materials that provide protection equivalent to manufacturer's packaging.
- B. Storage: Store in warm, dry, and temperature-stable location in original shipping packaging.
- C. Temporary Heating: Apply temporary heat in accordance with manufacturer's published instructions within enclosure of ventilated-type units, throughout periods during which equipment is not energized and when transformer is not in space that is continuously under normal control of temperature and humidity.
- D. Handling: Follow manufacturer's instructions for lifting and transporting transformers.

PART 2 - PRODUCTS**2.1 OWNER-FURNISHED PRODUCTS**

- A. Basis for Pricing: **<Insert name of manufacturer; model number or series for product that Owner intends to furnish to Contractor>.**
- B. Description: **<Insert description of product, including special features, options, and finishes for Owner-furnished product that may impact Contractor's installation>.**
- C. Accessories: **<Insert accessories that will be provided with product>.**

2.2 EXISTING PRODUCTS[TO BE MODIFIED][TO BE REMOVED AND RE-INSTALLED]

- A. Basis for Pricing: **<Insert name of manufacturer; model number or series for existing product>.**
- B. Description: **<Insert description of existing product, including special features, options, and finishes that may impact Work>.**
- C. Accessories: **<Insert accessories included with existing product>.**

2.3 LOW-VOLTAGE DISTRIBUTION TRANSFORMERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[ABB, Electrification Business]**
 2. **[Acme Electric; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 3. **[Dongan Electric Manufacturing Company]**
 4. **[Eaton]**
 5. **[Federal Pacific]**
 6. **[Hammond Power Solutions Inc.]**
 7. **[Jefferson Electric, Inc.]**
 8. **[Lincoln Electric Products Co., Inc.]**
 9. **[Mag-Tran; a division of Quality Transformer & Electronics]**
 10. **[Marcus Transformer LTD]**
 11. **[MGM Transformer Company]**
 12. **[Micron Industries Corporation]**
 13. **[Mirus International Inc.]**
 14. **[Powersmiths International Corp.; Socomec Group]**
 15. **[Prolec GE; A Xignux and General Electric Company Joint Venture]**
 16. **[Rex Power Magnetix]**
 17. **[Siemens Industry, Inc., Energy Management Division]**
 18. **[SolaHD; Emerson Electric Co., Automation Solutions]**
 19. **[Square D; Schneider Electric USA]**
 20. **[TEMCo Transformers]**
 21. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[ABB, Electrification Business]**
 2. **[Acme Electric; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 3. **[Dongan Electric Manufacturing Company]**
 4. **[Eaton]**
 5. **[Federal Pacific]**
 6. **[Hammond Power Solutions Inc.]**
 7. **[Jefferson Electric, Inc.]**
 8. **[Lincoln Electric Products Co., Inc.]**
 9. **[Mag-Tran; a division of Quality Transformer & Electronics]**
 10. **[Marcus Transformer LTD]**
 11. **[MGM Transformer Company]**
 12. **[Micron Industries Corporation]**
 13. **[Mirus International Inc.]**
 14. **[Powersmiths International Corp.; Socomec Group]**
 15. **[Prolec GE; A Xignux and General Electric Company Joint Venture]**
 16. **[Rex Power Magnetix]**
 17. **[Siemens Industry, Inc., Energy Management Division]**
 18. **[SolaHD; Emerson Electric Co., Automation Solutions]**
 19. **[Square D; Schneider Electric USA]**
 20. **[TEMCo Transformers]**
 21. **<Insert manufacturer's name>**
- C. Source Limitations: Obtain each type of transformer from single source from single manufacturer.

2.4 GENERAL TRANSFORMER REQUIREMENTS

- A. Description: Factory-assembled and -tested, air-cooled units for 60 Hz service.
- B. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- C. Transformers Rated 15 kVA and Larger:
 - 1. Comply with 10 CFR 431 (DOE 2016) efficiency levels.
 - 2. Marked as compliant with DOE 2016 efficiency levels by qualified electrical testing laboratory recognized by authorities having jurisdiction.
- D. Shipping Restraints: Paint or otherwise color-code bolts, wedges, blocks, and other restraints that are to be removed after installation and before energizing. Use fluorescent colors that are easily identifiable inside transformer enclosure.

2.5 DISTRIBUTION TRANSFORMERS

- A. Comply with NFPA 70[, and list and label as complying with UL 1561].
- B. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.
 - 1. One leg per phase.
 - 2. Core volume must allow efficient transformer operation at 10 percent above nominal tap voltage.
 - 3. Grounded to enclosure.
- C. Coils: Continuous windings[**without splices**] except for taps.
 - 1. Coil Material: **[Aluminum][Copper]**.
 - 2. Internal Coil Connections: Brazed or pressure type.
 - 3. Terminal Connections: **[Welded][Bolted]**.
- D. Encapsulation: Transformers smaller than 30 kVA must have core and coils completely resin encapsulated.
- E. Enclosure: **[Ventilated][Totally enclosed, nonventilated]**.
 - 1. Core and coil must be encapsulated within resin compound[**using vacuum-pressure impregnation process**] to seal out moisture and air.
 - 2. KVA Ratings: Based on convection cooling only and not relying on auxiliary fans.
 - 3. Wiring Compartment: Sized for conduit entry and wiring installation.
 - 4. Environmental Protection:
 - a. Indoor: UL 50E, **[Type 2][Type 3R][Type 4X, Stainless Steel]**.
 - b. Outdoor: UL 50E, **[Type 3R][Type 4X][Type 4X, Stainless Steel]**.
 - 5. Finish Color: **[Gray][ANSI 49 gray][ANSI 61 gray]** weather-resistant enamel.
- F. Taps for Transformers 3 kVA and Smaller: **[None][One 5 percent tap above normal full capacity]**.
- G. Taps for Transformers 7.5 to 24 kVA: **[One 5 percent tap above and one 5 percent tap below normal**

full capacity][Two 5 percent taps below rated voltage].

- H. Taps for Transformers 25 kVA and Larger: **[Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity][Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity].**
- I. Insulation Class, Smaller Than 30 kVA: 180 deg C, UL-component-recognized insulation system with maximum of 115 deg C rise above 40 deg C ambient temperature.
- J. Insulation Class, 30 kVA and Larger: 220 deg C, UL-component-recognized insulation system with maximum of **[150 deg C][115 deg C][80 deg C]** rise above 40 deg C ambient temperature.
- K. Grounding: Provide ground-bar kit or ground bar installed on inside of transformer enclosure.
- L. K-Factor Rating: Transformers indicated to be K-factor rated must comply with UL 1561 requirements for nonsinusoidal load current-handling capability to degree defined by designated K-factor.
 - 1. Unit may not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor, without exceeding indicated insulation class in 40 deg C maximum ambient and 24-hour average ambient of 30 deg C.
 - 2. Indicate value of K-factor on transformer nameplate.
 - 3. Unit must comply with requirements of DOE 2016 efficiency levels when tested in accordance with NEMA TP 2 with K-factor equal to one.
- M. Electrostatic Shielding: Windings must have independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.
 - 1. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.
 - 2. Include special terminal for grounding shield.
- N. Neutral: Rated 200 percent of full load current for K-factor-rated transformers.
- O. Wall Brackets: **[Manufacturer's standard brackets][Wall brackets fabricated from design drawings signed and sealed by qualified structural professional engineer].**
- P. Low-Sound-Level Requirements: Maximum sound levels when factory tested in accordance with IEEE C57.12.91, as follows:
 - 1. 9.00 kVA and Less: **[40 dB(A-weighted)]<Insert dB(A-weighted)>.**
 - 2. 9.01 to 30.00 kVA: **[45 dB(A-weighted)]<Insert dB(A-weighted)>.**
 - 3. 30.01 to 50.00 kVA: **[45 dB(A-weighted) for K-factors of 1, 4, and 9][48 dB(A-weighted) for K-factors of 13 and 20]<Insert dB(A-weighted)>.**
 - 4. 50.01 to 150.00 kVA: **[50 dB(A-weighted) for K-factors of 1, 4, and 9][53 dB(A-weighted) for K-factors of 13 and 20]<Insert dB(A-weighted)>.**
 - 5. 150.01 to 300.00 kVA: **[55 dB(A-weighted) for K-factors of 1, 4, and 9][58 dB(A-weighted) for K-factors of 13 and 20]<Insert dB(A-weighted)>.**
 - 6. 300.01 to 500.00 kVA: **[60 dB(A-weighted) for K-factors of 1, 4, and 9][63 dB(A-weighted) for K-factors of 13 and 20]<Insert dB(A-weighted)>.**
 - 7. 500.01 to 700.00 kVA: **[62 dB(A-weighted) for K-factors of 1, 4, and 9][65 dB(A-weighted) for K-factors of 13 and 20]<Insert dB(A-weighted)>.**
 - 8. 700.01 to 1000.00 kVA: **[64 dB(A-weighted) for K-factors of 1, 4, and 9][67 dB(A-weighted) for K-factors of 13 and 20]<Insert dB(A-weighted)>.**
 - 9. 1000.01 to 1500.00 kVA: **<Insert dB(A-weighted)>.**

2.6 IDENTIFICATION

A. Nameplates:

1. Engraved, laminated-acrylic or melamine plastic signs for distribution transformers, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 260553 "Identification for Electrical Systems."
2. Self-adhesive label for distribution transformers. Self-adhesive labels are specified in Section 260553 "Identification for Electrical Systems."

2.7 SOURCE QUALITY CONTROL

A. Testing Administrator: **[Owner will engage][Engage]** qualified electrical testing agency to evaluate transformer.

B. Factory Tests and Inspections: Test and inspect assembled system, by, or under supervision of, qualified electrical testing laboratory recognized by authorities having jurisdiction, in accordance with IEEE C57.12.01 and IEEE C57.12.91 before delivering to site. Affix label with name and date of **[manufacturer's][qualified electrical testing laboratory's]** certification of system compliance on control units.

1. Resistance measurements of windings at rated voltage connections and at tap connections.
2. Ratio tests at rated voltage connections and at tap connections.
3. Phase relation and polarity tests at rated voltage connections.
4. No load losses, and excitation current and rated voltage at rated voltage connections.
5. Impedance and load losses at rated current and rated frequency at rated voltage connections.
6. Applied and induced tensile tests.
7. Regulation and efficiency at rated load and voltage.
8. Insulation-Resistance Tests:
 - a. Line-side to ground.
 - b. Load-side to ground.
 - c. Line-side to load-side.
9. Temperature tests.
10. Factory Sound-Level Tests: **[Conduct sound-level tests on equipment for this Project][Conduct prototype sound-level tests on production-line products]**.

C. Nonconforming Work:

1. System equipment that does not pass tests and inspections will be considered defective.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for transformers.

- B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's published instructions.
- C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.
- D. Verify that ground connections are in place and requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance must be 5 Ω at location of transformer.
- E. Environment: Enclosures must be rated for environment in which they are located. Covers for UL 50E, Type 4X enclosures may not cause accessibility problems.
- F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install wall-mounted transformers level and plumb with wall brackets fabricated **[by transformer manufacturer][from design drawings signed and sealed by qualified structural professional engineer]**.
 - 1. Coordinate installation of wall-mounted and structure-hanging supports with actual transformer provided.
 - 2. Brace wall-mounted transformers as specified in **[Section 260548 "Vibration and Seismic Controls for Electrical Systems."][Section 260548.16 "Seismic Controls for Electrical Systems."]**
- B. Install transformers level and plumb on concrete base with vibration-dampening supports. Locate transformers away from corners and not parallel to adjacent wall surface.
- C. Construct concrete bases and anchor floor-mounted transformers in accordance with manufacturer's published instructions[, **seismic requirements applicable to Project,**] and requirements in Section 260529 "Hangers and Supports for Electrical Systems."
 - 1. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
- D. Secure transformer to concrete base in accordance with manufacturer's published instructions.
- E. Secure covers to enclosure and tighten bolts to manufacturer-recommended torques to reduce noise generation.
- F. Remove shipping bolts, blocking, and wedges.

3.3 CONNECTIONS

- A. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Tighten electrical connectors and terminals in accordance with manufacturer's published torque-

tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

- D. Provide flexible connections at conduit and conductor terminations and supports to eliminate sound and vibration transmission to building structure.

3.4 FIELD QUALITY CONTROL

- A. **[Acceptance]**Testing Preparation:

- 1. **<Insert requirements>**.

- B. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.

- C. Tests and Inspections:

- 1. Small (Up to 167 kVA Single-Phase or 500 kVA Three-Phase) Dry-Type Transformer Field Tests:

- a. Visual and Mechanical Inspection.

- 1) Inspect physical and mechanical condition.
- 2) Inspect anchorage, alignment, and grounding.
- 3) Verify that resilient mounts are free and that shipping brackets have been removed.
- 4) Verify that unit is clean.
- 5) Perform specific inspections and mechanical tests recommended by manufacturer.
- 6) Verify that as-left tap connections are as specified.
- 7) Verify presence of surge arresters and that their ratings are as specified.

- b. Electrical Tests:

- 1) Measure resistance at windings, taps, and bolted connections.
- 2) Perform insulation-resistance tests winding-to-winding and windings-to-ground. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index: value of index may not be less than 1.0.
- 3) Perform turns-ratio tests at tap positions. Test results may not deviate by more than one-half percent from either adjacent coils or calculated ratio. If test fails, replace transformer.
- 4) Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

- 2. Large (Larger Than 167 kVA Single Phase or 500 kVA Three Phase) Dry-Type Transformer Field Tests:

- a. Visual and Mechanical Inspection:

- 1) Inspect physical and mechanical condition.
- 2) Inspect anchorage, alignment, and grounding.
- 3) Verify that resilient mounts are free and that shipping brackets have been removed.
- 4) Verify that unit is clean.
- 5) Perform specific inspections and mechanical tests recommended by manufacturer.
- 6) Verify that as-left tap connections are as specified.
- 7) Verify presence of surge arresters and that their ratings are as specified.

b. Electrical Tests:

- 1) Measure resistance at windings, taps, and bolted connections.
- 2) Perform insulation-resistance tests winding-to-winding and windings-to-ground. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index: value of index may not be less than 1.0.
- 3) Perform power-factor or dissipation-factor tests on windings.
- 4) Perform turns-ratio tests at tap positions. Test results may not deviate by more than one-half percent from either adjacent coils or calculated ratio. If test fails, replace transformer.
- 5) Perform excitation-current test on each phase.
- 6) Perform applied voltage test on line- and load-side windings to ground. See IEEE C57.12.91, Sections 10.2 and 10.9.
- 7) Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

D. Test Labeling: On completion of satisfactory testing of units, attach dated and signed "Satisfactory Test" label to tested components.

E. Nonconforming Work:

1. Transformer will be considered defective if it does not pass tests and inspections.
2. Remove and replace units that do not pass tests or inspections and retest as specified above.

F. Assemble and submit test and inspection reports.

G. Manufacturer Services:

1. Engage factory-authorized service representative to [support][supervise] field tests and inspections.

3.5 ADJUSTING

A. Record transformer secondary voltage at unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 5 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

B. Output Settings Report: Prepare written report recording output voltages and tap settings.

3.6 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

3.7 MAINTENANCE

A. Infrared Scanning: Two months after Substantial Completion, perform infrared scan of transformer connections.

1. Use infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.



-
2. Perform two follow-up infrared scans of transformers, one at four months and another at 11 months after Substantial Completion.
 3. Prepare certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial actions taken, and scanning observations after remedial action.

END OF SECTION 26 22 13 00



Task	Specification	Specification Description
26 22 13 00	26 12 19 00a	Low-Voltage Switchgear



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SECTION 26 24 13 00 - SWITCHBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Switchboards.
2. Surge protection devices.
3. Disconnecting and overcurrent protective devices.
4. Instrumentation.
5. Control power.
6. Accessory components and features.

B. Related Requirements

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
3. Section 260573.19 "Arc-Flash Hazard Analysis" for arc-flash analysis and arc-flash label requirements.

1.2 COORDINATION

- A.** Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B.** Coordinate sizes and locations of concrete bases with actual equipment provided.

1.3 ACTION SUBMITTALS

A. Product Data:

1. Switchboards.
2. Overcurrent protective devices.
3. Surge protection devices.
4. Ground-fault protection devices.
5. Accessories.
6. Other components.
7. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

B. Shop Drawings: For each switchboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and



service space around equipment. Show tabulations of installed devices, equipment features, and ratings.

2. Detail enclosure types for types other than UL 50E, Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Detail short-circuit current rating of switchboards and overcurrent protective devices.
5. Include descriptive documentation of optional barriers specified for electrical insulation and isolation.
6. Detail utility company's metering provisions with indication of approval by utility company.
7. Include evidence of listing, by qualified electrical testing laboratory recognized by authorities having jurisdiction, for series rating of installed devices.
8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
9. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graph paper; include selectable ranges for each type of overcurrent protective device.
10. Include diagram and details of proposed mimic bus.
11. Include schematic and wiring diagrams for power, signal, and control wiring.

C. Samples: Representative portion of mimic bus with specified material and finish, for color selection.

D. Field Quality-Control Submittals:

1. Field Quality-Control Reports:
 - a. Test procedures used.
 - b. Test results that comply with requirements.
 - c. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.4 INFORMATIONAL SUBMITTALS

A. Manufacturers' Published Instructions: Record copy of official installation[**and testing**] instructions issued to Installer by manufacturer for the following:

1. Handling, storing, and providing temporary heat.
2. Mounting accessories and anchoring devices.
3. Testing and adjusting overcurrent protective devices.

B. Sample warranties.

1.5 CLOSEOUT SUBMITTALS

A. Warranty documentation.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Spare Parts: Furnish to Owner spare parts, for repairing switchboards, that are packaged with protective covering for storage on-site and identified with labels describing contents.[**Include the following:**]

1. Potential Transformer Fuses: Equal to 10 percent of quantity installed for each size and type but no fewer than two of each size and type.

2. Control-Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
3. Fuses and Fusible Devices for Fused Circuit Breakers: Equal to 10 percent of quantity installed for each size and type but no fewer than three of each size and type.
4. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type but no fewer than three of each size and type.
5. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type but no fewer than three of each size and type.
6. Indicating Lights: Equal to 10 percent of quantity installed for each size and type but no less than one of each size and type.

B. Special Tools: Furnish to Owner proprietary equipment, keys, and software required to operate, maintain, repair, adjust, or implement future changes to switchboards, that are packaged with protective covering for storage on-site and identified with labels describing contents. **[Include the following:]**

1. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
2. Portable Test Set: For testing functions of solid-state trip devices without removing from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.
3. Portable Circuit-Breaker Lifting Device: Floor-supported, roller-based, elevating carriage arranged for movement of circuit breakers in and out of compartments for present and future circuit breakers.
4. Overhead Circuit-Breaker Lifting Device: Mounted at top front of switchboard, with hoist and lifting yokes matching each drawout circuit breaker.
5. Spare-Fuse Cabinet: Suitably identified, wall-mounted, lockable, compartmented steel box or cabinet. Arrange for wall mounting.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.
- B. Remove loose packing and flammable materials from inside switchboards and **[install temporary electric heating (250 W per section)][connect factory-installed space heaters to temporary electrical service]** to prevent condensation.
- C. Handle and prepare switchboards for installation in accordance with **[NECA 400][NEMA PB 2.1]**.

1.8 WARRANTY

- A. Special Installer Extended Warranty: Installer warrants that fabricated and installed switchboard perform in accordance with specified requirements and agrees to repair or replace components that fail to perform as specified within extended-warranty period.
 1. Extended-Warranty Period: **[Two]<Insert number>** years from date of Substantial Completion; full coverage for labor, materials, and equipment.
- B. Special Manufacturer Extended Warranty: Manufacturer warrants that switchboard performs in accordance with specified requirements and agrees to provide repair or replacement of components that fail to perform as specified within extended-warranty period.
 1. **[Initial]**Extended-Warranty Period: **[Three]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for labor, materials, and equipment.
 2. Follow-On Extended-Warranty Period: **[Five]<Insert number>** years from date of Substantial

Completion; [full][prorated] coverage for materials[that failed because of transient voltage surges] only, free on board [origin][destination], freight prepaid.

PART 2 - PRODUCTS

2.1 SWITCHBOARDS

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
1. [ABB, Electrification Business]
 2. [Eaton]
 3. [Siemens Industry, Inc., Energy Management Division]
 4. [Square D; Schneider Electric USA]
 5. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [ABB, Electrification Business]
 2. [Eaton]
 3. [Siemens Industry, Inc., Energy Management Division]
 4. [Square D; Schneider Electric USA]
 5. <Insert manufacturer's name>
- C. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
- D. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- E. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- F. Comply with NEMA PB 2.
- G. Comply with NFPA 70.
- H. Comply with UL 891.
- I. Front-Connected, Front-Accessible Switchboards:
1. Main Devices: [Panel][Fixed, individually] mounted.
 2. Branch Devices: Panel mounted.
 3. Sections front and rear aligned.
- J. Front- and Side-Accessible Switchboards:
1. Main Devices: Fixed, individually mounted.

2. Branch Devices: Panel mounted.
 3. Section Alignment: **[Front][and][Rear]** aligned.
- K. Front- and Rear-Accessible Switchboards:
1. Main Devices: **[Fixed, individually][Drawout]** mounted.
 2. Branch Devices: **[Panel][Fixed, individually][Panel and fixed, individually][Fixed and individually compartmented][Individually compartmented and drawout]** mounted.
 3. Sections **[front and rear][rear]** aligned.
- L. Nominal System Voltage: **[480Y/277 V][208Y/120 V]<Insert system voltage>**.
- M. Main-Bus Continuous: **[5000][4000][3000][2500][2000][1600][1200]<Insert ampere rating>** A.
- N. Indoor Enclosures: Steel, UL 50E, **[Type 1][Type 2]**.
- O. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's **[standard gray][custom color]** finish over rust-inhibiting primer on treated metal surface.
- P. Outdoor Enclosures: **[Type 3R][Type 3R, with interior-lighted walk-in aisle]**.
1. Finish: Factory-applied finish in manufacturer's **[standard][custom]** color; undersurfaces treated with corrosion-resistant undercoating.
 2. Enclosure: **[Flat][Downward, rearward sloping]** roof; **[bolt-on rear covers][rear hinged doors]** for each section, with provisions for padlocking.
 3. Doors: Personnel door at each end of aisle, minimum width of **[30 inch (762 mm)]<Insert value>**; opening outwards; with panic hardware and provisions for **[padlocking][cylinder lock]**. At least one door must be sized to permit largest single switchboard section to pass through without disassembling doors, hinges, or switchboard section.
 4. Accessories: LED luminaires, ceiling mounted; wired to three-way light switch at each end of aisle; ground-fault circuit interrupter (GFCI) duplex receptacle; emergency battery pack luminaire installed on wall of aisle midway between personnel doors.
 5. Walk-in Aisle Heating and Ventilating:
 - a. Factory-installed electric unit heater(s), wall or ceiling mounted, with integral thermostat and disconnect and with capacities to maintain switchboard interior temperature of **[40 deg F (5 deg C)]<Insert temperature>** with outside design temperature of **[0 deg F (minus 18 deg C)]<Insert temperature>**.
 - b. Factory-installed exhaust fan with capacities to maintain switchboard interior temperature of **[100 deg F (38 deg C)]<Insert temperature>** with outside design temperature of **[90 deg F (32 deg C)]<Insert temperature>**.
 - c. Ventilating openings **[complete with replaceable fiberglass air filters]**.
 - d. Thermostat: Single stage; wired to control heat and exhaust fan.
 6. Power for Space Heaters, Ventilation, Lighting, and Receptacle: Include control-power transformer, with spare capacity of 25 percent, within switchboard. Supply voltage must be **[120 V(ac)][120/240 V(ac)][120/208 V(ac)]**.
 7. Power for space heaters, ventilation, lighting, and receptacle provided by remote source.
- Q. Barriers: Between adjacent switchboard sections.
- R. Insulation and isolation for **[main bus of main section and]** main and vertical buses of feeder sections.
- S. Space Heaters: Factory-installed electric space heaters of sufficient wattage in each vertical section to maintain enclosure temperature above expected dew point.



1. Space-Heater Control: **[Thermostats to maintain temperature of each section above expected dew point][Manual switching of branch-circuit protective device].**
 2. Space-Heater Power Source: **[Transformer, factory installed in switchboard][120 V external branch circuit].**
- T. Service Entrance Rating: Switchboards intended for use as service entrance equipment may contain from one to six service disconnecting means with overcurrent protection, neutral bus with disconnecting link, grounding electrode conductor terminal, and main bonding jumper.
- U. Utility Metering Compartment: Barrier compartment and section complying with utility company's requirements; hinged sealable door; buses provisioned for mounting utility company's current transformers and potential transformers or potential taps as required by utility company. If separate vertical section is required for utility metering, match and align with basic switchboard. Provide service entrance label and necessary applicable service entrance features.
- V. Customer Metering Compartment: Separate customer metering compartment **[and section with front hinged door,]** and section with front hinged door, for indicated metering, and current transformers for each meter. Current transformer secondary wiring must be terminated on shorting-type terminal blocks. **[Include potential transformers having primary and secondary fuses with disconnecting means and secondary wiring terminated on terminal blocks.]**
- W. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.
- X. Removable, Hinged Rear Doors and Compartment Covers: Secured by **[captive thumb screws][standard bolts]**, for access to rear interior of switchboard.
- Y. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.
- Z. Pull Box on Top of Switchboard:
1. Adequate ventilation to maintain temperature in pull box within same limits as switchboard.
 2. Set back from front to clear circuit-breaker removal mechanism.
 3. Removable covers may form top, front, and sides. Top covers at rear must be easily removable for drilling and cutting.
 4. Bottom must be insulating, fire-resistive material with separate holes for cable drops into switchboard.
 5. Cable supports must be arranged to facilitate cabling and adequate to support cables indicated, including those for future installation.
- AA. Buses and Connections: Three phase, four wire unless otherwise indicated.
1. Provide phase bus arrangement A, B, C from front to back, top to bottom, and left to right when viewed from front of switchboard.
 2. Phase- and Neutral-Bus Material:
 - a. Hard-drawn copper of 98 percent conductivity[, **silver-plated**].
 - b. Tin-plated, high-strength, electrical-grade aluminum alloy with tin-plated aluminum circuit-breaker line connections.
 3. Copper feeder circuit-breaker line connections.
 4. Tin-plated aluminum feeder circuit-breaker line connections.
 5. Load Terminals: Insulated, rigidly braced, runback bus extensions, of same material as through buses, equipped with **[mechanical][compression]** connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full-ampere rating of circuit-breaker position.

6. Ground Bus: [1/4 by 2 inch (6 by 50 mm-)][1/4 by 1 inch (6 by 25 mm-)][Minimum-size required by UL 891,] hard-drawn copper of 98 percent conductivity, equipped with [mechanical][compression] connectors for feeder and branch-circuit ground conductors.
 7. Main-Phase Buses and Equipment-Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
 8. Disconnect Links:
 - a. Isolate neutral bus from incoming neutral conductors.
 - b. Bond neutral bus to equipment-ground bus for switchboards utilized as service equipment or separately derived systems.
 9. Neutral Buses: [50][100] percent of ampacity of phase buses unless otherwise indicated, equipped with [mechanical][compression] connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
 10. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.
- BB. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.
- CC. Bus-Bar Insulation: Factory-applied, flame-retardant, tape wrapping of individual bus bars or flame-retardant, spray-applied insulation. Minimum insulation temperature rating of 105 deg C.
- DD. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components including instruments and instrument transformers.

2.2 SURGE PROTECTION DEVICES

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
1. [ABB, Electrification Business]
 2. [Advanced Protection Technologies Inc. (APT)]
 3. [Eaton]
 4. [Siemens Industry, Inc., Energy Management Division]
 5. [Square D; Schneider Electric USA]
 6. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [ABB, Electrification Business]
 2. [Advanced Protection Technologies Inc. (APT)]
 3. [Eaton]
 4. [Siemens Industry, Inc., Energy Management Division]
 5. [Square D; Schneider Electric USA]
 6. <Insert manufacturer's name>
- C. SPDs: Listed and labeled in accordance with UL 1449, [Type 1][Type 2].
- D. Features and Accessories:
1. Integral disconnect switch.
 2. Internal thermal protection that disconnects SPD before damaging internal suppressor components.

3. Indicator light display for protection status.
 4. Form-C contacts rated at **[5 A and 250 V(ac)][2 A and 24 V(ac)]<Insert values>**, one normally open and one normally closed, for remote monitoring of protection status. **[Contacts must reverse on failure of surge diversion module or on opening of current-limiting device. Coordinate with building power monitoring and control system.]**
 5. Surge counter.
- E. Peak Surge Current Rating: Minimum single-pulse surge current withstand rating per phase may not be less than **[200 kA][250 kA][300 kA]<Insert amperes>**. Peak surge current rating must be arithmetic sum of ratings of individual MOVs in each mode.
- F. Protection modes and UL 1449 VPR for grounded wye circuits with **[480Y/277 V][208Y/120 V]**, three-phase, four-wire circuits may not exceed the following:
1. Line to Neutral: **[1200 V for 480Y/277 V][700 V for 208Y/120 V]**.
 2. Line to Ground: **[1200 V for 480Y/277 V][1200 V for 208Y/120 V]**.
 3. Line to Line: **[2000 V for 480Y/277 V][1000 V for 208Y/120 V]**.
- G. Protection modes and UL 1449 VPR for 240/120 V, single-phase, three-wire circuits may not exceed the following:
1. Line to Neutral: 700 V.
 2. Line to Ground: **[700 V][1000 V]**.
 3. Line to Line: 1000 V.
- H. SCCR: Equal or exceed **[100 kA][200 kA]<Insert amperes>**.
- I. Nominal Rating: 20 kA.

2.3 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with **[series-connected rating][interrupting capacity]** to meet available fault currents.
1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
 3. Electronic trip circuit breakers with RMS sensing; field-replaceable rating plug or field-replaceable electronic trip; and the following field-adjustable settings:
 - a. Instantaneous trip.
 - b. Long- and short-time pickup levels.
 - c. Long and short time adjustments.
 - d. Ground-fault pickup level, time delay, and I squared t response.
 4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
 5. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.
 6. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6 mA trip).

7. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30 mA trip).
8. MCCB Features and Accessories:
 - a. Standard frame sizes, trip ratings, and number of poles.
 - b. Lugs: **[Mechanical][Compression]** style, suitable for number, size, trip ratings, and conductor material.
 - c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
 - d. Ground-Fault Protection: **[Integrally mounted][Remote-mounted]** relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 - e. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
 - f. Communication Capability: **[Circuit-breaker-mounted][Universal-mounted][Integral][Din-rail-mounted]** communication module with functions and features compatible with power monitoring and control system specified in Section 260913 "Electrical Power Monitoring and Control."
 - g. Shunt Trip: 120 V trip coil energized from separate circuit, set to trip at **[55][75]** percent of rated voltage.
 - h. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
 - i. Auxiliary Contacts: **[One SPDT switch][Two SPDT switches]** with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
 - j. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key must be removable only when circuit breaker is in off position.
- B. Insulated-Case Circuit Breaker (ICCB): **[80][100]** percent rated, sealed, insulated-case power circuit breaker with interrupting capacity rating to meet available fault current.
 1. **[Fixed][Drawout]** circuit-breaker mounting.
 2. Two-step, stored-energy closing.
 3. **[Standard][Full]**-function, microprocessor-based trip units with interchangeable rating plug, trip indicators, and the following field-adjustable settings:
 - a. Instantaneous trip.
 - b. Time adjustments for long- and short-time pickup.
 - c. Ground-fault pickup level, time delay, and I squared t response.
 - d. **<Insert settings>**.
 4. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
 5. Remote trip indication and control.
 6. Communication Capability: Web enabled integral Ethernet communication module and embedded Web server with factory-configured Web pages (HTML file format). Provide functions and features compatible with power monitoring and control system specified in Section 260913 "Electrical Power Monitoring and Control."
 7. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key must be removable only when circuit breaker is in off position.
 8. Control Voltage: **[40 V(dc)][125 V(dc)][250 V(dc)][120 V(ac)]**.
- C. Bolted-Pressure Contact Switch: Operating mechanism uses rotary-mechanical-bolting action to produce and maintain high clamping pressure on switch blade after it engages stationary contacts.
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering**

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

- a. **[Boltswitch, Inc.]**
 - b. **[Eaton]**
 - c. **[Siemens Industry, Inc., Energy Management Division]**
 - d. **[Square D; Schneider Electric USA]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[Boltswitch, Inc.]**
 - b. **[Eaton]**
 - c. **[Siemens Industry, Inc., Energy Management Division]**
 - d. **[Square D; Schneider Electric USA]**
 - e. **<Insert manufacturer's name>**
3. Main-Contact Interrupting Capability: Minimum of 12 times switch current rating.
4. Operating Mechanism: Manual handle operation to close switch; stores energy in mechanism for opening and closing.
- a. Electrical Trip: Operation of lever or push-button trip switch, or trip signal from ground-fault relay or remote-control device, causes switch to open.
 - b. Mechanical Trip: Operation of mechanical lever, push button, or other device causes switch to open.
5. Auxiliary Switches: Factory installed, SPDT, with leads connected to terminal block, and including one set more than quantity required for functional performance indicated.
6. Service-Rated Switches: Labeled for use as service equipment.
7. Ground-Fault Relay: Comply with UL 1053; self-powered type with mechanical ground-fault indicator, test function, tripping relay with internal memory, and three-phase current transformer/sensor.
- a. Configuration: **[Integrally mounted][Remote-mounted]** relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 - b. Internal Memory: Integrates cumulative value of intermittent arcing ground-fault currents and uses effect to initiate tripping.
 - c. No-Trip Relay Test: Permits ground-fault simulation test without tripping switch.
 - d. Test Control: Simulates ground fault to test relay and switch (or relay only if "no-trip" mode is selected).
8. Open-Fuse Trip Device: Arranged to trip switch open if phase fuse opens.
- D. High-Pressure, Butt-Type Contact Switch: Operating mechanism uses butt-type contacts and spring-charged mechanism to produce and maintain high-pressure contact when switch is closed.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
- a. **[ABB, Electrification Business]**
 - b. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **<Insert manufacturer's name>**
3. Main-Contact Interrupting Capability: Minimum of 12 times switch current rating.
4. Operating Mechanism: Manual handle operation to close switch; stores energy in mechanism for opening and closing.
 - a. Electrical Trip: Operation of lever or push-button trip switch, or trip signal from ground-fault relay or remote-control device, causes switch to open.
 - b. Mechanical Trip: Operation of mechanical lever, push button, or other device causes switch to open.
5. Auxiliary Switches: Factory installed, SPDT, with leads connected to terminal block, and including one set more than quantity required for functional performance indicated.
6. Service-Rated Switches: Labeled for use as service equipment.
7. Ground-Fault Relay: Comply with UL 1053; self-powered type with mechanical ground-fault indicator, test function, tripping relay with internal memory, and three-phase current transformer/sensor.
 - a. Configuration: **[Integrally mounted][Remote-mounted]** relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 - b. Internal Memory: Integrates cumulative value of intermittent arcing ground-fault currents and uses effect to initiate tripping.
 - c. No-Trip Relay Test: Permits ground-fault simulation test without tripping switch.
 - d. Test Control: Simulates ground fault to test relay and switch (or relay only if "no-trip" mode is selected).
8. Open-Fuse Trip Device: Arranged to trip switch open if phase fuse opens.
- E. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.
- F. Fuses are specified in Section 262813 "Fuses."

2.4 INSTRUMENTATION

- A. Instrument Transformers: NEMA EI 21.1, and the following:
 1. Potential Transformers: NEMA EI 21.1; 120 V, 60 Hz, **[single][tapped][double]** secondary; disconnecting type with integral fuse mountings. Burden and accuracy must be consistent with connected metering and relay devices.
 2. Current Transformers: NEMA EI 21.1; 5 A, 60 Hz, secondary; **[wound][bushing][bar or window]** type; **[single][double]** secondary winding and secondary shorting device. Burden and accuracy must be consistent with connected metering and relay devices.
 3. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.
 4. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker, ground-fault protection.
- B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:

1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:
 - a. Phase Currents, Each Phase: Plus or minus 0.5 percent.
 - b. Phase-to-Phase Voltages, Three Phase: Plus or minus 0.5 percent.
 - c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 0.5 percent.
 - d. Megawatts: Plus or minus 1 percent.
 - e. Megavars: Plus or minus 1 percent.
 - f. Power Factor: Plus or minus 1 percent.
 - g. Frequency: Plus or minus 0.1 percent.
 - h. Accumulated Energy, Megawatt Hours: Plus or minus 1 percent; accumulated values unaffected by power outages up to 72 hours.
 - i. Megawatt Demand: Plus or minus 1 percent; demand interval programmable from five to 60 minutes.
 - j. Contact devices to operate remote impulse-totalizing demand meter.
 2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.
- C. Analog Meters:
1. Meters: **4 inch (100 mm)** diameter or **6 inch (150 mm)** square, flush or semiflush, with anti-parallax 250-degree scales and external zero adjustment.
- D. Voltmeters: Cover expanded-scale range of nominal voltage plus 10 percent.
- E. Instrument Switches: Rotary type with off position.
1. Voltmeter Switches: Permit reading of phase-to-phase voltages and, where neutral is indicated, phase-to-neutral voltages.
 2. Ammeter Switches: Permit reading of current in each phase and maintain current-transformer secondaries in closed-circuit condition at all times.
- F. Ammeters: **2-1/2 inch (64 mm)** minimum size with 90- or 120-degree scale. Meter and transfer device with off position, located on overcurrent device door for indicated feeder circuits only.
- G. Watt-Hour Meters and Wattmeters:
1. Comply with ANSI C12.1.
 2. Three-phase induction type with two stators, each with current and potential coil, rated 5 A, 120 V, 60 Hz.
 3. Suitable for connection to three- and four-wire circuits.
 4. Potential indicating lamps.
 5. Adjustments for light and full load, phase balance, and power factor.
 6. Four-dial clock register.
 7. Integral demand indicator.
 8. Contact devices to operate remote impulse-totalizing demand meter.
 9. Ratchets to prevent reverse rotation.
 10. Removable meter with drawout test plug.
 11. Semiflush mounted case with matching cover.
 12. Appropriate multiplier tag.
- H. Impulse-Totalizing Demand Meter:
1. Comply with ANSI C12.1.
 2. Suitable for use with switchboard watt-hour meter, including two-circuit totalizing relay.

3. Cyclometer.
4. Four-dial, totalizing kilowatt-hour register.
5. Positive chart drive mechanism.
6. Capillary pen holding minimum of one month's ink supply.
7. Roll chart with minimum 31-day capacity; appropriate multiplier tag.
8. Capable of indicating and recording **[five][15][30]<Insert time period>**-minute integrated demand of totalized system.

2.5 CONTROL POWER

A. Control Circuits:

1. 120 V(ac), supplied through secondary disconnecting devices from control-power transformer.
2. 120 V(ac), supplied from remote branch circuit.
3. **<Insert control voltage>** V(dc).

B. Electrically Interlocked Main and Tie Circuit Breakers: Two control-power transformers in separate compartments, with interlocking relays, connected to primary side of each control-power transformer at line side of associated main circuit breaker. 120 V secondaries connected through automatic transfer relays to ensure fail-safe automatic transfer scheme.

C. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

D. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

2.6 ACCESSORY COMPONENTS AND FEATURES

A. Mounting Accessories: For anchors, mounting channels, bolts, washers, and other mounting accessories, comply with requirements in Section 260548.16 "Seismic Controls for Electrical Systems" or manufacturer's instructions.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store switchboards in accordance with **[NECA 400][NEMA PB 2.1]**.

1. Lift or move panelboards with spreader bars and manufacturer-supplied lifting straps following manufacturer's published instructions.
2. Use rollers, slings, or other manufacturer-approved methods if lifting straps are not furnished.
3. Protect from moisture, dust, dirt, and debris during storage and installation.
4. Install temporary heating during storage in accordance with manufacturer's published instructions.

B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.

C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and

other conditions affecting performance of the Work or that affect performance of equipment.

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

3.2 PREPARATION

- A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.

3.3 INSTALLATION

- A. Comply with manufacturer's published instructions.

- B. Reference Standards:

1. Switchboards and Accessories: Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with **[NECA 400][NEMA PB 2.1]**.
2. Consult Architect for resolution of conflicting requirements.

- C. Special Techniques:

1. Equipment Mounting: Install switchboards on concrete base, **4 inch (100 mm)** nominal thickness. Comply with requirements for concrete base specified in Section 260529 "Hangers and Supports for Electrical Systems."
 - a. Install conduits entering underneath switchboard, entering under vertical section where conductors will terminate. Install with couplings flush with concrete base. Extend **2 inch (50 mm)** above concrete base after switchboard is anchored in place.
 - b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18 inch (450 mm)** centers around full perimeter of concrete base.
 - c. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - d. Place and secure anchorage devices. Use setting drawings, templates, diagrams, published instructions, and directions furnished with items to be embedded.
 - e. Install anchor bolts to elevations required for proper attachment to switchboards.
 - f. Anchor switchboard to building structure at top of switchboard if required or recommended by manufacturer.
2. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, straps and brackets, and temporary blocking of moving parts from switchboard units and components.
3. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."
4. Operating Instructions: Frame and mount printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.
5. Install filler plates in unused spaces of panel-mounted sections.
6. Install overcurrent protective devices, surge protection devices, and instrumentation.
 - a. Set field-adjustable switches and circuit-breaker trip ranges.
7. Install spare-fuse cabinet.

3.4 CONNECTIONS

- A. Comply with requirements for terminating feeder bus specified in Section 262500 "Enclosed Bus Assemblies." Drawings indicate general arrangement of bus, fittings, and specialties.
- B. Comply with requirements for terminating cable trays specified in Section 260536 "Cable Trays for Electrical Systems." Drawings indicate general arrangement of cable trays, fittings, and specialties.
- C. Bond conduits entering underneath switchboard to equipment ground bus with bonding conductor sized in accordance with NFPA 70.
- D. Support and secure conductors within switchboard in accordance with NFPA 70.
- E. Extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.

3.5 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Switchboard Nameplates: Label each switchboard compartment with nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- D. Mimic Bus:
 - 1. Entire single-line switchboard bus work, as depicted on factory record drawing, on minimum **0.032 inch (0.813 mm)** thick anodized aluminum photoengraved nameplate, located at eye level on front cover of switchboard incoming service section.
 - 2. Entire single-line switchboard bus work, as depicted on factory record drawing, on engraved minimum **0.0625 inch (1.588 mm)** thick laminated-plastic (Gravoply) nameplate, located at eye level on front cover of switchboard incoming service section.
 - 3. Continuously integrated mimic bus factory applied to front of switchboard. Arrange in single-line diagram format, using symbols and letter designations consistent with final mimic-bus diagram.
 - 4. Coordinate mimic-bus segments with devices in switchboard sections to which they are applied. Produce concise visual presentation of principal switchboard components and connections.
 - 5. Presentation Media: Painted graphics in color contrasting with background color to represent bus and components, complete with lettered designations.
- E. Service Equipment Label: Labeled, by qualified electrical testing laboratory recognized by authorities having jurisdiction, for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

3.6 FIELD QUALITY CONTROL

- A. **[Acceptance]**Testing Preparation:
 - 1. **<Insert requirements>**.

- B. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.
- C. Tests and Inspections:
1. Acceptance Testing:
 - a. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit. Open control and metering circuits within switchboard, and remove neutral connection to surge protection and other electronic devices prior to insulation test. Reconnect after test.
 - b. Test continuity of each circuit.
 2. Test ground-fault protection of equipment for service equipment in accordance with NFPA 70.
 3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 4. Correct malfunctioning units on-site where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 5. Perform the following infrared scan tests and inspections, and prepare reports:
 - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared scan of each switchboard. Remove **[front][front and rear]** panels so joints and connections are accessible to portable scanner.
 - b. Follow-up Infrared Scanning: Perform additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.
 - c. Instruments and Equipment:
 - 1) Use infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 6. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Nonconforming Work:
1. Switchboard will be considered defective if it does not pass tests and inspections.
 2. Remove and replace defective units and retest.
- E. Collect, assemble, and submit test and inspection reports, including certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
- F. Manufacturer Services:
1. Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.
- 3.7 ADJUSTING
- A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges **[as indicated.][as specified in Section 260573.16]**

"Coordination Studies."]

3.8 PROTECTION

- A. Temporary Heating: Apply temporary heat, to maintain temperature in accordance with manufacturer's published instructions, until switchboard is ready to be energized and placed into service.

END OF SECTION 26 24 13 00



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Task	Specification	Specification Description
26 24 13 00	26 27 13 00	Electricity Metering
26 24 13 00	26 28 16 00	Enclosed Switches And Circuit Breakers



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SECTION 26 24 16 00 - PANELBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Panelboards.
2. Disconnecting and overcurrent protective devices.

B. Products Installed, but Not Furnished, under This Section:

1. **<Insert products identified in "Existing Products to be Modified" Article or "Existing Products to be Removed and Reinstalled" Article> .**

C. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies temperature, humidity, acoustical, and other field conditions applicable to the Work specified in this Section.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies seismic hazard, wind hazard, and other structural design conditions applicable to the Work specified in this Section.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional abbreviations, definitions, submittals, qualifications, testing agencies, and other requirements applicable to the Work for electrical, communications, and electronic safety and security systems on Project, including wiring methods.
4. Section 260529 "Hangers and Supports for Electrical Systems" specifies concrete bases and supports for panelboards installed by this Section.
5. Section 260548 "Vibration and Seismic Controls for Electrical Systems" specifies seismic control devices, mounting devices, and anchoring devices installed by this Section.
6. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs installed by this Section.
7. Section 260573 "Power System Studies" specifies short-circuit current studies, overcurrent protective device coordination studies, and arc-flash hazard analysis studies.
8. Section 260913 "Electrical Power Monitoring" specifies power monitoring and control systems installed by this Section.
9. Section 262813 "Fuses" specifies fuses and spare-fuse cabinets installed by this Section.
10. Section 264313 "Surge Protective Devices for Low-Voltage Electrical Power Circuits" specifies Type 1 and Type 2 surge protective devices installed by this Section.

1.2 DEFINITIONS

- A. MCCB: Molded-case circuit breaker.
- B. SPD: Surge protective device.
- C. VPR: Voltage protection rating.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of specified product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 - 2. Include operating characteristics, electrical characteristics, and furnished accessories.
 - 3. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing laboratory, certifying that model number corresponding to specified product complies with specified listing criteria.
 - 4. Include manufacturer's sample extended warranty language.
- B. Shop Drawings: For each panelboard and related equipment.
 - 1. Include plans, elevations, sections, details, and attachments to other Work.
 - 2. Show tabulations of installed devices with nameplates, conductor termination sizes, equipment features, and ratings.
 - 3. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.
 - 4. Detail bus configuration, current, and voltage ratings.
 - 5. Short-circuit current rating of panelboards and overcurrent protective devices.
 - 6. Include evidence of listing, by qualified electrical testing laboratory recognized by authorities having jurisdiction, for series rating of installed devices.
 - 7. Include evidence of listing, by qualified electrical testing laboratory recognized by authorities having jurisdiction, for SPD as installed in panelboard.
 - 8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 - 9. Include wiring diagrams for power, signal, and control wiring.
 - 10. Key interlock scheme drawing and sequence of operations.
 - 11. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device. Include Internet link for electronic access to downloadable PDF of coordination curves.
- C. Field Quality Control Reports: For specified tests and inspections.

1.4 INFORMATIONAL SUBMITTALS

- A. Panelboard Schedules: For installation in panelboards. [**Submit final versions after load balancing.**]
- B. Manufacturer's published instructions.
- C. Field Reports:
 - 1. Manufacturer's field reports for field quality-control support.
 - 2. Field reports for voltage monitoring and adjusting.
 - 3. Field reports for infrared scanning.

1.5 CLOSEOUT SUBMITTALS

- A. Warranty documentation.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Spare parts.
- B. Special tools.

1.7 QUALIFICATIONS

- A. Low-Voltage Electrical Testing and Inspecting Agency: Entities possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
 - 1. On-site electrical testing supervisors must have documented certification and experience with testing electrical equipment in accordance with NETA testing standards.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.
- B. Handle and prepare panelboards for installation in accordance with **[NECA 407][NEMA PB 1]** .

1.9 WARRANTY

- A. Special Installer Extended Warranty: Installer warrants that fabricated and installed panelboards perform in accordance with specified requirements and agrees to repair or replace components or products that fail to perform as specified within extended-warranty period.
 - 1. Extended-Warranty Period: **[Two]<Insert number>** years from date of Substantial Completion; full coverage for labor, materials, and equipment.
- B. Special Manufacturer Extended Warranty: Manufacturer warrants that panelboards perform in accordance with specified requirements and agrees to provide repair or replacement of components or products that fail to perform as specified within extended-warranty period.
 - 1. Initial Extended-Warranty Period: **[Three][Four]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for labor, materials, and equipment.
 - 2. Follow-On Extended-Warranty Period: **[Five]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for materials **[that failed because of transient voltage surges]** only, free on board **[origin][destination]** , freight prepaid.

PART 2 - PRODUCTS

2.1 EXISTING PRODUCTS TO BE MODIFIED

- A. Basis for Pricing: **<Insert name of manufacturer; model number or series for existing product>** .
- B. Description: **<Insert description of existing product, including special features, options, and finishes that may impact the Work>** .
 - 1. Sustainable Design Features:

- a. Material Reuse: Product is salvaged, refurbished, or reused.

- C. Accessories: **<Insert accessories included with existing product>** .

2.2 EXISTING PRODUCTS TO BE REMOVED AND REINSTALLED

- A. Basis for Pricing: **<Insert name of manufacturer; model number or series for existing product>** .

- B. Description: **<Insert description of existing product, including special features, options, and finishes that may impact the Work>** .

- 1. Sustainable Design Features:

- a. Material Reuse: Product is salvaged, refurbished, or reused.

- C. Accessories: **<Insert accessories included with existing product>** .

2.3 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

- B. Fabricate and test panelboards in accordance with IEEE 344 to withstand seismic forces specified in Section 018123 "Facility Seismic and Wind Criteria."

- C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

- D. Comply with NEMA PB 1.

- E. Enclosures: **[Flush][and][Surface]** -mounted, dead-front cabinets.

- 1. Rated for environmental conditions at installed location.

- a. Indoor Dry and Clean Locations: UL 50E, **[Type 1]<Insert type>** .
- b. Outdoor Locations: UL 50E, **[Type 3R]<Insert type>** .
- c. Kitchen and Wash-Down Areas: UL 50E, **[Type 4X]<Insert type>** , **[stainless steel]<Insert material>** .
- d. Other Wet or Damp Indoor Locations: UL 50E, **[Type 4]<Insert type>** .
- e. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: UL 50E, **[Type 5][Type 12]** .

- 2. Height: **7 ft (2.13 m)** maximum.

- 3. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box. Trims must cover live parts and may have no exposed hardware.

- 4. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims must cover live parts and may have no exposed hardware.

- 5. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.

6. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
 7. Finishes:
 - a. Panels and Trim: **[Steel][and][galvanized steel]** , factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
 - b. Back Boxes: **[Galvanized steel][Same finish as panels and trim]** .
 - c. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components.
- F. Phase, Neutral, and Ground Buses:
1. Material: **[Tin-plated aluminum][Hard-drawn copper, 98 percent conductivity]** .
 - a. Plating must run entire length of bus.
 - b. Bus must be fully rated for entire length.
 2. Interiors must be factory assembled into unit. Replacing switching and protective devices may not disturb adjacent units or require removing main bus connectors.
 3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
- G. Conductor Connectors: Suitable for use with conductor material and sizes.
1. Material: **[Tin-plated aluminum][Hard-drawn copper, 98 percent conductivity]** .
 2. Terminations must allow use of 75 deg C rated conductors without derating.
 3. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
 4. Main and Neutral Lugs: **[Compression][Mechanical]** type, with lug on neutral bar for each pole in panelboard.
 5. Ground Lugs and Bus-Configured Terminators: **[Compression][Mechanical]** type, with lug on bar for each pole in panelboard.
- H. Quality-Control Label: Panelboards or load centers must be labeled, by qualified electrical testing laboratory recognized by authorities having jurisdiction, for use as service equipment with one or more main service disconnecting and overcurrent protective devices. Panelboards or load centers must have meter enclosures, wiring, connections, and other provisions for utility metering. Coordinate with utility company for exact requirements.
- I. Future Devices: Panelboards or load centers must have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
1. Percentage of Future Space Capacity: **[5][10][20]<Insert number>** percent.
- J. Panelboard Short-Circuit Current Rating:
1. Rated for series-connected system with integral or remote upstream overcurrent protective devices and labeled by qualified electrical testing laboratory recognized by authorities having jurisdiction. Include label or manual with size and type of allowable upstream and branch devices listed and labeled, by qualified electrical testing laboratory recognized by authorities having jurisdiction, for series-connected short-circuit rating.
 - a. Panelboards rated 240 V or less must have short-circuit ratings as shown on Drawings, but not less than 10 000 A(rms) symmetrical.
 - b. Panelboards rated above 240 V and less than 600 V must have short-circuit ratings as

shown on Drawings, but not less than 14 000 A(rms) symmetrical.

2. Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed, by qualified electrical testing laboratory recognized by authorities having jurisdiction, for 100 percent interrupting capacity.
 - a. Panelboards and overcurrent protective devices rated 240 V or less must have short-circuit ratings as shown on Drawings, but not less than 10 000 A(rms) symmetrical.
 - b. Panelboards and overcurrent protective devices rated above 240 V and less than 600 V must have short-circuit ratings as shown on Drawings, but not less than 14 000 A(rms) symmetrical.

2.4 PANELBOARDS

A. UL QEUY - Distribution Panelboard :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[ABB Electrification Installations Products]**
 - b. **[Eaton]**
 - c. **[ESL Power Systems, Inc.]**
 - d. **[Mersen USA]**
 - e. **[Siemens Industry, Inc., Energy Management Division]**
 - f. **[Square D; Schneider Electric USA]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB Electrification Installations Products]**
 - b. **[Eaton]**
 - c. **[ESL Power Systems, Inc.]**
 - d. **[Mersen USA]**
 - e. **[Siemens Industry, Inc., Energy Management Division]**
 - f. **[Square D; Schneider Electric USA]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Distribution Type Panelboards: UL CCN QEUY; including UL 67 and NEMA PB 1.
5. Standard Features:
 - a. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
 - 1) For doors more than **[36 inch (914 mm)]<Insert dimension>** high, provide two latches, keyed alike.

- b. Mains: **[Circuit breaker][Fused switch][Lugs only]** .
 - 1) Location: **[Top][Bottom][Convertible between top and bottom]** .
 - 2) Main Breaker: Main lug interiors up to 400 A must be field convertible to main breaker.
 - c. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: **[Plug-in circuit breakers][Bolt-on circuit breakers][Plug-in circuit breakers where individual positive-locking device requires mechanical release for removal]** .
 - d. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: **[Bolt-on circuit breakers][Plug-in circuit breakers where individual positive-locking device requires mechanical release for removal]** .
 - e. Branch Overcurrent Protective Devices: Fused switches.
6. Other Available Features Required by Project:
- a. Surge Suppression: Factory installed as integral part of indicated panelboards, complying with UL 1449 SPD **[Type 1][Type 2]** .
 - b. Isolated Ground Bus: Adequate for branch-circuit isolated ground conductors; insulated from box.
 - c. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure.
 - d. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and listed and labeled, by qualified electrical testing laboratory recognized by authorities having jurisdiction, as suitable for nonlinear loads in electronic-grade panelboards and others designated on Drawings. Connectors must be sized for double-sized or parallel conductors as indicated on Drawings.
 - e. Do not mount neutral bus in gutter.
 - f. Feed-Through Lugs: **[Compression][Mechanical]** type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
 - g. Subfeed (Double) Lugs: **[Compression][Mechanical]** type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
 - h. Gutter-Tap Lugs: **[Compression][Mechanical]** type suitable for use with conductor material and with matching insulating covers. Locate at same end of bus as incoming lugs or main device.
 - i. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.
 - j. Split Bus: Vertical buses divided into individual vertical sections.
 - 1) Contactors in Main Bus: NEMA ICS 2, Class A, **[electrically][mechanically]** held, general-purpose controller, with same short-circuit interrupting rating as panelboard.
 - a) Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.
 - b) External Control-Power Source: **[120 V branch circuit][24 V control circuit]<Insert requirement>** .
- B. UL QEUY - Lighting and Appliance Branch-Circuit Panelboard :
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[ABB Electrification Installations Products]**



- b. **[Bender Inc.; Bender GmbH & Co. KG]**
 - c. **[Eaton]**
 - d. **[Siemens Industry, Inc., Energy Management Division]**
 - e. **[Square D; Schneider Electric USA]**
 - f. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB Electrification Installations Products]**
 - b. **[Bender Inc.; Bender GmbH & Co. KG]**
 - c. **[Eaton]**
 - d. **[Siemens Industry, Inc., Energy Management Division]**
 - e. **[Square D; Schneider Electric USA]**
 - f. **<Insert manufacturer's name>**
- 3. Source Limitations: Obtain products from single manufacturer.
- 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Lighting and Appliance Branch-Circuit Type Panelboards: UL CCN QEUY; including UL 67 and NEMA PB 1.
- 5. Standard Features:
 - a. Mains: **[Circuit breaker][or][lugs only]** .
 - 1) Location: **[Top][Bottom][Convertible between top and bottom]** .
 - 2) Main Breaker: Main lug interiors up to 400 A must be field convertible to main breaker.
 - b. Branch Overcurrent Protective Devices: **[Plug-in][Bolt-on]** circuit breakers, replaceable without disturbing adjacent units.
- 6. Other Available Features Required by Project:
 - a. Surge Suppression: Factory installed as integral part of indicated panelboards, complying with UL 1449 SPD **[Type 1][Type 2]** .
 - b. Isolated Ground Bus: Adequate for branch-circuit isolated ground conductors; insulated from box.
 - c. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure.
 - d. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and listed and labeled, by qualified electrical testing laboratory recognized by authorities having jurisdiction, as suitable for nonlinear loads in electronic-grade panelboards and others designated on Drawings. Connectors must be sized for double-sized or parallel conductors as indicated on Drawings.
 - e. Do not mount neutral bus in gutter.
 - f. Feed-Through Lugs: **[Compression][Mechanical]** type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
 - g. Subfeed (Double) Lugs: **[Compression][Mechanical]** type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
 - h. Gutter-Tap Lugs: **[Compression][Mechanical]** type suitable for use with conductor

material and with matching insulating covers. Locate at same end of bus as incoming lugs or main device.

- i. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.
- j. Split Bus: Vertical buses divided into individual vertical sections.
 - 1) Contactors in Main Bus: NEMA ICS 2, Class A, **[electrically][mechanically]** held, general-purpose controller, with same short-circuit interrupting rating as panelboard.
 - a) Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.
 - b) External Control-Power Source: **[120 V branch circuit][24 V control circuit]<Insert requirement>** .
- k. Doors: Door-in-door construction with concealed hinges; secured with **[flush][or][multipoint]** latch with tumbler lock; keyed alike. **[Outer door must permit full access to panel interior. Inner door must permit access to breaker operating handles and labeling, but current carrying terminals and bus must remain concealed.]**
- l. Column-Type Panelboards: Single row of overcurrent devices **[with narrow gutter extension][and][overhead junction box equipped with ground and neutral terminal buses]** .
 - 1) Column-Type Panelboard Doors: Concealed hinges secured with multipoint latch with tumbler lock; keyed alike.

C. UL QEUY - Electronic-Grade Panelboard :

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[ABB Electrification Installations Products]**
 - b. **[Eaton]**
 - c. **[Siemens Industry, Inc., Energy Management Division]**
 - d. **[Square D; Schneider Electric USA]**
 - e. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB Electrification Installations Products]**
 - b. **[Eaton]**
 - c. **[Siemens Industry, Inc., Energy Management Division]**
 - d. **[Square D; Schneider Electric USA]**
 - e. **<Insert manufacturer's name>**
- 3. Source Limitations: Obtain products from single manufacturer.
- 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Electronic-Grade Type Panelboards: UL CEN QEUY; including UL 67 and NEMA PB 1.

5. Standard Features:

- a. Main Overcurrent Protective Devices: Bolt-on thermal-magnetic circuit breakers.
- b. Branch Overcurrent Protective Devices: Bolt-on thermal-magnetic circuit breakers.
- c. Factory-Installed, Integral SPD:
 - 1) Peak Surge Current Rating: Minimum single-pulse surge current withstand rating per phase may not be less than **[100 kA]<Insert value>** . Peak surge current rating must be arithmetic sum of ratings of individual MOVs in given mode.
 - 2) Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V or 208Y/120 V, three-phase, four-wire circuits may not exceed the following:
 - a) Line to Neutral: **[1200 V for 480Y/277 V][700 V for 208Y/120 V]** .
 - b) Line to Ground: **[1200 V for 480Y/277 V][700 V for 208Y/120 V]** .
 - c) Neutral to Ground: **[1200 V for 480Y/277 V][700 V for 208Y/120 V]** .
 - d) Line to Line: **[2000 V for 480Y/277 V][1200 V for 208Y/120 V]** .
 - 3) Protection modes and UL 1449 VPR for 240/120 V, single-phase, three-wire circuits may not exceed the following:
 - a) Line to Neutral: 700 V.
 - b) Line to Ground: 700 V.
 - c) Neutral to Ground: 700 V.
 - d) Line to Line: 1200 V.
 - 4) SCCR: Equal to **[SCCR of panelboard in which installed][or exceed 100 kA][or exceed 200 kA][or exceed]<Insert value>** .
 - 5) Inominal Rating: **[20 kA][10 kA]** .
- d. Buses:
 - 1) Copper phase and neutral buses; 200 percent capacity neutral bus and lugs.
 - 2) Copper equipment and isolated ground buses.
- e. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

D. UL QEUY - Load Center :

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[ABB Electrification Installations Products]**
 - b. **[Eaton]**
 - c. **[Siemens Industry, Inc., Energy Management Division]**
 - d. **[Square D; Schneider Electric USA]**
 - e. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB Electrification Installations Products]**
 - b. **[Eaton]**

- c. **[Siemens Industry, Inc., Energy Management Division]**
- d. **[Square D; Schneider Electric USA]**
- e. **<Insert manufacturer's name>**
- 3. Source Limitations: Obtain products from single manufacturer.
- 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Electronic-Grade Type Panelboards: UL CCN QEUY; including UL 67.
- 5. Standard Features:
 - a. Mains: **[Circuit breaker][or][lugs only]** .
 - b. Branch Overcurrent Protective Devices: Plug-in circuit breakers, replaceable without disturbing adjacent units.
 - c. Doors: Concealed hinges secured with flush latch with tumbler lock; keyed alike.
 - d. Conductor Connectors: Mechanical type for main, neutral, and ground lugs and buses.

2.5 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - 1. **[ABB Electrification Installations Products]**
 - 2. **[Eaton]**
 - 3. **[Siemens Industry, Inc., Energy Management Division]**
 - 4. **[Square D; Schneider Electric USA]**
 - 5. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[ABB Electrification Installations Products]**
 - 2. **[Eaton]**
 - 3. **[Siemens Industry, Inc., Energy Management Division]**
 - 4. **[Square D; Schneider Electric USA]**
 - 5. **<Insert manufacturer's name>**
- C. MCCB: Comply with UL 489, with **[series-connected rating][interrupting capacity]** to meet available fault currents.
 - 1. Thermal-Magnetic Circuit Breakers:
 - a. Inverse time-current element for low-level overloads.
 - b. Instantaneous magnetic trip element for short circuits.
 - c. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 - 2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
 - 3. Electronic Trip Circuit Breakers:
 - a. RMS sensing.
 - b. Field-replaceable rating plug or electronic trip.

- c. Digital display of settings, trip targets, and indicated metering displays.
 - d. Multi-button keypad to access programmable functions and monitored data.
 - e. Ten-event, trip-history log. Each trip event must be recorded with type, phase, and magnitude of fault that caused trip.
 - f. Integral test jack for connection to portable test set or laptop computer.
 - g. Field-Adjustable Settings:
 - 1) Instantaneous trip.
 - 2) Long- and short-time pickup levels.
 - 3) Long- and short-time adjustments.
 - 4) Ground-fault pickup level, time delay, and I squared T response.
4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
 5. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6 mA trip).
 6. GFPE Circuit Breakers: Class B ground-fault protection (30 mA trip).
 7. Arc-Fault Circuit Interrupter Circuit Breakers: Comply with UL 1699; 120/240 V, single-pole configuration.
 8. Subfeed Circuit Breakers: Vertically mounted.
 9. MCCB Features and Accessories:
 - a. Standard frame sizes, trip ratings, and number of poles.
 - b. Breaker handle indicates tripped status.
 - c. UL listed for reverse connection without restrictive line or load ratings.
 - d. Lugs: **[Compression][Mechanical]** style, suitable for number, size, trip ratings, and conductor materials.
 - e. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and HID lighting circuits.
 - f. Ground-Fault Protection: **[Integrally mounted][Remote-mounted]** relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 - g. Communication Capability: **[Circuit-breaker-mounted][Universal-mounted][Integral][Din-rail-mounted]** communication module with functions and features compatible with power monitoring and control system.
 - h. Shunt Trip: **[120 V][24 V]<Insert voltage>** trip coil energized from separate circuit, set to trip at **[55][75]** percent of rated voltage.
 - i. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in **[on][off][on or off]** position.
 - j. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.
 - k. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage **[without intentional][with field-adjustable 0.1- to 0.6-second]** time delay.
 - l. Rating Plugs: Three-pole breakers with ampere ratings greater than **[150]<Insert value>** A must have interchangeable rating plugs or electronic adjustable trip units.
 - m. Auxiliary Contacts: **[One, SPDT switch][Two, SPDT switches]** with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts and "b" contacts operate in reverse of circuit-breaker contacts.
 - n. Alarm Switch: Single-pole, normally open contact that actuates only when circuit breaker trips.
 - o. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key must be removable only when circuit breaker is in off position.
 - p. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function with other upstream or downstream devices.
 - q. Multipole units enclosed in **[single housing with single handle][or][factory assembled to operate as single unit]**.

- D. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.
1. Provide fuses and spare fuse cabinet.
 2. Fused Switch Features and Accessories:
 - a. Standard ampere ratings and number of poles.
 - b. Mechanical cover interlock with manual interlock override, to prevent opening of cover when switch is in on position. Interlock must prevent switch from being turned on with cover open. Operating handle must have lock-off means with provisions for three padlocks.
 - c. Auxiliary Contacts: **[One][Two]** normally open and normally closed contact(s) that operate with switch handle operation.

2.6 MAINTENANCE MATERIAL ITEMS

- A. Spare Parts: Furnish to Owner spare parts, for repairing panelboards and related equipment, that are packaged with protective covering for storage on-site and identified with labels describing contents. [**Include the following:**]
1. Keys: **[Two]<Insert number>** spares for each type of panelboard cabinet lock.
 2. Circuit Breakers Including GFCI and GFPE Types: **[Two]<Insert number>** spares for each panelboard.
 3. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
 4. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
- B. Special Tools: Furnish to Owner proprietary equipment, keys, and software required to operate, maintain, repair, adjust, or implement future changes to panelboards and related equipment, that are packaged with protective covering for storage on-site and identified with labels describing contents. [**Include the following:**]
1. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
 2. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.
- B. Receive, inspect, handle, and store panelboards in accordance with **[NECA 407][NEMA PB 1.1]** .
- C. Examine panelboards before installation. Reject panelboards that are damaged, rusted, or have been subjected to water saturation.
- D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

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

3.2 INSTALLATION OF PANELBOARDS

- A. Comply with manufacturer's published instructions.
- B. Reference Standards:
1. Panelboards: Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with **[NECA 407][NEMA PB 1.1]** .
 2. Consult Architect for resolution of conflicting requirements.
- C. Special Techniques:
1. Equipment Mounting:
 - a. Install floor-mounted panelboards on cast-in-place concrete equipment base(s).
 - b. Attach panelboard to vertical finished or structural surface behind panelboard.
 - c. Mount surface-mounted panelboards to steel slotted supports **[5/8 inch (16 mm)][1-1/4 inch (32 mm)]** in depth. Orient steel slotted supports vertically.
 - d. Provide seismic control devices.
 2. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.
 3. Provide mounting and anchoring devices.
 4. Mount top of trim **[7.5 ft (2.3 m)]<Insert height>** above finished floor unless otherwise indicated.
 5. Mount panelboard cabinet plumb and rigid without distortion of box.
 6. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
 7. Install overcurrent protective devices and controllers not already factory installed.
 - a. Set field-adjustable, circuit-breaker trip ranges.
 - b. Tighten bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver in accordance with manufacturer's published instructions.
 8. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.
 9. Install filler plates in unused spaces.
 10. Stub four **1 inch (25 mm)** empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in future. Stub four **1 inch (25 mm)** empty conduits into raised floor space or below slab not on grade.
 11. Arrange conductors in gutters into groups and bundle and wrap with wire ties [**after completing load balancing**] .
 12. Mount spare fuse cabinet in accessible location.
- D. Interfaces with Other Work:
1. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

3.3 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components.
- B. Install warning signs.
- C. Panelboard Nameplates: Label each panelboard with nameplate.
- D. Device Nameplates: Label each branch circuit device in power panelboards with nameplate.
- E. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles must be located on interior of panelboard door.
- F. Breaker Labels: Faceplate must list current rating, UL and IEC certification standards, and AIC rating.
- G. Circuit Directory:
 - 1. Provide directory card inside panelboard door, mounted in **[transparent card holder][metal frame with transparent protective cover]** .
 - a. Circuit directory must identify specific purpose with detail sufficient to distinguish it from other circuits.
 - 2. Provide computer-generated circuit directory mounted inside panelboard door with transparent plastic protective cover.
 - a. Circuit directory must identify specific purpose with detail sufficient to distinguish it from other circuits.
 - 3. Create directory to indicate installed circuit loads **[after balancing panelboard loads]** ; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.

3.4 FIELD QUALITY CONTROL

- A. Adminstrant for Low-Voltage Electrical Tests and Inspections:
 - 1. **[Owner][Tenant]** will engage qualified low-voltage electrical testing and inspecting agency to administer and perform tests and inspections.
 - 2. Engage qualified low-voltage electrical testing and inspecting agency to administer and perform tests and inspections.
 - 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
 - 4. Administer and perform tests and inspections **[with assistance of factory-authorized service representative]** .
- B. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- C. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>** .

D. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers [**and low-voltage surge arrestors**] stated in NETA ATS, Paragraph 7.6 Circuit Breakers [**and Paragraph 7.19.1 Surge Arrestors, Low-Voltage**] . [Do not perform][Perform] optional tests. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Perform the following infrared scan tests and inspections and prepare reports:
 - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
 - b. Follow-up Infrared Scanning: Perform additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
 - c. Instruments and Equipment:
 - 1) Use infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

E. Nonconforming Work:

1. Panelboards will be considered defective if they do not pass tests and inspections.
2. Remove and replace defective units and retest.

F. Field Quality Control Reports: Collect, assemble, and submit test and inspection reports.

1. Include certified report that identifies panelboards included and that describes scanning results, with comparisons of two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

G. Manufacturer Services: Engage factory-authorized service representative to [support][supervise] field tests and inspections.

3.5 ADJUSTING

- A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended in writing by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges.
- C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes. Prior to making circuit changes to achieve load balancing, inform Architect of effect on phase color coding.
 1. Measure loads during period of normal facility operations.
 2. Perform circuit changes to achieve load balancing outside normal facility operation schedule or at times directed by Architect. Avoid disrupting services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
 3. After changing circuits to achieve load balancing, recheck loads during normal facility operations. Record load readings before and after changing circuits to achieve load balancing.
 4. Tolerance: Maximum difference between phase loads, within panelboard, may not exceed 20 percent.



3.6 PROTECTION

- A. Temporary Heating: Prior to energizing panelboards, apply temporary heat to maintain temperature in accordance with manufacturer's published instructions.

END OF SECTION 26 24 16 00



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SECTION 26 24 16 00A - ELECTRONICALLY OPERATED CIRCUIT-BREAKER PANELBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Panelboards.
2. Circuit breakers.
3. Main controllers.
4. Slave panel controllers.
5. Control network.
6. Manual switches and cover plates.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.2 DEFINITIONS

- A. Monitoring:** Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.

1.3 ACTION SUBMITTALS

A. Product Data:

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for control modules, power distribution components, manual switches and cover plates, and conductors and cables.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For each electronically operated, circuit-breaker panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types and details for types other than Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Short-circuit current rating of panelboards and overcurrent protective devices.
5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
6. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graph paper; include selectable ranges for

- each type of overcurrent protective device.
- 7. Include diagrams for power, signal, and control wiring.
- 8. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices to be used. Describe characteristics of network and other data communication lines.
- 9. Submit evidence that electronic controls are compatible with connected monitoring and control devices and systems specified in other Sections.
 - a. Show interconnecting signal and control wiring and interfacing devices that prove compatibility of inputs and outputs.
 - b. For networked controls, list network protocols and provide statements from manufacturers that input and output devices comply with interoperability requirements of network protocol.
- C. Field quality-control reports.
- D. Sample Warranty: For manufacturer's special warranty.

1.4 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Electrically Operated, Molded-Case Circuit Breakers: Equal to **<Insert number>** percent of amount installed[**for each size indicated**], but no fewer than **<Insert number>**.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Handle and prepare panelboards for installation according to **[NECA 407][NEMA PB 1.1]**.

1.6 WARRANTY

- A. Special Manufacturer Extended Warranty: Manufacturer warrants that components of panelboards perform in accordance with specified requirements and agrees to provide repair or replacement of components that fail to perform as specified within extended warranty period.
 - 1. Initial Extended Warranty Period: **[Two]<Insert number>** year(s) from date of Substantial Completion, for labor, materials, and equipment.
 - 2. Follow-on Extended Warranty Period: **[Five]<Insert number>** year(s) from date of Substantial Completion, for materials that failed because of transient voltage surges only, f.o.b. the nearest shipping point to Project site.

PART 2 - PRODUCTS

2.1 ELECTRICALLY OPERATED CIRCUIT-BREAKER PANELBOARDS

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

1. [ABB, Electrification Business]
2. [Eaton]
3. [Siemens Industry, Inc., Energy Management Division]
4. [Square D; Schneider Electric USA]
5. <Insert manufacturer's name>

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

1. [ABB, Electrification Business]
2. [Eaton]
3. [Siemens Industry, Inc., Energy Management Division]
4. [Square D; Schneider Electric USA]
5. <Insert manufacturer's name>

- C. Source Limitations: Obtain electrically operated circuit breakers and power distribution components from single manufacturer.

2.2 SYSTEM DESCRIPTION

- A. Input signal from field-mounted or on-board signal source must open or close one or more electrically operated circuit breakers in electronically operated, circuit-breaker panelboards. Any combination of inputs must be programmable to any combination outputs.
- B. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by the authorities having jurisdiction, and marked for intended location and application.
- C. Comply with 47 CFR Part 15, Subpart A and Subpart B, for Class A digital devices.

2.3 PERFORMANCE REQUIREMENTS

- A. Expansion Requirements: Capacity for future expansion of number of control functions by 25 percent of current capacity; to include equipment ratings, housing capacities, spare spaces for circuit breakers, terminals, number of conductors in control cables, and control software.
- B. Interface with DDC System for HVAC: Provide hardware and software to enable DDC system for HVAC to monitor, control, display, and record data for use in processing reports.
 1. Hardwired Points:
 - a. Monitoring: On-off status, <Insert monitoring point>.
 - b. Control: On-off operation, <Insert control point>.
 2. Communication Interface: Comply with [ASHRAE 135][ISO/IEC 14908-1][MODBUS Application Protocol Specification]<Insert type of interface> communication interface with DDC system for HVAC must enable DDC system for HVAC operator to remotely control and monitor electronically operated circuit breakers from a DDC system for HVAC operator workstation. Control features and monitoring points displayed locally at panelboard controller must be available through DDC system for HVAC.

2.4 PANELBOARDS

- A. Electronically operated, circuit-breaker panelboards may contain remotely operated circuit breakers and standard branch circuit breakers specified in Section 262416 "Panelboards."
- B. Assemblies: Comply with UL 67 and NEMA PB 1.
- C. Surge Protective Device:
 - 1. Field mounted, complying with Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."
 - 2. Integrally mounted, complying with UL 1449 Type 1.
 - a. Comply with IEEE C62.41, Category C, 200 kA short-circuit current rating.
 - b. Non-modular type with the following features and accessories:
 - 1) Digital-display indicator lights for power and protection status.
 - 2) **<Insert features and accessories>**.
- D. Enclosures: Comply with UL 50.
- E. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
- F. Panelboard Short-Circuit Current Rating:
 - 1. Rated for series-connected system with integral or remote upstream overcurrent protective devices and labeled by a qualified electrical testing laboratory. Include size and type of allowable upstream and branch devices, listed and labeled for series-connected, short-circuit rating by a qualified electrical testing laboratory.
 - 2. Fully rated to interrupt **[10 kA]** symmetrical short-circuit current available at terminals.

2.5 CIRCUIT BREAKERS

- A. Remotely operated branch circuit breakers must provide branch circuit overcurrent protection.
- B. Labeled with SWD and HID Ratings: Comply with UL 489 for 15 and 20 A, single-pole branch devices. **[15 and 20 A circuit breakers, if scheduled, must be a product of same manufacturer, and be of same class as rated circuit breakers.]**
- C. Switching Endurance Rating: Not less than **[50,000][200,000]<Insert number>** full-load open/close/open remote operations.
- D. Remotely Operated Circuit Breakers: Manual override switch or handle position must enable or disable remote operation of device and allow breaker handle to manually control breaker's on-off status.

2.6 MAIN CONTROLLERS

- A. Description: Controllers must contain power supply and electronic control for operating and monitoring remotely operated branch circuit breakers.
 - 1. Comply with UL 916 (CSA C22.2, No. 205); with a microprocessor-based, solid-state, 365-day

- timing and control unit.
2. Power Supply: Powered from panelboard, sized to provide control power for operation of remotely operated circuit breakers, controller, bus system, control-voltage inputs, and field-installed sensors.
3. Integral keypad and digital-display front panel for local setup, including the following:
 - a. Log and display remotely operated breaker on-time.
 - b. Provision to accept downloadable firmware so that latest features may be added in future without replacing module.
4. Nonvolatile memory must retain all setup configurations. After a power failure, controller must automatically reboot and return to normal system operation.
5. Ethernet Communications: Comply with [ASHRAE 135][ISO/IEC 14908-1][**"MODBUS Application Protocol Specification"**]<Insert network protocol> protocols.
 - a. Each input connected to controller must control any remotely operated breaker in any other networked electronically operated, circuit-breaker panelboard.
 - b. A schedule programmed at one controller must be able to control any remotely operated breaker in any other networked panelboard.
6. Time Synchronization: Timing unit must be updated not less than every <Insert number> hour(s) with network time server.
7. Web Server: Display information listed below over a standard Web-enabled server for displaying information over a standard Web browser.
 - a. A secure, password-protected login screen for modifying operational parameters, accessible to authorized users via Web page interface.
 - b. Separate Web page, showing status of each main and slave electronically operated, circuit-breaker panelboards with arrangement of breakers on page matching physical appearance of panel. Status must include breaker nametags, pole configuration, location in panel, actual contact state (on-off/tripped/manual), and breaker on-time.
 - c. Panel summary showing master and slave panels connected to controller.
 - d. Controller diagnostic information.
 - e. Show front panel mimic screens for setting up controller parameters, input types, zones, and operating schedules. These mimic screens must also allow direct breaker control and zone overrides.
8. Alarm and E-mail Notification: Automatically initiate alarms based on preconfigured conditions listed below and routing alarm alerts as set at control panel.
 - a. General Alarms: Power loss, non-responding breakers, loss and restoration of sub-net communications, loss and restoration of serial port communications, loss and restoration of DDC system for HVAC commands.
 - b. Specific Alarms: Input status, zone status, breaker status on-time (zero to 99999 hours).
 - c. E-mail Notification: Automatically route e-mail messages to five individual e-mail addresses. Within body text of e-mail, include a link that will automatically redirect user to associated panels' status Web page.

B. Timing Unit:

1. 365-day calendar, astronomical clock, and automatic adjustments for daylight savings and leap year.
2. Clock configurable for 12-hour (A.M./P.M.) or 24-hour format.
3. [16]<Insert number> independent schedules, each having [24]<Insert number> time periods.
4. Schedule periods settable to the minute.
5. Day of week, day of month, day of year with one-time or repeating capability.

6. [32]<Insert number> special date periods.

C. With [eight][16]<Insert number> inputs, each configurable to the following parameters:

1. Normally open, normally closed, two-wire maintained toggle, two-wire momentary toggle, two-wire momentary on, two-wire momentary off, or three-wire momentary operation.
2. On and off-delay timers for local override operation, adjustable from five minutes to 12 hours. Local override must be by field-installed, two-wire momentary toggle switch.

2.7 SLAVE PANEL CONTROLLERS

- A. Slave panels must contain necessary busses and network hardware to allow connection of sub-net wiring between panels, with programming at main panel controller. Programmable timing unit, Web server, alarm and e-mail notification, and Ethernet connection to control network is not required provided all of these functions are available for slave panel from main panel controller.
- B. Sub-net wiring connections must allow connection of wiring to a terminal that can be removed from panel without interrupting communications to other panels.
- C. Slave panels must contain a nameplate label attached to deadfront trim indicating panel designation, panel network address, and panel designation of associated master panel.

2.8 CONTROL NETWORK

- A. Panel Controllers: Networked with other [electronically operated, circuit-breaker panel controllers][DDC system for HVAC controllers] in a peer-to-peer configuration using Ethernet [10Base-T][100Base-T] network.
- B. Protocol: Controllers must support serial MS/TP and Ethernet IP communications, and must be able to communicate directly via DDC system for HVAC TIA-485 serial networks and Ethernet 10Base-T networks as a native device.

2.9 MANUAL SWITCHES AND COVER PLATES

- A. Keypads: Programmable, designed to control functions associated with equipment of this Section. Units must be able to control any system output device.
- B. Push-Button Switches: Modular, momentary-contact, control-voltage type.
 1. Match color specified in Section 262726 "Wiring Devices."
 2. Integral green [digital-display][neon] pilot light to indicate when circuit is on.
 3. Internal white [digital-display][neon] locator light to illuminate when circuit is off.
- C. Manual, Maintained Contact, Line-Voltage or Control-Voltage Switch: Comply with Section 262726 "Wiring Devices."
- D. Cover Plates: Single and multigang cover plates as specified in Section 260533.16 "Boxes and Covers for Electrical Systems."
- E. Legend: Engraved or permanently silk-screened on cover plate where indicated. Use designations indicated on Drawings.

2.10 CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Class 2 Power Source: Not smaller than No. 12 AWG. Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Class 2 and Class 3 Control Cables: Multiconductor cable with copper conductors not smaller than **[No. 18][No. 22][No. 24]** AWG. Comply with Section 260523 "Control-Voltage Electrical Power Cables."
- C. Class 1 Control Cables: Multiconductor cable with copper conductors not smaller than **[No. 14][No. 16][No. 18]** AWG. Comply with Section 260523 "Control-Voltage Electrical Power Cables."
- D. Twisted-Pair Data Cable:
 - 1. **[Category 5e][Category 6][Category 6a]**. Comply with requirements for twisted pair cabling in Section 260523 "Control-Voltage Electrical Power Cables."
 - 2. **[Category 5e][Category 6][Category 6a]**. Comply with requirements in Section 271513 "Communications Copper Horizontal Cabling."

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Receive, inspect, handle, and store panelboards according to **[NECA 407][NEMA PB 1.1]**.
- B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.
- C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF WIRING

- A. Wiring Method:
 - 1. Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
 - 2. Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters**[and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used]**. Conceal raceway and cables except in unfinished spaces.
 - a. Install plenum cable in environmental air spaces, including plenum ceilings.
 - b. Comply with requirements for cable trays specified in Section 260536 "Cable Trays for Electrical Systems."
 - c. Comply with requirements for raceways specified in Section 260533.13 "Conduits for Electrical Systems."
- B. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

3.3 INSTALLATION OF PANELBOARDS

- A. Install panelboards and accessories according to **[NECA 407][NEMA PB 1.1]**.
- B. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- C. Mounting Height: **[90 inch (2286 mm)]<Insert dimension>** to top of trim above finished floor unless otherwise indicated.
- D. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
- E. Install filler plates in unused spaces.

3.4 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Section 260553 "Identification for Electrical Systems."
- C. Create a directory to indicate loads served by each circuit; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are unacceptable.
- D. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

- A. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- B. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.
- C. Tests and Inspections:
- D. Perform the following tests and inspections **[with the assistance of a factory-authorized service representative]**:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 3. Perform the following infrared scan tests and inspections and prepare reports:

- a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
- b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
- c. Instruments and Equipment:
 - 1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

E. Nonconforming Work:

1. Panelboard will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

F. Prepare test and inspection reports, including a certified report that identifies panelboards included and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

G. Manufacturer Services:

1. Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.

3.6 STARTUP SERVICE

A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.

1. Complete installation and startup checks according to manufacturer's instructions.
2. Confirm correct communication wiring, initiate communications between panels, and program control system according to approved time-of-day schedules and input override assignments.
3. **<Insert startup steps if any>**.

3.7 ADJUSTING

A. Occupancy Adjustments: When requested within **[12]<Insert number>** months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to **[two]<Insert number>** visits to Project during other-than-normal occupancy hours for this purpose.

3.8 MAINTENANCE

A. Software and Firmware Service Agreement:

1. Technical Support: Beginning at Substantial Completion, verify that software and firmware service agreement includes software support for **[two]<Insert number>** years.
2. Upgrade Service: At Substantial Completion, update software and firmware to latest version. Install and program software upgrades that become available within **[two]<Insert number>** years from date of Substantial Completion. Verify upgrading software includes operating system and new or revised licenses for using software.

- a. Upgrade Notice: No fewer than **[30]<Insert number>** days to allow Owner to schedule and



access the system and to upgrade computer equipment if necessary.

3. Upgrade Reports: Prepare written report after each update, documenting upgrades installed.

END OF SECTION 26 24 16 00A

SECTION 26 24 19 00 - MOTOR-CONTROL CENTERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes MCCs for use with ac circuits rated 600 V and less, with combination controllers and having the following factory-installed components:
 - 1. Automatic power transfer.
 - 2. Feeder-tap units.
 - 3. Measurement and control.
 - 4. Auxiliary devices.
 - 5. Panelboards.
 - 6. Transformers.

1.2 DEFINITIONS

- A. CPT: Control power transformer.
- B. MCC: Motor-control center.
- C. MCCB: Molded-case circuit breaker.
- D. MCP: Motor-circuit protector.
- E. OCPD: Overcurrent protective device.
- F. PID: Control action; proportional plus integral plus derivative.
- G. PT: Potential transformer.
- H. SPD: Surge protective device.
- I. SCR: Silicon-controlled rectifier.
- J. VFC: Variable-frequency controller.
- K. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for MCCs.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories for each cell of the MCC.

B. Sustainable Design Submittals:

1. Product Data: For continuous metering equipment for energy consumption.
2. Product Data: For continuous metering equipment for energy consumption.
3. Product Data: For continuous metering equipment for energy consumption.
4. Product Data: For continuous metering equipment for energy consumption.
5. Product Data: For continuous metering equipment for energy consumption.

C. Shop Drawings: For each MCC, manufacturer's **[approval][custom][and][production]** drawings as defined in UL 845. In addition to requirements specified in UL 845, include dimensioned plans, elevations, and sections; and conduit entry locations and sizes, mounting arrangements, and details, including required clearances and service space around equipment.

1. Show tabulations of installed devices, equipment features, and ratings. Include the following:
 - a. Each installed unit's type and details.
 - b. Factory-installed devices.
 - c. Enclosure types and details.
 - d. Nameplate legends.
 - e. Short-circuit current (withstand) rating of complete MCC, and for bus structure and each unit.
 - f. Features, characteristics, ratings, and factory settings of each installed controller and feeder device, and installed devices.
 - g. Specified optional features and accessories.
 - h. **<Insert required information>**.
2. Schematic **[and Connection]** Wiring Diagrams: For power, signal, and control wiring for each installed controller.
3. Nameplate legends.
4. Vertical and horizontal bus capacities.
5. Features, characteristics, ratings, and factory settings of each installed unit.
6. **<Insert required information>**.

1.4 INFORMATIONAL SUBMITTALS

- A. Standard Drawings: For each MCC, as defined in UL 845.
- B. Production Drawings: For each MCC, as defined in UL 845.
- C. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around MCCs where pipe and ducts are prohibited. Show MCC layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.
- D. Qualification Data: For testing agency.
- E. Seismic Qualification Data: Certificates, for MCCs, accessories, and components, from manufacturer.
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their

installation requirements.

- F. Product Certificates: For each MCC.
- G. Source quality-control reports.
- H. Field quality-control reports.
- I. Load-Current and Overload Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.
- J. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor running overload protection suit actual motors to be protected.
- K. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For MCCs, all installed devices, and components to include in emergency, operation, and maintenance manuals.
 - 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - 2. Manufacturer's Record Drawings: As defined in UL 845. In addition to requirements specified in UL 845, include field modifications **[and field-assigned wiring identification]** incorporated during construction by manufacturer, Contractor, or both.
 - 3. Manufacturer's written instructions for testing and adjusting circuit breaker and MCP trip settings.
 - 4. Manufacturer's written instructions for setting field-adjustable overload relays.
 - 5. Manufacturer's written instructions for testing, adjusting, and reprogramming reduced-voltage, solid-state controllers.
 - 6. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
 - 7. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Power Fuses: Equal to **[10]<Insert number>** percent of quantity installed for each size and type, but no fewer than **[three]<Insert number>** of each size and type.
 - 2. Control Power Fuses: Equal to **[10]<Insert number>** percent of quantity installed for each size and type, but no fewer than **[two]<Insert number>** of each size and type.
 - 3. Indicating Lights: **[Two]<Insert number>** of each type and color installed.
 - 4. Auxiliary Contacts: Furnish **[one]<Insert number>** spare(s) for each size and type of magnetic controller installed.
 - 5. Power Contacts: Furnish **[three]<Insert number>** spares for each size and type of magnetic contactor installed.
 - 6. **<Insert extra materials>**.

1.7 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Member company of NETA.
 - 1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.
- B. Source Limitations: Obtain MCCs and controllers of a single type from single source from single manufacturer.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, and marked for intended use.
- D. UL Compliance: MCCs shall comply with UL 845 and shall be listed and labeled by a qualified testing agency.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Deliver MCCs in shipping splits of lengths that can be moved past obstructions in delivery paths.
- B. Handle MCCs according to the following:
 - 1. NECA 402, "Recommended Practice for Installing and Maintaining Motor Control Centers."
 - 2. NEMA ICS 2.3, "Instructions for the Handling, Installation, Operation, and Maintenance of Motor Control Centers Rated Not More Than 600 Volts."
- C. If stored in space that is not permanently enclosed and air conditioned, remove loose packing and flammable materials from inside MCCs; **[install temporary electric heating, with at least 250 W per vertical section][connect factory-installed space heaters to temporary electrical service]**.

1.9 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace **[MCC][and][SPD]<Insert devices>** that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: **[Five]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS**2.1 MOTOR-CONTROL CENTERS**

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[ABB, Electrification Business]**
 - 2. **[Eaton]**
 - 3. **[Rockwell Automation, Inc.]**
 - 4. **[Siemens Industry, Inc., Energy Management Division]**
 - 5. **[Square D; Schneider Electric USA]**

6. <Insert manufacturer's name>

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

1. [ABB, Electrification Business]
2. [Eaton]
3. [Rockwell Automation, Inc.]
4. [Siemens Industry, Inc., Energy Management Division]
5. [Square D; Schneider Electric USA]
6. <Insert manufacturer's name>

2.2 SYSTEM DESCRIPTION

A. NEMA Compliance: Fabricate and label MCCs to comply with NEMA ICS 18.

B. Ambient Environment Ratings:

1. Ambient Temperature Rating: Not less than **0 deg F (minus 18 deg C)** and not exceeding **104 deg F (40 deg C)**, with an average value not exceeding **95 deg F (35 deg C)** over a 24-hour period.
2. Ambient Storage Temperature Rating: Not less than **minus 4 deg F (minus 20 deg C)** and not exceeding **140 deg F (60 deg C)**
3. Humidity Rating: Less than 95 percent (noncondensing).
4. Altitude Rating: Not exceeding **6600 feet (2000 m)**, or **3300 feet (1000 m)** if MCC includes solid-state devices.
5. <Insert unusual service condition>.

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

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: MCCs shall withstand the effects of earthquake motions determined according to **[ASCE/SEI 7]<Insert requirement>**.

1. The term "withstand" means "the system will remain in place without separation of any parts when subjected to the seismic forces specified[**and the system will be fully operational after the seismic event**]."
2. Component Importance Factor: **[1.5][1.0]**.
3. Component Amplification Factor: 2.5.
4. Component Response Modification Factor: 6.0.

B. Capacities and Characteristics:

1. MCC Enclosure and Assembly:
 - a. Nominal System Voltage: **[277][277/480][600]<Insert number(s)>-V ac**.
 - b. Service Equipment Rated: **[Yes][No]**.
 - c. Enclosure: NEMA 250, Type **<Insert number or number and a letter>**.
2. Integrated Short-Circuit Rating for MCC:

- a. Combination series rated; **<Insert number> kA.**
 - b. Fully rated; **<Insert number> kA.**
3. Integrated Short-Circuit Rating for Each Unit:
 - a. Combination series rated; **<Insert number> kA.**
 - b. Fully rated; **<Insert number> kA.**
4. Wiring Class: **<Insert numbers and letters>.**
5. Bus:
 - a. Horizontal Bus: **<Insert number> kA.**
 - b. Neutral Bus: **[None][50 percent][Full size][150 percent]<Insert percentage>.**
6. Main Disconnect Device:
 - a. Main Disconnect: **[MCCB, UL 489,][Fusible switch, UL 98,] three pole, <Insert number> A.[Manually operated, electrically tripped.]**
 - b. SPD: UL 1449, **[Type 1][Type 2].**
 - c. Optional Features: **<Insert items>.**
7. Automatic Power Transfer: Electrically operated MCCBs, three pole, **<Insert number> A.**
8. Magnetic Controllers:
 - a. Tag Number: **<Insert numbers and letters>, <Insert description>, <Insert number> hp, <Insert number> full-load A.**
 - 1) Classification by Starting Method: **<Insert text>.**
 - 2) Controller Size: **<Insert number or numbers and letters> complying with NEMA ICS 2.**
 - 3) Optional Features: **<Insert items>.**
9. Reduced-Voltage Solid-State Controllers:
 - a. Tag Number: **<Insert numbers and letters>, <Insert description>, <Insert number> hp, <Insert number> full-load A.**
 - 1) Starting Configuration: **<Insert text>.**
 - 2) Starting Mode: **<Insert text>.**
 - 3) Stopping Mode: **<Insert text>.**
 - 4) Controller Size: **<Insert number or numbers and letters> complying with NEMA ICS 2.**
 - 5) Bypass Contactor: **Comply with NEMA ICS 2.**
 - 6) Acceleration Control: **<Insert number>.**
 - 7) Overload Relays: **[Melting alloy][Bimetallic][Solid state]. Class [10][20][30].**
 - 8) Isolated Overload Alarm Contact: **[NC][NO].**
 - 9) Optional Features: **<Insert items>.**
10. VFCs:
 - a. Tag Number: **<Insert numbers and letters>, <Insert description>, <Insert number> hp, <Insert number> full-load A.**
 - 1) Bypass Mode: **[Manual][Field selectable, manual or automatic].**
 - 2) Bypass Style: **[Two][Three] contactor style.**

- 3) Bypass Contactor Classification: **[Full-voltage (across-the-line)][Reduced-voltage autotransformer, open transition][Reduced-voltage autotransformer, closed transition]<Insert type>**.
 - 4) Overload Relays: **[Melting alloy][Bimetallic][Solid state]**. Class **[10][20][30]**.
 - 5) Isolated Overload Alarm Contact: **[NC][NO]**.
 - 6) Optional Features: **<Insert items>**.
11. Controller-Mounted Auxiliary Devices:
- a. Push Buttons and Selector Switches: **[Heavy][Standard]-duty, [oiltight]** type.
 - b. **<Insert devices>**.
 - c. Feeder Tap Units: Main Disconnect: **[MCCB, UL 489,][Fusible switch, UL 98,]** three pole, **<Insert number> A.[Manually operated, electrically tripped.]**
12. Panelboards: Tag Number **<Insert designation>**.
- a. Mains: **[MCCB][Main lugs only]**, **<Insert number>** phase, **<Insert number>** V, **<Insert number>** A.
 - b. **[Plug-in][Bolt-on]** circuit breakers.
13. Transformer(s): Tag Number **<Insert designation>**, **<Insert number>** kVA, **<Insert number>** V primary, **<Insert number>** V secondary.
- a. Primary Circuit Breaker: MCCB, **<Insert number>** A.
14. Transfer Switch: Tag Number **<Insert designation>**, **<Insert number>** pole, **<Insert number>** A.

2.4 MOTOR-CONTROL CENTER ENCLOSURES

- A. Indoor Enclosures: Freestanding steel cabinets unless otherwise indicated. NEMA 250, **[Type 1][Type 1A][Type 2][Type 12]** unless otherwise indicated to comply with environmental conditions at installed location.
- B. Space Heaters: Factory-installed electric space heaters of sufficient wattage in each vertical section to maintain enclosure temperature above expected dew point.
 1. Space-Heater Control: **[Thermostats to maintain temperature of each section above expected dew point][Manual switching of branch-circuit protective device]**.
 2. Space-Heater Power Source: **[Transformer, factory installed in MCC][120-V external branch circuit]**.
- C. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's **[standard gray][custom color]** finish over a rust-inhibiting primer on treated metal surface.
- D. Outdoor Enclosures: Type 3R, **[non-walk-in aisle][with interior-lighted walk-in aisle]**.
 1. Finish: Factory-applied finish in manufacturer's **[standard][custom]** color; undersurfaces treated with corrosion-resistant undercoating.
 2. Enclosure: **[Flat][Downward, rearward sloping]** roof; **[bolt-on rear covers][rear hinged doors]** for each section, with provisions for padlocking.
 3. Doors: Personnel door at each end of aisle, minimum width of **[30 inches (762 mm)]<Insert dimension>**; opening outwards; with panic hardware and provisions for **[padlocking][cylinder lock]**.
 4. Accessories: Fluorescent luminaires, ceiling mounted; wired to a three-way light switch at each

end of aisle; GFCI duplex receptacle; emergency battery pack luminaire installed on wall of aisle midway between personnel doors.

5. Walk-in Aisle Heating and Ventilating:
 - a. Factory-installed electric unit heater(s), wall or ceiling mounted, with integral thermostat and disconnect and with capacities to maintain switchboard interior temperature of [40 deg F (5 deg C)]<Insert temperature> with outside design temperature of [plus 23 deg F (minus 5 deg C)]<Insert temperature>.
 - b. Factory-installed exhaust fan with capacities to maintain switchboard interior temperature of [100 deg F (38 deg C)]<Insert temperature> with outside design temperature of [104 deg F (40 deg C)]<Insert temperature>.
 - c. Ventilating openings[**complete with replaceable fiberglass air filters**].
 - d. Thermostat: Single stage; wired to control heat and exhaust fan.
6. Power for Space Heaters, Ventilation, Lighting, and Receptacle: Include a CPT within the switchboard. Supply voltage shall be [120][120/240][120/208]-V ac.
7. Power for space heaters, ventilation, lighting, and receptacle supplied from a remote source.

2.5 ASSEMBLY

- A. Structure:
 1. Comply with UL requirements for service entrance equipment.
 2. Units up to and including Size 3 shall have drawout mountings with connectors that automatically line up and connect with vertical-section buses while being racked into their normal, energized positions.
 3. Units in Type B and Type C MCCs shall have pull-apart terminal strips for external control connections.
 4. Pull Boxes:
 - a. Include provisions for ventilation to maintain temperature in pull box within same limits as the MCC.
 - b. Set the box back from front to clear circuit-breaker removal mechanism.
 - c. Covers: Removable covers forming top, front, and sides.
 - d. Insulated bottom of fire-resistive material with separate holes for cable drops into MCC.
 - e. Cable Supports: Arranged to facilitate cabling and adequate to support cables, including supports for future cables.
 - f. When equipped with barriers, supply with access to check bus bolt tightness.
- B. Compartments: Modular; individual [**lift-off**]doors with concealed hinges and quick-captive screw fasteners.
 1. Interlock compartment door to require that the disconnecting means is "off" before door can be opened or closed, except by operating a concealed release device.
 2. Compartment construction shall allow for removal of units without opening adjacent doors, disconnecting adjacent compartments, or disturbing operation of other units in MCC.
 3. The same-size compartments shall be interchangeable to allow rearrangement of units, such as replacing three single units with a unit requiring three spaces, without cutting or welding.
- C. Bus Transition and Incoming Pull Sections: Included and aligned with the structure of the MCC.
- D. Utility Metering Compartment: Fabricated, barrier compartment and section complying with utility company's requirements; hinged sealed door; buses provisioned for mounting utility company's current transformers and PTs or potential taps as required by utility company. If separate vertical section is

required for utility metering, match and align with basic MCC. Install service entrance label and applicable service entrance features. Comply with requirements in Section 262713 "Electricity Metering."

- E. Owner's Metering Compartment: A separate customer metering compartment and section with front hinged door, metering, and current transformers for each meter. Current transformer secondary wiring shall be terminated on shorting-type terminal blocks. **[Include PTs having primary and secondary fuses with disconnecting means and secondary wiring terminated on terminal blocks.]**
- F. Interchangeability: Compartments constructed to allow for removal of units without opening adjacent doors, disconnecting adjacent compartments, or disturbing operation of other units in MCC; same-size compartments to permit interchangeability and ready rearrangement of units, such as replacing three single units with a unit requiring three spaces, without cutting or welding.
- G. Wiring Spaces:
 - 1. Vertical wireways in each vertical section for vertical wiring to each unit compartment; supports to hold wiring in place.
 - 2. Horizontal wireways in **[bottom][and][top]** of each vertical section for horizontal wiring between vertical sections; supports to hold wiring in place.
- H. Provisions for Future:
 - 1. Compartments marked "future" shall be bused, wired and equipped with guide rails or equivalent, and ready for insertion of drawout units.
 - 2. Compartments marked "spare" shall include provisions for connection to the vertical bus.
- I. Integrated Short-Circuit Rating:
 - 1. Short-Circuit Current Rating for Each Unit: **[Combination series rated][Fully rated]; [22][42][65][100]<Insert number> kA.**
 - 2. Short-Circuit Current Rating of MCC: **[Combination series rated][Fully rated]** with its main overcurrent device; **[22][42][65][100]<Insert number> kA.**
- J. Control Power:
 - 1. 120-V ac, supplied centrally **[from a CPT][from a remote branch circuit]**.
 - 2. **[24][120]<Insert number>-V ac**; obtained from CPT integral with controller; with primary and secondary fuses. The CPT shall be of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
 - 3. Control Circuits: 24-V dc, supplied centrally from two redundant, automatically switched power supplies.
 - 4. CPT Spare Capacity: **[50][100][200]<Insert number> VA.**
- K. Factory-Installed Wiring: Factory installed, with bundling, lacing, and protection included. Use flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.
 - 1. Wiring Class:
 - a. NEMA ICS 18, **[Class I][Class I-S], [Type A][Type B, for starters larger than Size 3][Type B-D, for starters Size 3 and smaller][Type B-T, for starters Size 3 and smaller][Type C].**
 - b. NEMA ICS 18, **[Class II][Class II-S], [Type B, for starters larger than Size 3][Type B-D, for starters Size 3 and smaller][Type B-T, for starters Size 3 and smaller][Type C].**

2. Control and Load Wiring: Factory installed, with bundling, lacing, and protection included. Use flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

L. Bus:

1. Main Horizontal and Equipment Ground Buses: Uniform capacity for entire length of MCC's main and vertical sections. Provide for future extensions[**from both ends**].
2. Vertical Phase and Equipment Ground Buses: Uniform capacity for entire usable height of vertical sections, except for sections incorporating single units.
3. Phase- and Neutral-Bus Material:
 - a. Hard-drawn copper of 98 percent minimum conductivity or **[silver][tin]**-plated alloy, with **[mechanical][compression]** connectors for outgoing conductors.
 - b. Hard-drawn copper of 98 percent minimum conductivity or tin-plated, high-strength, electrical-grade aluminum alloy, with **[mechanical][compression]** connectors for outgoing conductors.
4. Ground Bus: Hard-drawn copper of 98 percent minimum conductivity, with pressure connector for ground conductors, minimum size **1/4-by-2 inches (6 by 50 mm)**. Equip with **[mechanical][compression]** connectors for outgoing conductors.
5. Neutral Disconnect Link: Bolted, uninsulated, **1/4-by-2-inch (6-by-50-mm)** copper bus, arranged to connect neutral bus to ground bus.
6. Bus-Bar Insulation: Factory-applied, flame-retardant, tape wrapping of individual bus bars or flame-retardant, spray-applied insulation. Insulation temperature rating shall not be less than 105 deg C.

2.6 MAIN DISCONNECT AND OVERCURRENT PROTECTIVE DEVICE(S)

- A. MCCB (to 2500 A): Fixed mounted, manually operated air-circuit breaker. Comply with UL 489.
 1. MCCB shall have quick-make, quick-break, over-center switching mechanism that is mechanically trip-free, its position shall be shown by the position of the handle, and manual push-to-trip push button.
 2. Solid-state monitoring and tripping system to show system status monitoring, adjustable time-current protection, and shunt trip.
 - a. Interchangeable current sensors and timing circuits for adjustable time-current protection settings and status signals.
 - b. Trip-setting dials or interchangeable plugs to establish the continuous trip of the circuit breaker. Plugs shall not be interchangeable between frames, and the breaker may not be closed without the plug. With neutral ground-fault sensor.
 - c. Time-current adjustments to achieve protective-device coordination as follows:
 - 1) Adjustable long-time delay.
 - 2) Adjustable short-time setting and delay to shape the time-current curve.
 - 3) Adjustable instantaneous setting.
 - 4) Individually adjustable ground-fault setting and time delay.
 - d. Built-in connector to test the long-time delay, instantaneous, and ground-fault functions of the breaker.[**Provide one test set for testing the installed circuit breakers 225-A frame and higher.**]
 - e. Built-in digital ammeter display, showing load current and tripping cause.

3. Switch operator power shall be from control power specified in "Assembly" Article.
 - B. MCCB (1600 to 2500 A): Fixed mounted, manually operated air-circuit breaker. Comply with UL 489.
 1. MCCB shall have quick-make, quick-break, over-center switching mechanism that is mechanically trip-free, its position shall be indicated by the position of the handle, and manual push-to-trip push button.
 2. Solid-state monitoring and tripping system to show system status monitoring, adjustable time-current protection, and shunt trip.
 - a. Interchangeable current sensors and timing circuits for adjustable time-current protection settings and status signals.
 - b. LED indicators or display, with manual reset, to show reasons of automatic trip.
 - c. Display panel to indicate the status of the system circuitry, or give fault location based on automatic diagnosis.
 - d. Trip the circuit breaker when closing on a fault.
 - e. Time-current adjustments to achieve protective-device coordination as follows:
 - 1) Adjustable long-delay pickup and time.
 - 2) Individual adjustments for short-delay pickup, time, and I-squared-t setting.
 - 3) Adjustable instantaneous pickup.
 - 4) Individually adjustable ground-fault pickup and time, with **[I-squared-t setting][ground alarm]**.
 - f. One test kit to test each trip function.
 - g. Battery backup for informational displays after automatic trip, with battery status indicator.
 3. Switch operator power shall be from control power specified in "Assembly" Article.
 - C. MCC Main Disconnect Device: Fusible switch; fixed-mounted, manually operated, **[electrically tripped]**, quick-make, quick-break switch. Comply with UL 98.
 1. Indication whether the switch is open or closed, and provisions for padlocking the operating handle.
 2. Fuse clips and fuses.
 3. Electrically tripped switches shall include the following:
 - a. Shunt trip.
 - b. Ground-fault protection, with adjustable time delay and test panel.
 - c. Single-phase protection, tripping the switch on loss of a source phase.
 - d. Blown fuse protection, tripping the switch on a blown fuse, with blown fuse indication.
 - e. Switch operator power shall be from control power specified in "Assembly" Article.
 - D. Surge Suppression: Factory installed as an integral part of the incoming feeder, complying with UL 1449, SPD **[Type 1][Type 2]**.
- 2.7 AUTOMATIC POWER TRANSFER
- A. Two-Breaker Transfer Control:
 1. Transfer control, using electrically operated MCCBs, for an MCC supplied from two normally energized low-voltage power sources, designated "normal" and "standby." The circuit breakers connecting the two power sources to the load bus shall be controlled by a microprocessor-based automatic transfer control. Power for the transfer control shall be from the voltage-sensing transformers.

2. MCCBs (to 2500 A): Fixed mounted, manually operated air-circuit breaker. Comply with UL 489.
 - a. MCCB shall have quick-make, quick-break, over-center switching mechanism that is mechanically trip-free, its position shall be indicated by the position of the handle, and manual push-to-trip push button.
 - b. Solid-state monitoring and tripping system to show system status monitoring, adjustable time-current protection, and shunt trip.
 - 1) Interchangeable current sensors and timing circuits for adjustable time-current protection settings and status signals.
 - 2) Trip-setting dials or interchangeable plugs to establish the continuous trip of the circuit breaker. Plugs shall not be interchangeable between frames, and the breaker may not be closed without the plug. With neutral ground-fault sensor.
 - 3) Time-current adjustments to achieve protective-device coordination as follows:
 - a) Adjustable long-time delay.
 - b) Adjustable short-time setting and delay to shape the time-current curve.
 - c) Adjustable instantaneous setting.
 - d) Individually adjustable ground-fault setting and time delay.
 - 4) Built-in connector to test the long-time delay, instantaneous, and ground-fault functions of the breaker. **[Provide one test set for testing the installed circuit breakers 225-A frame and higher.]**
 - 5) Built-in digital ammeter display, showing load current and tripping cause.
3. In the automatic mode, the load bus is connected to the normal power source. When the normal source fails, the control shall automatically open the normal power source and close the standby source circuit breaker.
4. Sequence of Operation:
 - a. The default operation shall be with the normal source main breaker closed and standby main breaker open. On detection of an undervoltage to the line side of the normal main breaker and after a field-adjustable time delay, the main breaker shall open and, after an additional field-adjustable time delay, the standby breaker shall close and restore power to the facility.
 - b. On restoration of voltage to the line side of the normal main breaker and after a field-adjustable time delay, the standby main breaker shall open and, after a field-adjustable time delay, the normal main breaker shall close.
5. Field-Adjustable Transfer Parameters:
 - a. Delay the transfer from the normal power source to the standby power source and from the standby power source to the normal source. The time delay is to allow the load voltage to decay before reconnecting to another power source. Delay range is zero seconds to 30 minutes.
 - b. Delay the initiation of the transfer sequence. The time delay is recommended to override a momentary power outage or voltage fluctuation. Delay range is zero to 120 seconds.
 - c. Delay the transfer from the standby power source to the normal power source. Delay range is zero seconds to 30 minutes.
 - d. A relay with contact that changes state when the power is available on the normal source, and a relay with contact that changes state when the power is available on the standby source.
6. Controls and Indicators: In addition to the delay setting controls, include the following:

- a. Interlocks or relay control to prevent transfer when either of the two controlled circuit breakers trip due to overcurrent or ground-fault.
 - b. Three-position selector switch to select the normal source: Source 1, Source 2, or none.
 - c. Transfer-control automatic and manual selector.
 - 1) Interlock shall prevent paralleling of the two power sources in manual mode.
 - d. Open-close control switch for manual electrical operation of each controlled circuit breaker.
 - e. Selector to place control into programming mode.
 - f. Circuit breaker control switch for each of the normal and standby source breakers, providing open and close operation.
 - g. Push button to initiate manual retransfer to the normal source when the transfer controller is in the automatic mode.
 - h. Meters and display to show the following:
 - 1) Voltage and frequency of both sources.
 - 2) A multiline display showing the following:
 - a) Set points of timers, and voltage pickup and dropout set points.
 - b) Date, time, and reason for minimum of the last 10 transfers. The display may show the information for one transfer at a time using a scrolling control, with the others held in memory.
 - c) When the control system is in the transferring process, the display shall show delay countdown in seconds.
 - i. LED indicators to show the following:
 - 1) Normal source available.
 - 2) Standby source available.
 - 3) Normal source connected.
 - 4) Standby source connected.
 - 5) Load bus energized.
7. Voltage Transformers: Primary and secondary protection and disconnecting means for sensing functions and control power.
8. Voltage Sensing Relays: Microprocessor-based, IEEE device number 27/47 voltage detection relays for three-phase undervoltage protection and negative sequence voltage protection.

2.8 MAGNETIC CONTROLLERS

A. Controller Units: Combination controllers.

B. Disconnects:

1. Fusible Switch:

- a. UL 98 and NEMA KS 1, heavy-duty, horsepower-rated fusible switch, with clips or bolt pads to accommodate **[UL 248-8 Class J][UL 248-10 Class L]<Insert class>** fuses.
- b. Lockable Handle: For three padlocks and interlocks with cover in closed position.
- c. Auxiliary Contacts: **[NC][NO]**, arranged to activate before switch blades open.

2. MCP:

- a. UL 489, with interrupting capacity complying with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with

- motor locked-rotor amperes.
- b. Lockable Handle: For three padlocks and interlocks with cover in closed position.
- c. Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
- d. **[NC][NO]** alarm contact that operates only when MCP has tripped.
- e. Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.

3. MCCB:

- a. UL 489, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
- b. Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
- c. Lockable Handle: For three padlocks and interlocks with cover in closed position.
- d. Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.
- e. **[NC][NO]** alarm contact that operates only when MCCB has tripped.

4. Molded-Case Switch:

- a. UL 489, with in-line fuse block for **[UL 248-8 Class J][UL 248-10 Class L]** power fuses (depending on ampere rating), providing an interrupting capacity to comply with available fault currents; MCCB with fixed, high-set instantaneous trip only.
- b. Lockable Handle: For three padlocks and interlocks with cover in closed position.
- c. Auxiliary contacts "a" and "b" arranged to activate with molded-case switch handle.
- d. **[NC][NO]** alarm contact that operates only when molded-case switch has tripped.

C. Controllers: Comply with UL 508.

1. Full-Voltage Magnetic Controllers: Electrically held, full voltage, NEMA ICS 2, general purpose, Class A.
 - a. Classification: **[Nonreversing][and][reversing]<Insert classification>**.
2. Reduced-Voltage Magnetic Controllers: Electrically held, NEMA ICS 2, general purpose, Class A; **[closed][open]** transition; adjustable time delay on transition. **[Electrically][Mechanically]** held.
 - a. Wye-Delta Controller: Four contactors, with a three-phase starting resistor/reactor bank.
 - b. Part-Winding Controller: Separate START and RUN contactors, with separate overload relays for starting and running sequences.
 - c. Autotransformer Reduced-Voltage Controller: Medium-duty service, with integral overtemperature protection; taps for starting at 50, 65, and 80 percent of line voltage; one RUN and two START contactors.
3. Multispeed Magnetic Controllers: Electrically held, full voltage, NEMA ICS 2, general purpose, Class A.
 - a. Classification, Nonreversing: **[Consequent pole][Two winding]**.
 - 1) Two speed, with compelling relays to ensure that motor will start only at low speed.
 - 2) Timer Relays:
 - a) Accelerating, for properly timed acceleration through speeds lower than that selected.
 - b) Decelerating, for automatically timed deceleration through each speed.

- b. Classification, Reversing: **[Consequent pole][Two winding]**.
 - 1) Two speed, with compelling relay to ensure that motor will start only at low speed.
 - 2) Timer Relays:
 - a) Accelerating, for properly timed acceleration through speeds lower than that selected.
 - b) Decelerating, for automatically timed deceleration through each speed.
 - c. Antiplugging Relays: Time delay when transferring from FORWARD to REVERSE and back.
- D. Overload Relays:
- 1. Melting-Alloy Overload Relays:
 - a. Inverse-time-current characteristic.
 - b. **[Class 10][Class 20][Class 30]** tripping characteristic.
 - c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 - 2. Bimetallic Overload Relays:
 - a. Inverse-time-current characteristic.
 - b. **[Class 10][Class 20][Class 30]** tripping characteristic.
 - c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 - d. Ambient compensated.
 - e. Automatic resetting.
 - 3. Solid-State Overload Relays:
 - a. Switch or dial selectable for motor-running overload protection.
 - b. Sensors in each phase.
 - c. **[Class 10][Class 20][Class 10/20 selectable]** tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
 - d. UL 1053 Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
 - e. Analog communication module.
 - 4. **[NC][NO]** isolated overload alarm contact.
 - 5. External overload reset push button.
- 2.9 REDUCED-VOLTAGE SOLID-STATE CONTROLLERS
- A. Controller Units: An integrated unit with disconnects, power SCRs, heat sink, microprocessor logic board, door-mounted digital display and keypad, bypass contactor, and overload relays. Comply with UL 508.
 - 1. Suitable for use with NEMA MG 1 Design B, polyphase induction motors.
 - 2. **<Insert special applications>**.
 - B. Disconnects:

1. Fusible Switch:
 - a. UL 98 and NEMA KS 1, heavy-duty, horsepower-rated fusible switch, with clips or bolt pads to accommodate **[UL 248-8 Class J][UL 248-10 Class L]<Insert class>** fuses.
 - b. Lockable Handle: For three padlocks and interlocks with cover in closed position.
 - c. Auxiliary Contacts: **[NC][NO]**, arranged to activate before switch blades open.
2. MCP:
 - a. UL 489, with interrupting capacity complying with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
 - b. Lockable Handle: For three padlocks and interlocks with cover in closed position.
 - c. Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
 - d. **[NC][NO]** alarm contact that operates only when MCP has tripped.
 - e. Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.
3. MCCB:
 - a. UL 489, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
 - b. Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 - c. Lockable Handle: For three padlocks and interlocks with cover in closed position.
 - d. Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.
 - e. **[NC][NO]** alarm contact that operates only when MCCB has tripped.
4. Molded-Case Switch:
 - a. UL 489, with in-line fuse block for **[UL 248-8 Class J][UL 248-10 Class L]** power fuses (depending on ampere rating), providing an interrupting capacity to comply with available fault currents; MCCB with fixed, high-set instantaneous trip only.
 - b. Lockable Handle: For three padlocks and interlocks with cover in closed position.
 - c. Auxiliary contacts "a" and "b" arranged to activate with molded-case switch handle.
 - d. **[NC][NO]** alarm contact that operates only when molded-case switch has tripped.
- C. Configuration: **[Standard][Severe]** duty; **[nonreversible][reversible]**.
- D. Starting Mode: **[Voltage ramping][Current limit][Torque control][Torque control with voltage boost][; field selectable]**.
- E. Stopping Mode: **[Coast to stop][Adjustable torque deceleration][Adjustable braking][; field selectable]**.
- F. Bypass Controller: Operates automatically to bypass the SCRs when the motor has reached rated speed and full voltage is applied to motor. Solid-state controller protective features shall remain active when the bypass relay is in the bypass mode.
 1. Bypass Contactor: **[Manufacturer's standard product][or][NEMA ICS 2, general-purpose, Class A contactor, rated to start the load across the line][, as indicated on Drawings]**.
 2. Bypass Contactor Coils: Pressure-encapsulated type; manufacturer's standard operating voltage, matching control power or line voltage, depending on contactor size and line-voltage rating.

- G. Acceleration Control: Adjustable, using voltage or current ramp, and adjustable starting torque control with up to [400]<Insert number> percent current limitation for 20 seconds.
- H. SCR Bridge: At least two SCRs per phase, for stable and smooth acceleration [with][without] external feedback from the motor or driven equipment.
- I. Keypad: Front accessible; for programming the controller parameters, functions, and features; shall be manufacturer's standard and include not less than the following functions:
 - 1. Adjusting motor full-load amperes, as a percentage of the controller's rating.
 - 2. Adjusting current limitation on starting, as a percentage of the motor full-load current rating.
 - 3. Adjusting linear acceleration and deceleration ramps, in seconds.
 - 4. Setting initial torque, as a percentage of the nominal motor torque.
 - 5. Adjusting torque limit, as a percentage of the nominal motor torque.
 - 6. Adjusting maximum start time, in seconds.
 - 7. Adjusting voltage boost, as a percentage of the nominal supply voltage.
 - 8. Selecting stopping mode and adjusting parameters.
 - 9. Selecting motor thermal-overload protection class between 5 and 30.
 - 10. Activating and deactivating protection modes.
 - 11. Selecting or activating communications modes.
 - 12. <Insert function>.
- J. Digital Display: Front accessible; for showing motor, controller, and fault status; shall be manufacturer's standard and include not less than the following:
 - 1. Controller Condition: Ready, starting, running, stopping.
 - 2. Motor Condition: Amperes, voltage, power factor, power, and thermal state.
 - 3. Fault Conditions: Controller thermal fault, motor overload alarm and trip, motor underload, overcurrent, shorted SCRs, line or phase loss, phase reversal, and line frequency over or under normal.
 - 4. <Insert items>.
- K. Controller Diagnostics and Protection:
 - 1. Microprocessor-based thermal protection system for monitoring SCR and motor thermal characteristics, and providing controller overtemperature and motor overload alarm and trip; settings selectable via the keypad.
 - 2. Protection from line-side reverse phasing; line-side and motor-side phase loss; motor jam, stall, and underload conditions; and line frequency excursions to over- or under-normal. Accomplish protection by the following:
 - a. Input isolation contactor that opens when the controller diagnostics detect a faulted solid-state component, or when the motor is stopped.
 - b. Shunt trip that opens the disconnecting means when the controller diagnostics detect a faulted solid-state component.
 - c. <Insert items>.
- L. Remote Output Features:
 - 1. All outputs prewired to terminal blocks.
 - 2. Form C status contacts that change state when controller is running.
 - 3. Form C alarm contacts that change state when a fault condition occurs.
 - 4. <Insert items>.
- M. Overload Relays:

1. Melting-Alloy Overload Relays:
 - a. Inverse-time-current characteristic.
 - b. **[Class 10][Class 20][Class 30]** tripping characteristic.
 - c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 2. Bimetallic Overload Relays:
 - a. Inverse-time-current characteristic.
 - b. **[Class 10][Class 20][Class 30]** tripping characteristic.
 - c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 - d. Ambient compensated.
 - e. Automatic resetting.
 3. Solid-State Overload Relays:
 - a. Switch or dial selectable for motor-running overload protection.
 - b. Sensors in each phase.
 - c. **[Class 10][Class 20][Class 10/20 selectable]** tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
 - d. UL 1053, Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
 - e. Analog communication module.
- N. Optional Features:
1. Analog output for field-selectable assignment of motor operating characteristics; **[0- to 10-V dc][4- to 20-mA dc]**.
 2. **[Two]<Insert number>** additional field-assignable Form C contacts for alarm outputs.
 3. Full-voltage/BYPASS selector switch. Power contacts shall be totally enclosed, double break, made of silver-cadmium oxide, and assembled to allow inspection and replacement without disturbing line or load wiring.

2.10 VFC

- A. Controller Units: Combination controllers, consisting of variable-frequency power converter that is factory packaged in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged for self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency. Comply with NEMA ICS 7, NEMA ICS 61800-2, UL 508C, and **[UL 508E]<Insert standard>**.
1. Units suitable for operation of NEMA MG 1, Design A and Design B motors as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both."
 2. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
 3. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.
 4. Listed and labeled for single-phase use by an NRTL acceptable to authorities having jurisdiction.
- B. Disconnects:

1. Fusible Switch:
 - a. UL 98 and NEMA KS 1, heavy-duty, horsepower-rated fusible switch, with clips or bolt pads to accommodate **[UL 248-8 Class J][UL 248-10 Class L]<Insert class>** fuses.
 - b. Lockable Handle: For three padlocks and interlocks with cover in closed position.
 - c. Auxiliary Contacts: **[NC][NO]**, arranged to activate before switch blades open.
2. MCP:
 - a. UL 489, with interrupting capacity complying with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
 - b. Lockable Handle: For three padlocks and interlocks with cover in closed position.
 - c. Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
 - d. **[NC][NO]** alarm contact that operates only when MCP has tripped.
 - e. Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.
3. MCCB:
 - a. UL 489, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
 - b. Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 - c. Lockable Handle: For three padlocks and interlocks with cover in closed position.
 - d. Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.
 - e. **[NC][NO]** alarm contact that operates only when MCCB has tripped.
4. Molded-Case Switch:
 - a. UL 489, with in-line fuse block for **[UL 248-8 Class J][UL 248-10 Class L]** power fuses (depending on ampere rating), providing an interrupting capacity to comply with available fault currents; MCCB with fixed, high-set instantaneous trip only.
 - b. Lockable Handle: For three padlocks and interlocks with cover in closed position.
 - c. Auxiliary contacts "a" and "b" arranged to activate with molded-case switch handle.
 - d. **[NC][NO]** alarm contact that operates only when molded-case switch has tripped.
5. Disconnect Rating:
 - a. Not less than 115 percent of VFC input current rating.
 - b. Not less than 115 percent of NFPA 70 motor full-load current rating or VFC input current rating, whichever is larger.
6. Auxiliary Contacts: **[NC][NO]**, arranged to activate before switch blades open.
7. Auxiliary contacts "a" and "b" arranged to activate with circuit-breaker handle.
8. **[NC][NO]** alarm contact that operates only when circuit breaker has tripped.

C. Operating Requirements:

1. Input AC Voltage Tolerance: Plus 10 and minus **[10][15]** percent of VFC input voltage rating.
2. Input AC Voltage Unbalance: Not exceeding **[3][5]** percent.
3. Input Frequency Tolerance: Plus or minus 3 percent of VFC frequency rating.
4. Minimum Efficiency: **[96][97]<Insert number>** percent at 60 Hz, full load.
5. Minimum Displacement Primary-Side Power Factor: **[96][98]<Insert number>** percent under any load or speed condition.

6. Overload Capability:
 - a. For variable-torque controllers, 1.1 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
 - b. For constant-torque controllers, 1.5 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
7. Starting Torque: Minimum of 100 percent of rated torque from 3 to 60 Hz.
8. Speed Regulation: Plus or minus **[5][10]** percent.
9. Output Carrier Frequency: Field selectable.
10. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.
11. Internal Adjustability Capabilities:
 - a. Minimum Speed: 5 to 25 percent of maximum rpm.
 - b. Maximum Speed: 80 to 100 percent of maximum rpm.
 - c. Acceleration: **[0.1 to 999.9]<Insert range>** seconds.
 - d. Deceleration: **[0.1 to 999.9]<Insert range>** seconds.
 - e. Current Limit: 30 to a minimum of 150 percent of maximum rating.
 - f. **<Insert adjustment and parameters>**.
12. Self-Protection and Reliability Features:
 - a. Input transient protection by means of SPDs for three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
 - b. Loss of Input Signal Protection: Selectable response strategy including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
 - c. Under- and overvoltage trips.
 - d. Inverter overcurrent trips.
 - e. VFC and Motor Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFCs and motor thermal characteristics, and for providing VFC overtemperature and motor overload alarm and trip; settings selectable via the keypad; NRTL approved and listed and labeled by an NRTL.
 - f. Critical frequency rejection, with **[three]<Insert number>** selectable, adjustable deadbands.
 - g. Instantaneous line-to-line and line-to-ground overcurrent trips.
 - h. Loss-of-phase protection.
 - i. Reverse-phase protection.
 - j. Short-circuit protection.
 - k. Motor overtemperature fault.
 - l. **<Insert additional protection or reliability feature>**.
13. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.
14. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

D. Operator Station:

1. Inverter Logic: Microprocessor based, **[16][32]** bit, isolated from all power circuits.
2. Isolated Control Interface: Allows VFCs to follow remote-control signal over a minimum 40:1 speed range.
3. Panel-mounted, manufacturer's standard front-accessible, sealed keypad and plain-English-language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.

- a. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
- b. Security Access: Electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.

E. Displays:

1. Historical Logging Information and Displays:

- a. Real-time clock with current time and date.
- b. Running log of total power versus time.
- c. Total run time.
- d. Fault log, maintaining last **[four]<Insert number>** faults with time and date stamp for each.
- e. **<Insert information or display>**.

2. Indicating Devices: Digital display[**and additional readout devices as required,**] mounted flush in VFC door and connected to display VFC parameters including the following:

- a. Output frequency (Hz).
- b. Motor speed (rpm).
- c. Motor status (running, stop, fault).
- d. Motor current (amperes).
- e. Motor torque (percentage).
- f. Fault or alarming status (code).
- g. PID feedback signal (percentage).
- h. DC-link voltage (V dc).
- i. Set-point frequency (Hz).
- j. Motor output voltage (V ac).
- k. **<Insert parameter>**.

F. Bypass Systems:

1. Bypass Operation: Safely transfers motor between power converter output and bypass circuit, manually, automatically, or both. Selector switches set modes, and indicator lights indicate mode selected. Unit is capable of stable operation (starting, stopping, and running) with motor completely disconnected from power converter.
2. Manual Bypass Mode: Manual operation only; requires local operator selection at VFC. Transfer between power converter and bypass contactor and retransfer shall only be allowed with the motor at zero speed.
3. Field-Selectable Bypass Mode: Field-selectable automatic or manual, allows local and remote transfer between power converter and bypass contactor and retransfer, either via manual operator interface or automatic control system feedback.
4. Two-Contactor Bypass Controller: Allows motor operation via the power converter or the bypass controller[; **with input isolating switch and barrier arranged to isolate the power converter and permit safe troubleshooting and testing, both energized and de-energized, while motor is operating in bypass mode**].
 - a. Bypass Contactor: Load-break, **[IEC][NEMA]**-rated contactor.
 - b. Output Isolating Contactor: Non-load-break, **[IEC][NEMA]**-rated contactor.
 - c. Isolating Switch: Non-load-break switch arranged to isolate power converter and permit safe troubleshooting and testing of the power converter, both energized and de-energized, while motor is operating in bypass mode; pad-lockable, door-mounted handle mechanism.
5. Three-Contactor Bypass Controller: Allows motor operation via the power converter or the bypass controller[; **with input isolating switch and barrier**] arranged to isolate the power converter

input and output and permit safe testing[**and troubleshooting**] of the power converter, both energized and de-energized, while motor is operating in bypass mode.

- a. Bypass Contactor: Load-break, **[IEC][NEMA]**-rated contactor.
 - b. Input and Output Isolating Contactors: Non-load-break, **[IEC][NEMA]**-rated contactors.
 - c. Isolating Switch: Non-load-break switch arranged to isolate power converter and permit safe troubleshooting and testing of the power converter, both energized and de-energized, while motor is operating in bypass mode; pad-lockable, door-mounted handle mechanism.
6. Bypass Contactor Classification: **[Full-voltage (across-the-line)][Reduced-voltage autotransformer, open transition][Reduced-voltage autotransformer, closed transition]<Insert type>** type.
 7. NORMAL/BYPASS selector switch.
 - a. HAND/OFF/AUTO selector switch.
 - b. NORMAL/TEST Selector Switch: Allows testing and adjusting of VFC while the motor is running in the bypass mode.
 - c. Contactor Coils: Pressure-encapsulated type[**with coil transient suppressors**].
 - 1) Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
 - 2) Power Contacts: Totally enclosed, double break, and silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
 8. Overload Relays: NEMA ICS 2.
 - a. Melting-Alloy Overload Relays:
 - 1) Inverse-time-current characteristic.
 - 2) **[Class 10][Class 20][Class 30]** tripping characteristic.
 - 3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 - b. Bimetallic Overload Relays:
 - 1) Inverse-time-current characteristic.
 - 2) **[Class 10][Class 20][Class 30]** tripping characteristic.
 - 3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 - 4) Ambient compensated.
 - 5) Automatic resetting.
 - c. Solid-State Overload Relays:
 - 1) Switch or dial selectable for motor-running overload protection.
 - 2) Sensors in each phase.
 - 3) **[Class 10][Class 20][Class 10/20 selectable]** tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
 - 4) Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
 - 5) Analog communication module.
 - d. **[NC][NO]** isolated overload alarm contact.
 - e. External overload reset push button.

- G. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.
- H. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.
- I. Bidirectional Autospeed Search: Capable of starting VFC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.
- J. Firefighter's Override (Smoke Purge) Input: On a remote contact closure from **[the firefighter's control station][smoke-control fan controller]<Insert location>**, the following password-protected input:
 - 1. Overrides all other local and external inputs (analog/digital, serial communication, and all keypad commands).
 - 2. Forces VFC to operate motor, without any other run or speed command, at a field-adjustable, preset speed.
 - 3. Forces VFC to transfer to bypass mode and operate motor at full speed.
 - 4. Causes display of override mode on the VFC display.
 - 5. Reset VFC to normal operation on removal of override signal **[automatically][manually]**.
- K. Communication Port: **[Ethernet][RS-232 port][USB 2.0 port]** or equivalent connection Capable of connecting a printer **[and a notebook computer]**.
- L. **<Insert feature>**.

2.11 CONTROLLER-MOUNTED AUXILIARY DEVICES

- A. Control-Circuit and Pilot Devices: Factory installed in controller enclosure cover unless otherwise indicated. Comply with NEMA ICS 5.
 - 1. Push Buttons, Pilot Lights, and Selector Switches: **[Heavy][Standard]**-duty, **[oiltight]** type.
 - a. Push Buttons: **[Covered][Lockable][Recessed][Shielded][Shrouded][Unguarded]** types; **[maintained][momentary]** contact unless otherwise indicated.
 - b. Pilot Lights: **[LED][Resistor][Transformer]** types; **<Insert color(s)>; push to test**.
 - c. Selector Switches: **[Rotary]<Insert description>** type.
- B. Elapsed-Time Meters: Heavy duty with digital readout in hours; **[nonresettable]; [resettable]**.
- C. Meters: Panel type, **2-1/2-inch (64-mm)** minimum size with 90- or 120-degree scale and plus or minus 2 percent accuracy, with selector switches having an off position.
- D. Auxiliary Dry Contacts: **[NC][NO][Reversible NC/NO]**.
- E. Control Relays:
 - 1. Time Delay: Auxiliary and adjustable **[pneumatic][solid-state]** time-delay relays.
 - 2. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections and adjustable undervoltage, overvoltage, and time-delay settings.
 - 3. **<Insert control device>**.

2.12 MEASUREMENT AND CONTROL DEVICES

- A. Instrument Transformers: IEEE C57.13, NEMA EI 21.1, and the following:
1. PTs: IEEE C57.13; 120 V, 60 Hz, **[single][tapped][double]** secondary; disconnecting type with integral fuse mountings. Burden and accuracy shall be consistent with connected metering and relay devices.
 2. Current Transformers: IEEE C57.13; 5 A, 60 Hz, secondary; **[wound][bushing][bar or window]** type; **[single][double]** secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.
 3. CPTs: Dry type, mounted in separate compartments for units larger than 3 kVA.
 4. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, for selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker and ground-fault protection.
- B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:
1. Listed or recognized by a nationally recognized testing laboratory.
 2. Inputs from sensors or 5-A current-transformer secondaries, and potential terminals rated to 600 V.
 3. Switch-selectable digital display of the following values with the indicated maximum accuracy tolerances:
 - a. Phase Currents, Each Phase: Plus or minus 1 percent.
 - b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
 - c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
 - d. Three-Phase Real Power (Megawatts): Plus or minus 2 percent.
 - e. Three-Phase Reactive Power (Megavars): Plus or minus 2 percent.
 - f. Power Factor: Plus or minus 2 percent.
 - g. Frequency: Plus or minus 0.5 percent.
 - h. Accumulated Energy, Megawatt Hours: Plus or minus 2 percent; accumulated values unaffected by power outages up to 72 hours.
 - i. Megawatt Demand: Plus or minus 2 percent; demand interval programmable from 5 to 60 minutes.
 - j. Contact devices to operate remote impulse-totalizing demand meter.
 4. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.
- C. Ammeters, Voltmeters, and Power-Factor Meters: ANSI C39.1. **4-inch (100-mm)** diameter or **6 inches (150 mm)** square, flush or semiflush, with antiparallax 250-degree scale and external zero adjustment.
1. Voltmeters: Cover an expanded-scale range of nominal voltage plus 10 percent.
 2. Feeder Ammeters: **2-1/2-inch (64-mm)** minimum size with 90- or 120-degree scale. Meter and transfer device with off position, located on overcurrent device door for feeder circuits, unless otherwise indicated.
- D. Instrument Switches: Rotary type with off position.
1. Voltmeter Switches: Permit reading of all phase-to-phase voltages and phase-to-neutral voltages where a neutral is included.
 2. Ammeter Switches: Permit reading of current in each phase and maintain current-transformer secondaries in a closed-circuit condition at all times.
- E. Watt-Hour Meters and Wattmeters:

1. Comply with ANSI C12.1.
2. Three-phase induction type with two stators, each with current and potential coil, rated 5 A, 120 V, 60 Hz.
3. Suitable for connection to three- and four-wire circuits.
4. Potential indicating lamps.
5. Adjustments for light and full load, phase balance, and power factor.
6. Four-dial clock register.
7. Integral demand indicator.
8. Contact devices to operate remote impulse-totalizing demand meter.
9. Ratchets to prevent reverse rotation.
10. Removable meter with drawout test plug.
11. Semiflush mounted case with matching cover.
12. Appropriate multiplier tag.

F. Impulse-Totalizing Demand Meter:

1. Comply with ANSI C12.1.
2. Suitable for use with MCC watt-hour meter, including two-circuit totalizing relay.
3. Cyclometer.
4. Four-dial, totalizing kilowatt-hour register.
5. Positive chart drive mechanism.
6. Capillary pen holding a minimum of one month's ink supply.
7. Roll chart with minimum 31-day capacity; appropriate multiplier tag.
8. Capable of indicating and recording **[five][15][30]<Insert time>**-minute integrated demand of totalized system.

G. Control Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

2.13 FEEDER TAP UNITS

A. MCCBs (to 1200 A): Fixed mounted, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger. Comply with UL 489, and NEMA AB 3, with interrupting capacity to comply with available fault currents.

1. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
2. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:
 - a. Instantaneous trip.
 - b. Long- and short-time pickup levels.
 - c. Long- and short-time time adjustments.
 - d. Ground-fault pickup level, time delay, and I₂t response.
3. Communication Capability: **[Circuit-breaker-mounted][Universal-mounted][Integral][Din-rail-mounted]** communication module with functions and features compatible with power monitoring and control system specified in Section 260913 "Electrical Power Monitoring and Control."
4. With built-in digital ammeter and a digital display, showing tripping cause.
5. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
6. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
7. Auxiliary Contacts: **[One SPDT switch][Two SPDT switches]** with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker



contacts.

8. Alarm Switch: One **[NC][NO]** contact that operates only when circuit breaker has tripped.
9. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
10. Zone-Selective Interlocking: Integral with **[electronic][ground-fault]** trip unit; for interlocking ground-fault protection function.
11. Electrical Operator: Remote control for on, off, and reset operations.

- B. Fusible Switches (to 600 A): Fixed-mounted, manually operated, **[electrically tripped]**, fusible, quick-make, quick-break switch with 200-kA interrupting and short-circuit current rating when fitted with UL 248-8 Class J fuses. Comply with UL 98.

1. Indication whether the switch is open or closed, and provisions for padlocking the operating handle.
2. Include fuse clips and fuses.
3. Electrically tripped switches shall include the following:
 - a. Shunt trip.
 - b. Ground-fault protection, with adjustable time delay and test panel.
 - c. Single-phase protection, tripping the switch on loss of a source phase.
 - d. Blown fuse protection, tripping the switch on a blown fuse, with blown fuse indication.

2.14 PANELBOARDS

- A. Comply with NEMA PB 1.
- B. Branch OCPDs for Circuit-Breaker Frame Sizes 125 A and Smaller: **[Plug-in][Bolt-on]** circuit breakers.
- C. Branch OCPDs for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; or plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.
- D. Contactors in Main Bus: NEMA ICS 2, Class A, **[electrically][mechanically]** held, general-purpose controller, with same short-circuit interrupting rating as panelboard.
- E. Accessory Control Power Voltage: Integrally mounted, self-powered, **<Insert number> [Remote mounted and powered]**.

2.15 TRANSFORMERS

- A. Factory-assembled and -tested, air-cooled, two-winding, low-voltage dry-type transformers; with primary circuit breaker. Comply with NEMA ST 20.
- B. Taps for Transformers Smaller Than 3 kVA: **[None][One 5 percent tap above normal full capacity]**.
- C. Taps for Transformers 7.5 to 24 kVA: **[One 5 percent tap above and one 5 percent tap below normal full capacity][Two 5 percent taps below rated voltage]**.
- D. Taps for Transformers 25 kVA and Larger: **[Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity][Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity]**.
- E. Insulation Class: 220 deg C, UL-component-recognized insulation system with a maximum of

[150][115][80] deg C rise above 40 deg C ambient temperature.

F. Energy Efficiency for Transformers Rated 15 kVA and Larger:

1. Complying with NEMA TP 1, Class 1 efficiency levels.
2. Tested according to NEMA TP 2.

2.16 TRANSFER SWITCHES

- A. Factory-assembled and -tested, open-transition transfer switches. The transfer switch shall comply with UL 1008[**and be listed and labeled by a qualified testing agency**].
- B. Comply with NEMA ST 20.
- C. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.
- D. Tested Fault-Current Closing and Withstand Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.
1. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.
- E. Solid-State Controls: Repetitive accuracy of all settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.
- F. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41.1. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.
- G. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.
- H. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are unacceptable.
 2. Switch Action: Double throw; mechanically held in both directions.
 3. Contacts: Silver composition or silver alloy for load-current switching. Conventional automatic transfer-switch units, rated 225 A and higher, shall have separate arcing contacts.
- I. Neutral Switching. Where four-pole switches are indicated, equip with **[neutral pole switched simultaneously with phase poles][overlapping neutral contacts]**.
- J. Neutral Terminal: Solid and rated the same as the neutral bus.
- K. Oversize Neutral: Ampacity and switch rating of neutral path through units indicated for oversize neutral shall be double the nominal rating of circuit in which switch is installed.
- L. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels shall

have communication capability matched with remote device.

2.17 SOURCE QUALITY CONTROL

- A. MCC Testing: Test and inspect MCCs according to requirements in **[NEMA ICS 18]<Insert standard>**.
- B. VFC Testing: Test and inspect VFCs according to requirements in **[NEMA ICS 61800-2]<Insert standard>**.
 - 1. Test each VFC while connected to **[its specified motor][a motor that is comparable to that for which the VFC is rated]**.
 - 2. Verification of Performance: Rate VFCs according to operation of functions and features specified.
- C. MCCs will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and surfaces to receive MCCs, with Installer present, for compliance with requirements for installation tolerances, **<Insert Project-specific conditions,>** and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. NEMA Industrial Control and Systems Standards: Comply with parts of NEMA ICS 2.3 for installation and startup of MCCs.
- B. Floor Mounting: Install MCCs on **4-inch (100-mm)** nominal-thickness concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."
 - 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch (450-mm)** centers around the full perimeter of concrete base.
 - 2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 4. Install anchor bolts to elevations required for proper attachment to supported equipment.
- C. Seismic Bracing: Comply with requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

- E. Install fuses in each fusible switch.
- F. Install fuses in control circuits if not factory installed. Comply with requirements in Section 262813 "Fuses."
- G. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.
- H. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.
- I. Install power factor correction capacitors. Connect to the **[line][load]** side of overload relays. If connected to the load side of overload relays, adjust overload heater sizes to accommodate the reduced motor full-load currents.
- J. Comply with NECA 1.

3.3 IDENTIFICATION

- A. Comply with requirements in Section 260553 "Identification for Electrical Systems" for identification of MCC, MCC components, and control wiring.
 - 1. Identify field-installed conductors, interconnecting wiring, and components.
 - 2. Install required warning signs.
 - 3. Label MCC and each cubicle with engraved nameplate.
 - 4. Label each enclosure-mounted control and pilot device.
 - 5. Mark up a set of manufacturer's connection wiring diagrams with field-assigned wiring identifications and return to manufacturer for inclusion in Record Drawings.
- B. Operating Instructions: Frame printed operating instructions for MCCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of MCCs.

3.4 INSTALLATION OF CONTROL WIRING

- A. Install wiring between **[enclosed controllers][master terminal boards]** and remote devices **[and facility's BAS][and facility's central-control system]**. Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."
- B. Bundle, train, and support wiring in enclosures.
- C. Connect selector switches and other automatic-control selection devices where applicable.
 - 1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switch is in manual-control position.
 - 2. Connect selector switches within enclosed controller circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.5 CONNECTIONS

- A. Comply with requirements for installation of conduit in Section 260533.13 "Conduits for Electrical Systems." Drawings indicate general arrangement of conduit, fittings, and specialties.

- B. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.6 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections **[with the assistance of a factory-authorized service representative]**.
- D. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each enclosed controller, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- E. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 4. Perform the following infrared (thermographic) scan tests and inspections and prepare reports:
 - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each multipole enclosed controller. Remove front panels so joints and connections are accessible to portable scanner.
 - b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each multipole enclosed controller 11 months after date of Substantial Completion.
 - c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Submit calibration record for device.
 - 5. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
 - 6. Mark up a set of manufacturer's drawings with all field modifications incorporated during construction and return to manufacturer for inclusion in Record Drawings.
- F. MCCs will be considered defective if they do not pass tests and inspections.
- G. Prepare test and inspection reports.

3.7 STARTUP SERVICE

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.
 - 1. Complete installation and startup checks according to NETA Acceptance Testing Specification and manufacturer's written instructions.

2. <Insert startup steps if any>.

3.8 ADJUSTING

- A. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload relay pickup and trip ranges.
- B. Adjust overload relay heaters or settings if power factor correction capacitors are connected to the load side of the overload relays.
- C. Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to six times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify **[Architect][Construction Manager][Owner]** before increasing settings.
- D. Set the taps on reduced-voltage autotransformer controllers at **[50][65][80]** percent.
- E. Set field-adjustable switches and program microprocessors for required start and stop sequences in reduced-voltage, solid-state controllers.
- F. Program microprocessors in VFCs for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.
- G. Set field-adjustable circuit-breaker trip ranges **[as specified in Section 260573.16 "Coordination Studies."]**

3.9 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain enclosed controllers **[, and to use and reprogram microprocessor-based, reduced-voltage, solid-state controllers].**

END OF SECTION 26 24 19 00



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Task	Specification	Specification Description
26 24 19 00	26 09 13 00	Electrical Power Monitoring
26 24 19 00	26 11 16 11	Secondary Unit Substations with Switchgear Secondary
26 24 19 00	26 27 33 00	Power Distribution Units



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SECTION 26 25 00 00 - LOW-VOLTAGE ENCLOSED BUS ASSEMBLIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Enclosed bus assemblies.
2. Plug-in devices.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.2 ACTION SUBMITTALS

A. Shop Drawings: For each type of product.

1. Show fabrication and installation details for enclosed bus assemblies. Include plans, elevations, and sections of components. Designate components and accessories, including clamps, brackets, hanger rods, connectors, straight lengths, and fittings.
2. Show fittings, materials, fabrication, and installation methods for **[listed firestop barriers][and][weather barriers]**.
3. Indicate required clearances, method of field assembly, and location and size of each field connection.
4. Detail connections to switchgear, switchboards, transformers, and panelboards.
5. Cable and conductor terminal sizes for bus and plug-in device terminations.
6. Wiring Diagrams: Power[**and signal**][**and control**][, **signal, and control**] wiring.

B. Delegated Design Submittal: For seismic-restraint details, signed and sealed by a qualified structural professional engineer.

1. Include design calculations for selecting seismic restraints.
2. Detail fabrication, including anchorages and attachments to structure and to supported equipment.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Plug-in Units: [10]<Insert number> percent of amount installed[**for each size indicated**], but no fewer than <Insert number> unit(s).

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, and handle enclosed bus assemblies according to NEMA BU 1.1, "General Instructions for Handling, Installation, Operation, and Maintenance of Busway Rated 600 Volts or Less."

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTIONS

- A. Source Limitations: Obtain enclosed bus assemblies[**and plug-in devices**] from single source from single manufacturer.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with UL 857.

2.2 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified electrical professional engineer to design enclosed bus assemblies, plug-in devices, and components.

2.3 ENCLOSED BUS ASSEMBLIES

- A. Feeder-Bus Assemblies: Low-impedance bus assemblies in totally enclosed, nonventilated housing; single-bolt joints; ratings as indicated.

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [ABB, Electrification Business]
 - b. [EAE USA]
 - c. [Eaton]
 - d. [Siemens Industry, Inc., Energy Management Division]
 - e. [Square D; Schneider Electric USA]
 - f. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [ABB, Electrification Business]
 - b. [EAE USA]
 - c. [Eaton]

- d. **[Siemens Industry, Inc., Energy Management Division]**
 - e. **[Square D; Schneider Electric USA]**
 - f. **<Insert manufacturer's name>**
3. Seismic Fabrication Requirements: Fabricate mounting provisions and attachments for feeder-bus assemblies with reinforcement strong enough to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems" when mounting provisions and attachments are anchored to building structure.
 4. Electrical Characteristics:
 - a. Voltage: **[120/208][240][480][277/480]** V.
 - b. Phase: Three; **[3 wire][4 wire]**.
 - c. Percent of Neutral Capacity: **[50][100][200]<Insert value>**.
 5. Short-Circuit Interrupting Rating:
 - a. For Bus Amperage of 800: 85 symmetrical kAIC.
 - b. For Bus Amperage of 1200: 100 symmetrical kAIC.
 - c. For Bus Amperage of 1600: 125 symmetrical kAIC.
 - d. For Bus Amperage of 2500: 150 symmetrical kAIC.
 - e. For Bus Amperage of 5000: 200 symmetrical kAIC.
 6. Temperature Rise: 55 deg C above 40 deg C ambient maximum for continuous rated current.
 7. Bus Materials: Current-carrying **[copper][aluminum]** conductors, fully insulated with Class 130C insulation except at joints; plated surface at joints.
 8. Voltage Drop:
 - a. Measure voltage drop at 30 deg C ambient with bus thermally stabilized at full rated load.
 - b. Three-phase, line-to-line voltage drop less than 3.1 V per **100 ft. (30.5 m)** at 40 percent power factor.
 9. Ground: 50 percent capacity, **[integral with housing][internal bus bar of material matching bus material][isolated, internal bus bar of material matching bus material]**.
 10. Enclosure: **[Steel][Aluminum]**, with manufacturer's standard finish.**[Weatherproof, sealed seams, drains, and removable closures.]**
 11. Fittings and Accessories: Manufacturer's standard.
 12. Firestop: Comply with UL 1479 firestop system, listed and labeled by an NRTL acceptable to authorities having jurisdiction for penetrations of fire-rated walls, ceilings, and floors.
 13. Mounting: Arranged flat, edgewise, or vertically without derating. Rated for hanger spacing of up to **10 ft. (3 m)** for horizontally mounted runs and up to **16 ft. (5 m)** for vertically mounted runs.
 14. Expansion Section: Manufacturer's standard expansion fitting for the provided busway with expansion capability to accommodate thermal expansion of bus and enclosure, and to accommodate movement across building expansion joints.
- B. Plug-in Bus Assemblies: Low-impedance bus assemblies in totally enclosed, nonventilated housing; single-bolt joints; ratings as indicated.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[Eaton]**
 - c. **[Siemens Industry, Inc., Energy Management Division]**
 - d. **[Square D; Schneider Electric USA]**

- e. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [ABB, Electrification Business]
 - b. [Eaton]
 - c. [Siemens Industry, Inc., Energy Management Division]
 - d. [Square D; Schneider Electric USA]
 - e. <Insert manufacturer's name>
 3. Electrical Characteristics:
 - a. Voltage: [120/208][240][480][277/480] V.
 - b. Phase: Three; [3 wire][4 wire].
 - c. Percent of Neutral Capacity: [100][200]<Insert value>.
 4. Short-Circuit Interrupting Rating:
 - a. For Bus Amperage of 800: 85 symmetrical kAIC.
 - b. For Bus Amperage of 1200: 100 symmetrical kAIC.
 - c. For Bus Amperage of 1600: 125 symmetrical kAIC.
 - d. For Bus Amperage of 2500: 150 symmetrical kAIC.
 - e. For Bus Amperage of 5000: 200 symmetrical kAIC.
 5. Temperature Rise: 55 deg C above 40 deg C ambient maximum for continuous rated current.
 6. Bus Materials: Current-carrying [copper][aluminum] conductors, fully insulated with Class 130C insulation except at stabs and joints; plated surface at stabs and joints.
 7. Ground: 50 percent capacity, [integral with housing][internal bus bar of material matching bus material][isolated, internal bus bar of material matching bus material].
 8. Enclosure: [Steel][Aluminum], with manufacturer's standard finish.
 9. Plug-in Openings: 24 inch (600 mm) on center on each side of bus, and hinged covers over unused openings. Plug-in openings must be finger-safe with covers open or closed.
 10. Fittings and Accessories: Manufacturer's standard.
 11. Firestop: Comply with UL 1479 firestop system, listed and labeled by an NRTL acceptable to authorities having jurisdiction for penetrations of fire-rated walls, ceilings, and floors.
 12. Mounting: Arranged flat, edgewise, or vertically without derating. Rated for hanger spacing of up to 10 ft. (3 m) for horizontally mounted runs and up to 16 ft. (5 m) for vertically mounted runs.
 13. Expansion Section: Manufacturer's standard expansion fitting for the provided busway with expansion capability to accommodate thermal expansion of bus and enclosure, and to accommodate movement across building expansion joints.
- C. Joints:
1. Busway joints must use one high-strength steel bolt with Belleville washers.
 2. Bolts must be torque indicating type and at ground potential.
 3. Bolts must be two-headed design to indicate when proper torque has been applied and require only a standard long handle wrench to be properly activated.
 4. Access must be required to only one side of the busway for tightening joint bolts.
 5. Joint connection assemblies must be removable without disturbing adjacent busway lengths.
 6. Joint connection assemblies that rely on the joint cover to provide ground continuity are unacceptable.

2.4 PLUG-IN DEVICES

- A. Fusible Switches: NEMA KS 1, heavy duty; with **[R-type rejection][J-type][L-type]** fuse clips to accommodate specified fuses; hookstick-operated handle, lockable with two padlocks, and interlocked with cover in closed position. Interlocked to prevent plug-in device insertion into or removal from bus with switch in closed position. See Section 262813 "Fuses" for fuses and fuse installation requirements.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Eaton]**
 - b. **[Siemens Industry, Inc., Energy Management Division]**
 - c. **[Square D; Schneider Electric USA]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Eaton]**
 - b. **[Siemens Industry, Inc., Energy Management Division]**
 - c. **[Square D; Schneider Electric USA]**
 - d. **<Insert manufacturer's name>**
- B. Molded-Case Circuit Breakers: UL 489; hookstick-operated handle, lockable with two padlocks, and interlocked with cover in closed position. Interlocked to prevent plug-in device insertion into or removal from bus with switch in closed position.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[Eaton]**
 - c. **[NOARK Electric North America]**
 - d. **[Siemens Industry, Inc., Energy Management Division]**
 - e. **[Square D; Schneider Electric USA]**
 - f. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Eaton]**
 - c. **[NOARK Electric North America]**
 - d. **[Siemens Industry, Inc., Energy Management Division]**
 - e. **[Square D; Schneider Electric USA]**
 - f. **<Insert manufacturer's name>**
- C. SPD: NEMA 250, Type 1 enclosure with NEMA KS 1, fusible, disconnect switch and external handle to isolate SPD from busway. SPD product and installation requirements are specified in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."



1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[Advanced Protection Technologies Inc. (APT)]**
 - c. **[ALLTEC LLC]**
 - d. **[Eaton]**
 - e. **[Emerson Electric Co., Automation Solutions]**
 - f. **[LEA International]**
 - g. **[Leviton Manufacturing Co., Inc.]**
 - h. **[Mersen USA]**
 - i. **[PowerLogics, Inc./PQ Protection]**
 - j. **[Schneider Electric USA, Inc.]**
 - k. **[Siemens Industry, Inc., Energy Management Division]**
 - l. **<Insert manufacturer's name>**

 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Advanced Protection Technologies Inc. (APT)]**
 - c. **[ALLTEC LLC]**
 - d. **[Eaton]**
 - e. **[Emerson Electric Co., Automation Solutions]**
 - f. **[LEA International]**
 - g. **[Leviton Manufacturing Co., Inc.]**
 - h. **[Mersen USA]**
 - i. **[PowerLogics, Inc./PQ Protection]**
 - j. **[Schneider Electric USA, Inc.]**
 - k. **[Siemens Industry, Inc., Energy Management Division]**
 - l. **<Insert manufacturer's name>**
- D. Motor Controllers: NEMA ICS 2, Class A, full voltage, nonreversing, across the line unless otherwise indicated.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[ABB, Motion Business]**
 - c. **[Cerus Industrial, Inc.]**
 - d. **[Eaton]**
 - e. **[Rockwell Automation, Inc.]**
 - f. **[Siemens Industry, Inc., Energy Management Division]**
 - g. **[Square D; Schneider Electric USA]**
 - h. **<Insert manufacturer's name>**

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

- a. **[ABB, Electrification Business]**
 - b. **[ABB, Motion Business]**
 - c. **[Cerus Industrial, Inc.]**
 - d. **[Eaton]**
 - e. **[Rockwell Automation, Inc.]**
 - f. **[Siemens Industry, Inc., Energy Management Division]**
 - g. **[Square D; Schneider Electric USA]**
 - h. **<Insert manufacturer's name>**
3. Control Circuit: 120 V; obtained from **[integral control power transformer]<Insert source of control power>** with a control power **[transformer][source]** of enough capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity.
 4. Combination Controller: Factory-assembled combination controller and disconnect switch with or without overcurrent protection as indicated.
 - a. Fusible Disconnecting Means: NEMA KS 1, heavy-duty, fusible switch with **[R-type rejection][J-type]** fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1, as certified by an NRTL acceptable to authorities having jurisdiction. See Section 262813 "Fuses" for fuses and fuse installation requirements.
 - b. Circuit-Breaker Disconnecting Means: UL 489, motor-circuit protector with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
 5. Overload Relay: Ambient-compensated type with inverse-time-current characteristic and NEMA ICS 2, **[Class 10][Class 20][Class 30]** tripping characteristic. Overload relays must have heaters or sensors in each phase matched to nameplate full-load current of specific motor to which they connect and with appropriate adjustment for duty cycle.
 6. Adjustable Overload Relay: Dipswitch selected for motor running overload protection with NEMA ICS 2, **[Class 10][Class 20][Class 30]** tripping characteristic, and selected to protect motor against voltage and current unbalance and single phasing. Adjustable overload relays must have Class II ground-fault protection with start and run delays to prevent nuisance trip on starting.
- E. Multispeed Magnetic Controllers: Match controller to motor type, application, and number of speeds.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[ABB, Motion Business]**
 - c. **[Eaton]**
 - d. **[Rockwell Automation, Inc.]**
 - e. **[Siemens Industry, Inc., Energy Management Division]**
 - f. **[Square D; Schneider Electric USA]**
 - g. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[ABB, Motion Business]**
 - c. **[Eaton]**
 - d. **[Rockwell Automation, Inc.]**
 - e. **[Siemens Industry, Inc., Energy Management Division]**

- f. **[Square D; Schneider Electric USA]**
- g. **<Insert manufacturer's name>**

- 3. Compelling relay ensures motor starts only at low speed.
- 4. Accelerating relay ensures properly timed acceleration through speeds lower than that selected.
- 5. Decelerating relay ensures automatically timed deceleration through each speed.

- F. Accessories: Hookstick operator, adjustable to maximum extension of **[14 ft. (4.3 m)]<Insert dimension>**.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Coordinate layout and installation of enclosed bus assemblies and suspension system with other construction that penetrates ceilings or floors or is supported by them, including luminaires, HVAC equipment, fire-suppression system, and partition assemblies.
- B. Equipment Mounting:
 - 1. Install enclosed bus assemblies on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 2. Coordinate size and location of concrete curbs around openings for vertical bus. Concrete, reinforcement, and formwork requirements are specified with concrete.
- C. Support bus assemblies independent of supports for other elements such as equipment enclosures at connections to panelboards and switchboards, pipes, conduits, ceilings, and ducts.
 - 1. Design each fastener and support to carry load indicated by seismic requirements and to comply with seismic-restraint details according to Section 260548.16 "Seismic Controls for Electrical Systems."
 - 2. Design each fastener and support to carry **200 lb (90 kg)** or 4 times the weight of bus assembly, whichever is greater.
 - 3. Support bus assembly to prevent twisting from eccentric loading.
 - 4. Support bus assembly with not less than **[3/8 inch (10 mm)]<Insert dimension>** steel rods. Install side bracing to prevent swaying or movement of bus assembly. Modify supports after completion to eliminate strains and stresses on bus bars and housings.
 - 5. Fasten supports securely to building structure according to Section 260529 "Hangers and Supports for Electrical Systems."
 - 6. Bolts and nuts that are loosened for any reason after tightening to manufacturer's recommended torque setting must be discarded and replaced with new bolts and nuts.
- D. Install expansion fittings at locations where bus assemblies cross building expansion joints. Install at other locations so distance between expansion fittings does not exceed manufacturer's recommended distance between fittings.
- E. Construct rated firestop assemblies where bus assemblies penetrate fire-rated elements such as walls, floors, and ceilings. Seal around penetrations according to Section 078413 "Penetration Firestopping."
- F. Install weatherseal fittings and flanges where bus assemblies penetrate exterior elements such as walls or roofs. Seal around openings to make weathertight. See Section 079200 "Joint Sealants" for materials and application.

- G. Coordinate bus-assembly terminations to equipment enclosures to ensure proper phasing, connection, and closure.
- H. Tighten bus-assembly joints with torque wrench or similar tool recommended by bus-assembly manufacturer. Tighten joints again after bus assemblies have been energized for 30 days.
- I. Install bus-assembly, plug-in units. Support connecting conduit independent of plug-in unit.

3.2 CONNECTIONS

- A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Terminate to transformer enclosures with matching bus assemblies according to Section 262200 "Low-Voltage Transformers."
- D. Terminate to switchgear enclosures with matching bus assemblies according to Section 262300 "Low-Voltage Switchgear."
- E. Terminate to switchboard enclosures with matching bus assemblies according to Section 262413 "Switchboards."
- F. Terminate to panelboard enclosures with matching bus assemblies according to Section 262416 "Panelboards."
- G. Terminate to motor-control centers enclosures with matching bus assemblies according to Section 262419 "Motor-Control Centers."

3.3 FIELD QUALITY CONTROL

- A. Field tests must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.
- B. Tests and Inspections:
 - 1. After installing equipment, test for compliance with requirements according to NETA ATS.
 - 2. Visual and Mechanical Inspection:
 - a. Compare equipment nameplate data with Drawings and Specifications.
 - b. Inspect physical and mechanical condition.
 - c. Inspect anchorage, alignment, and grounding.
 - d. Verify correct connection according to single-line diagram.
 - e. Inspect bolted electrical connections for high resistance using one or more of the following methods:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data.
 - 3) Perform thermographic survey.
 - 3. Electrical Tests:



- a. Perform insulation resistance measurements through bolted connections and bus joints with low-resistance ohmmeter.
- b. Perform insulation resistance tests of each busway, phase to phase, and phase to ground.
- c. Perform a dielectric withstand voltage test on each busway, phase to ground with phases not under test grounded for one minute.
- d. Measure resistance of assembled busway sections on insulated busway and compare values with adjacent phases.
- e. Perform phasing test on each busway tie section energized by separate sources.
- f. Verify operation of busway space heaters.

- C. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.
 1. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 2. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
 3. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.
- D. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.
- E. Nonconforming Work:
 1. Enclosed bus assemblies will be considered defective if they do not pass tests and inspections.
- F. Prepare test and inspection reports.

3.4 ADJUSTING

- A. Set field-adjustable, circuit-breaker trip ranges[**and overload relay trip settings**] as indicated.

3.5 CLEANING

- A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

3.6 PROTECTION

- A. Provide final protection to ensure that moisture does not enter bus assembly.

END OF SECTION 26 25 00 00



Task	Specification	Specification Description
26 25 13 00	26 25 00 00	Low-Voltage Enclosed Bus Assemblies
26 25 16 00	26 25 00 00	Low-Voltage Enclosed Bus Assemblies



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SECTION 26 27 13 00 - ELECTRICITY METERING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Electricity meters.
2. Work to accommodate utility company revenue meters, and Owner's electricity meters used to manage electrical power system.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.2 DEFINITIONS

- A. KY or KYZ Pulse:** Term used by metering industry to describe method of measuring consumption of electricity (kWh) that is based on relay opening and closing in response to rotation of disk in meter. Electronic meters generate pulses electronically.

1.3 COORDINATION

A. Electrical Service Connections:

1. Coordinate with utility companies and utility-furnished components.
 - a. Comply with requirements of utility providing electrical power services.
 - b. Coordinate installation and connection of utilities and services, including provision for electricity-metering components.

1.4 ACTION SUBMITTALS

A. Product Data:

1. For each type of meter.
2. For metering infrastructure components.
3. For metering software.

B. Shop Drawings: For electricity-metering equipment.

1. Include elevation views of front panels of control and indicating devices and control stations.
2. Include diagrams for power, signal, and control wiring.
3. Wire Termination Diagrams and Schedules: Include diagrams for power, signal, and control

wiring. Identify terminals and wiring designations and color-codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features. Differentiate between manufacturer-installed and field-installed wiring.

4. Include series-combination rating data for modular meter centers with main disconnect device.
5. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices used. Describe characteristics of network and other data communication lines.
6. Submit evidence that meters are compatible with connected monitoring and control devices and systems specified in **[Section 260913 "Electrical Power Monitoring and Control."]<Insert Section number and title.>**
 - a. Show interconnecting signal and control wiring, and interface devices to show compatibility of meters.
 - b. For reporting and billing interfaces and adapters, list network protocols and provide statements from manufacturers that input and output devices comply with interoperability requirements of the protocol.

C. Field quality-control reports.

1.5 INFORMATIONAL SUBMITTALS

- A. Manufacturers' Published Instructions: Record copy of official installation **[and testing]** instructions issued to Installer by manufacturer for the following:
 1. Installation of metering equipment.
- B. Sample warranties.

1.6 CLOSEOUT SUBMITTALS

- A. Maintenance Contracts:
 1. Software and firmware service agreement.
- B. Warranty documentation.

1.7 WARRANTY

- A. Special Installer Extended Warranty: Installer warrants that fabricated and installed metering equipment performs in accordance with specified requirements and agrees to repair or replace components or products that fail to perform as specified within extended-warranty period.
 1. Extended-Warranty Period: **[Two]<Insert number>** years from date of Substantial Completion; full coverage for labor, materials, and equipment.
- B. Special Manufacturer Extended Warranty: Manufacturer warrants that metering equipment performs in accordance with specified requirements and agrees to provide repair or replacement of components or products that fail to perform as specified within extended-warranty period.

1. Initial Extended-Warranty Period: **[Three]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for labor, materials, and equipment.
2. Follow-On Extended-Warranty Period: **[Eight]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for materials **[that failed because of transient voltage surges]** only, free on board **[origin][destination]**, freight prepaid.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- B. Comply with UL 916.

2.2 UTILITY METERING INFRASTRUCTURE

- A. Install metering accessories furnished by utility company, complying with its requirements.
- B. Utility-Furnished Meters: Connect data transmission facility of metering equipment installed by Utility.
 1. Data Transmission: Transmit pulse data over control-circuit conductors, classified as Class 1 per NFPA 70, Article 725. Comply with Section 260523 "Control-Voltage Electrical Power Cables."
- C. Current-Transformer Cabinets: Comply with requirements of electrical-power utility company.
- D. Meter Sockets:
 1. Comply with requirements of electrical-power utility company.
 2. Steady-state and short-circuit current ratings must meet indicated circuit ratings.
- E. Modular Meter Center: Factory-coordinated assembly of main service **[terminal box with lugs only][disconnect device]**, wireways, meter socket modules, and feeder circuit breakers arranged in adjacent vertical sections complete with interconnecting buses.
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[Eaton]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Siemens Industry, Inc., Energy Management Division]**
 - e. **[Square D; Schneider Electric USA]**
 - f. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[ABB, Electrification Business]**
 - b. **[Eaton]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Siemens Industry, Inc., Energy Management Division]**
 - e. **[Square D; Schneider Electric USA]**
 - f. **<Insert manufacturer's name>**
 3. Comply with requirements of utility company for meter center.
 - a. Comply with UL 67.
 4. Housing: UL 50E, **[Type 1][Type 3R][Type 4X]** enclosure.
 5. Meter Socket Rating: Coordinated with connected feeder circuit rating.
 6. Minimum Short-Circuit Rating: **[22 000 A][42 000 A][65 000 A][100 000 A]<Insert amperes>** symmetrical at rated voltage.
 7. Steady-state and short-circuit current ratings must have ratings that match connected circuit ratings.
 8. Main Disconnect Device:
 - a. Circuit breaker, series-combination rated for use with downstream feeder and branch circuit breakers and having adjustable magnetic trip setting for circuit-breaker frame sizes of 250 A and larger. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers." Circuit breakers must be operable from outside enclosure to disconnect unit. Configure cover so it can be opened only when disconnect switch is open.
 - b. Fusible switch, UL 98 Type GD, series-combination rated by fuse manufacturer to protect downstream feeder and branch circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers." Switch must be operable from outside enclosure to disconnect unit. Configure cover so that it can be opened only when disconnect switch is open.
 9. Feeder Circuit Breakers: Series-combination-rated molded-case units, rated to protect downstream circuit breakers and to house load centers and panelboards that have **[10 000 A]<Insert amperes>** interrupting capacity.
 - a. Identification: Complying with requirements in Section 260553 "Identification for Electrical Systems."
 - b. Physical Protection: Tamper resistant, with hasp for padlock.
 10. Surge Protection:
 - a. Factory-installed in main disconnect, integrally mounted, UL 1449 Type 1. Comply with Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."
 - b. Field-mounted external to main disconnect, UL 1449 Type 2, with integral disconnect and overcurrent protective device. Comply with Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."
 - c. Factory-installed in main terminal box, integrally mounted, UL 1449 Type 1. Comply with Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."
 - d. Field-mounted external to main terminal box, UL 1449 Type 2, with integral disconnect and overcurrent protective device. Comply with Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."
- F. Arc-Flash Warning Labels:
1. Comply with requirements for "Arc-Flash Warning Labels" in Section 260573.19 "Arc-Flash Studies." Apply **3-1/2-by-5 inch (76-by-127 mm)** thermal transfer label of high-adhesion

- polyester for each work location included in the analysis.
2. Comply with requirements for "Self-Adhesive Equipment Labels" and "Signs" in Section 260553 "Identification for Electrical Systems." Apply **3-1/2-by-5 inch (76-by-127 mm)** thermal transfer label of high-adhesion polyester for each work location included in the analysis. Labels must be machine printed, with no field-applied markings.
 - a. Label must have orange header with wording, "WARNING, ARC-FLASH HAZARD," and must include the following information taken directly from arc-flash hazard analysis:
 - 1) Location designation.
 - 2) Nominal voltage.
 - 3) Flash protection boundary.
 - 4) Hazard risk category.
 - 5) Incident energy.
 - 6) Working distance.
 - 7) Engineering report number, revision number, and issue date.

2.3 ELECTRICITY METERS

- A. System Description: Able to meter designated activity loads, with or without external alarm, control, and communication capabilities, or other optional features.
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 1. **[ABB, Electrification Business]**
 2. **[Davidge Controls]**
 3. **[E-Mon]**
 4. **[Eaton]**
 5. **[GE Power; General Electric Company]**
 6. **[Leviton Manufacturing Co., Inc.]**
 7. **[National Meter Industries]**
 8. **[Sensus Metering Systems]**
 9. **[Siemens Industry, Inc., Energy Management Division]**
 10. **[Square D; Schneider Electric USA]**
 11. **<Insert manufacturer's name>**
- C. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 1. **[ABB, Electrification Business]**
 2. **[Davidge Controls]**
 3. **[E-Mon]**
 4. **[Eaton]**
 5. **[GE Power; General Electric Company]**
 6. **[Leviton Manufacturing Co., Inc.]**
 7. **[National Meter Industries]**
 8. **[Sensus Metering Systems]**
 9. **[Siemens Industry, Inc., Energy Management Division]**
 10. **[Square D; Schneider Electric USA]**
 11. **<Insert manufacturer's name>**
- D. General Requirements for Meters:



1. Comply with NEMA ANSI C12.1 and NEMA ANSI C12.20, [0.1][0.2][0.5] accuracy class.
 2. Ambient Temperature: Minus 22 deg F to plus 158 deg F (Minus 30 deg C to plus 70 deg C).
 3. Humidity: Zero to 95 percent, noncondensing.
 4. Capacities and Characteristics:
 - a. Circuit: 120/240 V(ac), 100 A.
 - b. Measure: kWh, onboard LED display.
 - c. Remote-Reading Options: None.
 5. Billing Meters Accuracy: [0.2][0.5][1.0] percent of reading, complying with NEMA ANSI C12.20.
 6. Meter Certification: Certified by [California Type Evaluation Program]<Insert agency> as complying with [4 CCR 4027, Article 2.2]<Insert state or Federal regulatory requirement>.
 7. Certify that meters comply with NEMA ANSI C12.20 requirements by laboratory accredited by the National Voluntary Laboratory Accreditation Program (NVLAP) of the National Institute of Standards and Technology (NIST). Laboratory must use test equipment that is certified annually and is traceable to NIST standards.
 8. Enclosure: Supplied by meter manufacturer, UL 50E, [Type 1][Type 3R][Type 4X] minimum, with provisions for locking or sealing.
 9. Identification: Comply with requirements in Section 260553 "Identification for Electrical Systems."
 10. Onboard Nonvolatile Data Storage: kWh, until reset.
 11. Sensors: Current-sensing type, supplied by electronic meter manufacturer, with current or voltage output, selected for optimum range and accuracy for meters indicated for this application.
 - a. Type: [Split][and][solid] core, complying with recommendation of meter manufacturer.
- E. kWh Meter: Electronic [single-phase][and][three-phase] meters, measuring electricity use.
1. Voltage and Phase Configuration: Meter must be designed for use on circuits with voltage rating and phase configuration indicated for its application.
 2. Display:
 - a. LCD with characters not less than 0.25 inch (6 mm) high, indicating accumulative kWh and current kilowatt load. Retain accumulated kWh in nonvolatile memory, until reset.
 - b. Digital electromechanical counter, indicating accumulative kWh.
- F. kWhd Meter: Electronic [single-phase][and][three-phase] meters, measuring electricity use and demand. Demand must be integrated over [15-minute]<Insert time> interval.
1. Voltage and Phase Configuration: Meter must be designed for use on circuits with voltage rating and phase configuration indicated for its application.
 2. Display: LCD with characters not less than 0.25 inch (6 mm) high, indicating the following:
 - a. Accumulative kWh.
 - b. Current time and date.
 - c. Current demand.
 - d. Historic peak demand.
 - e. Time and date of historic peak demand.
 3. Retain accumulated kWh and historic peak demand in nonvolatile memory, until reset.
- G. KY and KYZ Pulse Totalizer:
1. Pulse Totalizer: Instrument for demand and billing applications where one or more utility revenue meters stream KY or KYZ energy pulses. Instrument must totalize kWh accumulated over user-selected period and must log maximum and minimum kWhd for that period. Record each period

with date/time stamp. Time period must be user selected from one to 60 minutes.

- a. Pulse Input: **[One]<Insert number>**, individually programmable, KYZ Form C (three-wire) contact pulse channels. Pulse interval, pulse rate, and minimum pulse width must be field adjustable, set for pulse stream provided by utility revenue meter.
 - b. Data Totalizing Capacity of Each Channel: Not less than 149 days at 15-minute intervals.
 - c. Instrument Power: User selectable, 120 V(ac) and 277 V(ac).
 - d. Clock: Line frequency.
- H. Remote Reading Options:
1. Pulse Output: **[KY][KYZ]**, complete with optical sensor and interface devices.
 2. TIA-232 serial interface.
 3. TIA-485 serial interface, with **[Modbus RTU protocol]<Insert protocol name>**.
 4. USB interface.
 5. TCP/IP adapter.
- I. Current-Transformer Cabinet: Size and configuration as recommended by metering equipment manufacturer for use with indicated connected feeder and sensors.
- J. Uninterruptible Power Supply: Single phase, 120 V(ac), sized and rated to provide continuous power to meter for operations of **[48]<Insert number>** hours after interruption of normal power.
1. Output: Sine wave, total harmonic distortion less than 5 percent at full load.
 2. Battery: Maintenance free, sealed, lead acid, and leakproof.
 3. Control Panel: LED status display of "on-battery," "replace battery," and "overload."
- K. Data Transmission Cable: Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."
- L. Software: PC-based product **[of][recommended by]** meter manufacturer, suitable for calculating utility cost allocation.
1. Utility Cost Allocation: Automatically import electricity-usage records to allocate electricity costs for the following:
 - a. At least **[15]<Insert number>** departments.
 - b. At least **[30]<Insert number>** tenants or activities.
 - c. At least **[five]<Insert number>** processes.
 - d. At least **[five]<Insert number>** buildings.
 - e. **<Insert entity>**.
 2. Activity Billing Software: Automatically import electricity-usage records to automatically compute and prepare electricity-use statements[**and invoices**] based on electricity use[**and peak demand**]. Maintain separate directory for each allocation. Prepare summary reports in user-defined formats and time intervals.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with manufacturer's published instructions.

B. Reference Standards:

1. Install modular meter center according to switchboard installation requirements in NECA 400.
2. Install arc-flash labels as required by NFPA 70.

C. Special Techniques:

1. Install meters furnished by utility company. Install raceways and equipment according to utility company's published instructions. Provide empty conduits for metering leads and extend grounding connections as required by utility company.
2. Wiring Methods:
 - a. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and Section 260533.13 "Conduits for Electrical Systems."
 - b. Install unshielded, twisted-pair cable for control and signal transmission conductors, complying with Section 271513 "Communications Copper Horizontal Cabling."
 - c. Minimum conduit size is metric designator 16 (trade size 1/2).

3.2 IDENTIFICATION**A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."**

1. Series Combination Warning Label: Self-adhesive labels, with text as required by NFPA 70.
2. Equipment Identification Labels: Self-adhesive labels with clear protective overlay. For residential meters, provide additional card holder suitable for **[printed, weather-resistant card][typewritten card]** with occupant's name.

3.3 FIELD QUALITY CONTROL**A. Acceptance Testing Preparation:**

1. **<Insert requirements>**.

B. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>.****C. Tests and Inspections:**

1. Equipment and Software Setup:
 - a. Set meter date and time clock.
 - b. Test, calibrate, and connect pulse metering system.
 - c. Set and verify billing demand interval for demand meters.
 - d. Report settings and calibration results.
 - e. Set up reporting and billing software, insert billing location names and initial constant values and variable needed for billing computations.
2. Connect load of known power rating, **[1.5 kW]<Insert kilowatts>** minimum, to circuit supplied by metered feeder.
3. Turn off circuits supplied by metered feeder and secure them in off condition.
4. Run test load continuously for eight hours minimum, or longer, to obtain measurable meter

- indication. Use test-load placement and setting that ensures continuous, safe operation.
5. Check and record meter reading at end of test period and compare with actual electricity used, based on test-load rating, duration of test, and sample measurements of supply voltage at test-load connection. Record test results.
 6. Generate test report and billing for each tenant or activity from meter reading tests.

D. Nonconforming Work:

1. Electricity metering will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

E. Collect, assemble, and submit test and inspection reports.

F. Manufacturer Services:

1. Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.

3.4 PROTECTION

- A. After installation, protect metering equipment from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

3.5 MAINTENANCE

A. Software and Firmware Service Agreement:

1. Technical Support: Beginning at Substantial Completion, verify that software and firmware service agreement includes software and firmware support for **[two]<Insert number>** years.
2. Upgrade Service: At Substantial Completion, update software and firmware to latest version. Install and program software and firmware upgrades that become available within **[two]<Insert number>** years from date of Substantial Completion. **[Verify that upgrading software includes operating system and new or revised licenses for using software.]**
 - a. Upgrade Notice: No fewer than **[30]<Insert number>** days to allow Owner to schedule and access the system **[and to upgrade computer equipment if necessary.]**
3. Upgrade Reports: Prepare report after each update, documenting upgrades installed.

END OF SECTION 26 27 13 00



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SECTION 26 27 16 00 - ELECTRICAL CABINETS AND ENCLOSURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cabinets and cutout boxes.
2. Termination boxes.
3. Miscellaneous enclosures.
4. Rack or frame systems.
5. Enclosure-mounted power distribution.

B. Products Installed, but Not Furnished, under This Section:

1. **<Insert products identified in "Existing Products to be Modified" Article or "Existing Products to be Removed and Reinstalled" Article>.**

C. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies temperature, humidity, acoustical, and other field conditions applicable to the Work specified in this Section.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies seismic hazard, wind hazard, and other structural design conditions applicable to the Work specified in this Section.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional coordination, scheduling, sequencing, submittal, and installation requirements applicable to the Work for electrical, communications, and electronic safety and security systems on the Project, including wiring methods.
4. Section 078413 "Penetration Firestopping" specifies materials and methods for sealing penetrations of rated walls and partitions referenced by this Section.
5. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs referenced by this Section.
6. Section 260526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding for RBBs referenced by this Section.
7. Section 260573 "Power System Studies" specifies arc-flash hazard analysis and warning labels referenced by this Section.
8. Section 270528 "Pathways for Communications Systems"[**and Section 271100 "Communications Equipment Room Fittings"**] specifies additional requirements for raceway materials, routing, locations, and identification of communications equipment and cabling.

1.2 DEFINITIONS

- A. RBB: Rack bonding busbar, located in equipment cabinets and racks.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Prepare and submit the following:

1. Shop Drawings for Custom Enclosures and Cabinets: Include plans, elevations, sections, and attachment details.
2. Shop Drawings for Racks or Frames:
 - a. Include plans, elevations, sections, details, and attachments to other work.
 - b. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - c. Include workspace requirements and access for cable connections.
 - d. Grounding: Indicate location of RBB and its mounting detail showing standoff insulators and wall-mounting brackets.

C. Sustainable Design Submittals:

1. Product data for sustainable design features for each type of product.

D. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

- A. Manufacturers' published instructions.

1.5 QUALIFICATIONS

- A. Electrical Power Testing (EPT) Technician III: Possessing active NICET EPT Level III certification. Able to manage switching procedures; conduct tests of complex equipment; analyze test and equipment data; plan a job; and lead a team. Has experience performing NFPA 70B, IEEE, and NETA electrical tests.
- B. Electrical Power Testing (EPT) Technician IV: Possessing active NICET EPT Level IV certification. Able to conduct tests of complex metering and relay systems; evaluate tests, test equipment, test results, and power system performance; recommend actions to maintain or improve system performance; and lead multi-team projects.
- C. Electrical Power Testing and Inspecting Agency: Entities possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
1. On-site electrical testing supervisors must possess active NICET EPT Technician [III][IV] certification.
- D. Communications Testing and Inspecting Agency: Entity possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
1. On-site communications testing supervisor must have **[BICSI Technician (TECH)]<Insert certification program>** certification and documented training, and be experienced with testing communications equipment in accordance with **[BICSI]<Insert code enforced by authorities having jurisdiction>** testing standards.

PART 2 - PRODUCTS

2.1 EXISTING PRODUCTS TO BE MODIFIED

- A. Basis for Pricing: **<Insert name of manufacturer; model number or series for existing product>.**
- B. Description: **<Insert description of existing product, including special features, options, and finishes that may impact the Work>.**
 - 1. Sustainable Design Features:
 - a. Material Reuse: Product is salvaged, refurbished, or reused.
- C. Accessories: **<Insert accessories included with existing product>.**

2.2 EXISTING PRODUCTS TO BE REMOVED AND REINSTALLED

- A. Basis for Pricing: **<Insert name of manufacturer; model number or series for existing product>.**
- B. Description: **<Insert description of existing product, including special features, options, and finishes that may impact the Work>.**
 - 1. Sustainable Design Features:
 - a. Material Reuse: Product is salvaged, refurbished, or reused.
- C. Accessories: **<Insert accessories included with existing product>.**

2.3 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2.4 CABINETS AND CUTOOT BOXES

- A. UL CYIV - Indoor Sheet Metal Cabinets :
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[Adalet; division of Scott Fetzer Co.]**
 - c. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - d. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - e. **[Erickson Electrical Equipment Company]**
 - f. **[FSR Inc.]**
 - g. **[Hoffman; brand of nVent Electrical plc]**
 - h. **[Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**

- i. [Milbank Manufacturing Company]
 - j. [N J Sullivan Company]
 - k. [Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - l. [Robroy Enclosures; Robroy Industries]
 - m. [Siemens Industry, Inc., Building Technologies Division]
 - n. [Square D; Schneider Electric USA]
 - o. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [ABB, Electrification Business]
 - b. [Adalet; division of Scott Fetzer Co.]
 - c. [Cooper B-line; brand of Eaton, Electrical Sector]
 - d. [Crouse-Hinds; brand of Eaton, Electrical Sector]
 - e. [Erickson Electrical Equipment Company]
 - f. [FSR Inc.]
 - g. [Hoffman; brand of nVent Electrical plc]
 - h. [Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - i. [Milbank Manufacturing Company]
 - j. [N J Sullivan Company]
 - k. [Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - l. [Robroy Enclosures; Robroy Industries]
 - m. [Siemens Industry, Inc., Building Technologies Division]
 - n. [Square D; Schneider Electric USA]
 - o. <Insert manufacturer's name>
3. Listing Criteria:
 - a. UL CCN CYIV.
 - b. Non-Environmental Characteristics: UL 50.
 - c. Environmental Characteristics: UL 50E.
4. Standard Features:
 - a. Enclosure provided with frame, mat, or trim in which swinging door or doors are or can be hung.
 - b. Degree of Protection: [Type 1][Type 2][Type 5][Type 12][Type 12K][Type 13].
5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide [third-party-verified]corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

B. UL CYIV - Indoor Sheet Metal Cutout Boxes :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[Adalet; division of Scott Fetzer Co.]**
 - c. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - d. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - e. **[Erickson Electrical Equipment Company]**
 - f. **[FSR Inc.]**
 - g. **[Hoffman; brand of nVent Electrical plc]**
 - h. **[Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - i. **[Milbank Manufacturing Company]**
 - j. **[N J Sullivan Company]**
 - k. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - l. **[Robroy Enclosures; Robroy Industries]**
 - m. **[Siemens Industry, Inc., Building Technologies Division]**
 - n. **[Square D; Schneider Electric USA]**
 - o. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Adalet; division of Scott Fetzer Co.]**
 - c. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - d. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - e. **[Erickson Electrical Equipment Company]**
 - f. **[FSR Inc.]**
 - g. **[Hoffman; brand of nVent Electrical plc]**
 - h. **[Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - i. **[Milbank Manufacturing Company]**
 - j. **[N J Sullivan Company]**
 - k. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - l. **[Robroy Enclosures; Robroy Industries]**
 - m. **[Siemens Industry, Inc., Building Technologies Division]**
 - n. **[Square D; Schneider Electric USA]**
 - o. **<Insert manufacturer's name>**
3. Listing Criteria:
 - a. UL CCN CYIV.
 - b. Non-Environmental Characteristics: UL 50.
 - c. Environmental Characteristics: UL 50E.
4. Standard Features:
 - a. Enclosure that has swinging doors or covers secured directly to and telescoping with walls of enclosure.
 - b. Degree of Protection: **[Type 1][Type 2][Type 5][Type 12][Type 12K][Type 13].**
5. Sustainable Design Features:

- a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
- b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
- c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
- d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
- e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

C. UL CYIV - Outdoor Sheet Metal Cabinets :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[Adalet; division of Scott Fetzer Co.]**
 - c. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - d. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - e. **[Erickson Electrical Equipment Company]**
 - f. **[FSR Inc.]**
 - g. **[Hoffman; brand of nVent Electrical plc]**
 - h. **[Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - i. **[Milbank Manufacturing Company]**
 - j. **[N J Sullivan Company]**
 - k. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - l. **[Robroy Enclosures; Robroy Industries]**
 - m. **[Siemens Industry, Inc., Building Technologies Division]**
 - n. **[Square D; Schneider Electric USA]**
 - o. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Adalet; division of Scott Fetzer Co.]**
 - c. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - d. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - e. **[Erickson Electrical Equipment Company]**
 - f. **[FSR Inc.]**
 - g. **[Hoffman; brand of nVent Electrical plc]**
 - h. **[Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - i. **[Milbank Manufacturing Company]**
 - j. **[N J Sullivan Company]**
 - k. **[Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - l. **[Robroy Enclosures; Robroy Industries]**
 - m. **[Siemens Industry, Inc., Building Technologies Division]**
 - n. **[Square D; Schneider Electric USA]**

- o. <Insert manufacturer's name>
3. Listing Criteria:
 - a. UL CCN CYIV.
 - b. Non-Environmental Characteristics: UL 50.
 - c. Environmental Characteristics: UL 50E.
4. Standard Features:
 - a. Enclosure provided with frame, mat, or trim in which swinging door or doors are or can be hung.
 - b. Degree of Protection: [Type 3][Type 3X][Type 3R][Type 3RX][Type 3S][Type 3SX][Type 4][Type 4X][Type 6][Type 6P].
5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide [third-party-verified]corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
- D. UL CYIV - Outdoor Sheet Metal Cutout Boxes :
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [ABB, Electrification Business]
 - b. [Adalet; division of Scott Fetzer Co.]
 - c. [Cooper B-line; brand of Eaton, Electrical Sector]
 - d. [Crouse-Hinds; brand of Eaton, Electrical Sector]
 - e. [Erickson Electrical Equipment Company]
 - f. [FSR Inc.]
 - g. [Hoffman; brand of nVent Electrical plc]
 - h. [Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - i. [Milbank Manufacturing Company]
 - j. [N J Sullivan Company]
 - k. [Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - l. [Robroy Enclosures; Robroy Industries]
 - m. [Siemens Industry, Inc., Building Technologies Division]
 - n. [Square D; Schneider Electric USA]
 - o. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the

following:

- a. [ABB, Electrification Business]
 - b. [Adalet; division of Scott Fetzer Co.]
 - c. [Cooper B-line; brand of Eaton, Electrical Sector]
 - d. [Crouse-Hinds; brand of Eaton, Electrical Sector]
 - e. [Erickson Electrical Equipment Company]
 - f. [FSR Inc.]
 - g. [Hoffman; brand of nVent Electrical plc]
 - h. [Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - i. [Milbank Manufacturing Company]
 - j. [N J Sullivan Company]
 - k. [Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - l. [Robroy Enclosures; Robroy Industries]
 - m. [Siemens Industry, Inc., Building Technologies Division]
 - n. [Square D; Schneider Electric USA]
 - o. <Insert manufacturer's name>
3. Listing Criteria:
- a. UL CCN CYIV.
 - b. Non-Environmental Characteristics: UL 50.
 - c. Environmental Characteristics: UL 50E.
4. Standard Features:
- a. Enclosure that has swinging doors or covers secured directly to and telescoping with walls of enclosure.
 - b. Degree of Protection: [Type 3][Type 3X][Type 3R][Type 3RX][Type 3S][Type 3SX][Type 4][Type 4X][Type 6][Type 6P].
5. Sustainable Design Features:
- a. Corporate Sustainability Report: Provide [third-party-verified]corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

2.5 TERMINATION BOXES

- A. Description: Enclosure for termination base consisting of lengths of bus bars, terminal strips, or terminal blocks with provision for wire connectors to accommodate incoming or outgoing conductors or both.
- B. UL XCKT - Termination Boxes and Termination Bases for Installation on Line Side of Service Equipment :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [ABB, Electrification Business]
 - b. [Appleton; Emerson Electric Co., Automation Solutions]
 - c. [Cooper B-line; brand of Eaton, Electrical Sector]
 - d. [Erickson Electrical Equipment Company]
 - e. [Hoffman; brand of nVent Electrical plc]
 - f. [Metron; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - g. [Milbank Manufacturing Company]
 - h. [N J Sullivan Company]
 - i. [Square D; Schneider Electric USA]
 - j. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [ABB, Electrification Business]
 - b. [Appleton; Emerson Electric Co., Automation Solutions]
 - c. [Cooper B-line; brand of Eaton, Electrical Sector]
 - d. [Erickson Electrical Equipment Company]
 - e. [Hoffman; brand of nVent Electrical plc]
 - f. [Metron; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - g. [Milbank Manufacturing Company]
 - h. [N J Sullivan Company]
 - i. [Square D; Schneider Electric USA]
 - j. <Insert manufacturer's name>
3. Listing Criteria:
 - a. UL CCN XCKT; including UL 1773.
 - b. Non-Environmental Characteristics: UL 50.
 - c. Environmental Characteristics: UL 50E.
4. Standard Features:
 - a. Listed and labeled for installation on line side of service equipment.
 - b. Indoor Degree of Protection: [Type 1][Type 2][Type 5][Type 12][Type 12K][Type 13].
 - c. Outdoor Degree of Protection: [Type 3][Type 3X][Type 3R][Type 3RX][Type 3S][Type 3SX][Type 4][Type 4X][Type 6][Type 6P].
5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide [third-party-verified]corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard

- development organization, is publicly available for product.
- e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
- C. UL XCKT - Termination Boxes and Termination Bases for Installation on Load Side of Service Equipment :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[Appleton; Emerson Electric Co., Automation Solutions]**
 - c. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - d. **[Erickson Electrical Equipment Company]**
 - e. **[Hoffman; brand of nVent Electrical plc]**
 - f. **[Metron; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - g. **[Milbank Manufacturing Company]**
 - h. **[N J Sullivan Company]**
 - i. **[Square D; Schneider Electric USA]**
 - j. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Appleton; Emerson Electric Co., Automation Solutions]**
 - c. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - d. **[Erickson Electrical Equipment Company]**
 - e. **[Hoffman; brand of nVent Electrical plc]**
 - f. **[Metron; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - g. **[Milbank Manufacturing Company]**
 - h. **[N J Sullivan Company]**
 - i. **[Square D; Schneider Electric USA]**
 - j. **<Insert manufacturer's name>**
 3. Listing Criteria:
 - a. UL CCN XCKT; including UL 1773.
 - b. Non-Environmental Characteristics: UL 50.
 - c. Environmental Characteristics: UL 50E.
 4. Standard Features:
 - a. Listed and labeled for installation on load side of service equipment.
 - b. Indoor Degree of Protection: **[Type 1][Type 2][Type 5][Type 12][Type 12K][Type 13]**.
 - c. Outdoor Degree of Protection: **[Type 3][Type 3X][Type 3R][Type 3RX][Type 3S][Type 3SX][Type 4][Type 4X][Type 6][Type 6P]**.
 5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts

- of extraction operations and activities associated with product and its supply chain.
- b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
- c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
- d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
- e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

2.6 MISCELLANEOUS ENCLOSURES

A. UL XCKT or NWIN - Indoor Sheet Metal Miscellaneous Enclosures :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[Appleton; Emerson Electric Co., Automation Solutions]**
 - c. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - d. **[Erickson Electrical Equipment Company]**
 - e. **[Hoffman; brand of nVent Electrical plc]**
 - f. **[Metron; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - g. **[Milbank Manufacturing Company]**
 - h. **[N J Sullivan Company]**
 - i. **[Square D; Schneider Electric USA]**
 - j. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Appleton; Emerson Electric Co., Automation Solutions]**
 - c. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - d. **[Erickson Electrical Equipment Company]**
 - e. **[Hoffman; brand of nVent Electrical plc]**
 - f. **[Metron; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - g. **[Milbank Manufacturing Company]**
 - h. **[N J Sullivan Company]**
 - i. **[Square D; Schneider Electric USA]**
 - j. **<Insert manufacturer's name>**
3. Listing Criteria:
 - a. UL CCN XCKT; including UL 1773; or UL CCN NWIN, including UL 2416.
 - b. Non-Environmental Characteristics: UL 50.
 - c. Environmental Characteristics: UL 50E.

4. Standard Features:

- a. Degree of Protection: **[Type 1][Type 2][Type 5][Type 12][Type 12K][Type 13]**.

5. Sustainable Design Features:

- a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
- b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
- c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
- d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
- e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

B. UL XCKT or NWIN - Outdoor Sheet Metal Miscellaneous Enclosures :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[Appleton; Emerson Electric Co., Automation Solutions]**
 - c. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - d. **[Erickson Electrical Equipment Company]**
 - e. **[Hoffman; brand of nVent Electrical plc]**
 - f. **[Metron; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - g. **[Milbank Manufacturing Company]**
 - h. **[N J Sullivan Company]**
 - i. **[Square D; Schneider Electric USA]**
 - j. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Appleton; Emerson Electric Co., Automation Solutions]**
 - c. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - d. **[Erickson Electrical Equipment Company]**
 - e. **[Hoffman; brand of nVent Electrical plc]**
 - f. **[Metron; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - g. **[Milbank Manufacturing Company]**
 - h. **[N J Sullivan Company]**
 - i. **[Square D; Schneider Electric USA]**
 - j. **<Insert manufacturer's name>**
3. Listing Criteria:
 - a. UL CCN XCKT; including UL 1773; or UL CCN NWIN, including UL 2416.
 - b. Non-Environmental Characteristics: UL 50.

- c. Environmental Characteristics: UL 50E.
- 4. Standard Features:
 - a. Degree of Protection: **[Type 3][Type 3X][Type 3R][Type 3RX][Type 3S][Type 3SX][Type 4][Type 4X][Type 6][Type 6P]**.
- 5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

2.7 RACK OR FRAME SYSTEMS

- A. Description: This category covers rack or frame systems that are not complete but include components and assemblies that are intended to power, protect, heat, cool, or otherwise support electrical or electronic equipment that will be installed at a later time.
- B. UL NWIN - 19 Inch Open Equipment Rack :
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Belden Inc.]**
 - b. **[Black Box Corporation]**
 - c. **[Bud Industries, Inc.]**
 - d. **[CommScope, Inc]**
 - e. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - f. **[Dell Technologies Inc.]**
 - g. **[Hammond Mfg. Co. Inc]**
 - h. **[Hoffman; brand of nVent Electrical plc]**
 - i. **[Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - j. **[Kendall Howard]**
 - k. **[Leviton Manufacturing Co., Inc.]**
 - l. **[Liebert; Vertiv Holdings Co.]**
 - m. **[Middle Atlantic Products; Legrand North America, LLC]**
 - n. **[Ortronics, Inc.]**
 - o. **[Panduit Corp]**
 - p. **[Siemon Co. (The)]**
 - q. **[Tripp-Lite]**
 - r. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Belden Inc.]**
 - b. **[Black Box Corporation]**
 - c. **[Bud Industries, Inc.]**
 - d. **[CommScope, Inc]**
 - e. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - f. **[Dell Technologies Inc.]**
 - g. **[Hammond Mfg. Co. Inc]**
 - h. **[Hoffman; brand of nVent Electrical plc]**
 - i. **[Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - j. **[Kendall Howard]**
 - k. **[Leviton Manufacturing Co., Inc.]**
 - l. **[Liebert; Vertiv Holdings Co.]**
 - m. **[Middle Atlantic Products; Legrand North America, LLC]**
 - n. **[Ortronics, Inc.]**
 - o. **[Panduit Corp]**
 - p. **[Siemon Co. (The)]**
 - q. **[Tripp-Lite]**
 - r. **<Insert manufacturer's name>**

3. Listing Criteria:
 - a. UL CCN NWIN; including UL 2416.
 - b. Non-Environmental Characteristics: UL 50.
 - c. Environmental Characteristics: UL 50E or UL 2416.

4. Standard Features:
 - a. Threaded rails designed for mounting telecommunications equipment.
 - b. Width: Compatible with EIA/ECIA 310-E, **19 inch (482.6 mm)** equipment mounting with an opening of **17.72 inch (450 mm)** between rails.
 - c. Frames: Modular units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
 - d. Finish: Manufacturer's standard, baked-polyester powder coat.
 - e. Cable Management:
 - 1) Metal, with integral wire retaining fingers.
 - 2) Baked-polyester powder coat finish.
 - 3) Vertical cable management panels have front and rear channels with covers.
 - 4) Horizontal crossover cable manager at top of each relay rack, with minimum height of two rack units each.
 - f. Configuration: **[Two post][and][four post]**.
 - g. Material: **[Extruded steel][Extruded aluminum][Sheet steel][Sheet aluminum]**.

5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted,

- manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
- 6. Other Available Features Required by the Project:
 - a. Color: **[Black]<Insert color>**.
 - b. Floor-Mounted Racks:
 - 1) Overall Height: **[72 inch (1828.8 mm)][84 inch (2133.6 mm)][As indicated on Drawings]<Insert value>**.
 - 2) Overall Depth: **[23 inch (584.2 mm)][29 inch (736.6 mm)]<Insert value>**.
 - 3) Rail Depth: **[3 inch (76.2 mm)][6 inch (152.4 mm)]<Insert value>**
 - 4) Two-Post Load Rating: **[200 lb (91 kg)][400 lb (181 kg)]<Insert value>**.
 - 5) Four-Post Load Rating: **[1000 lb (454 kg)][2000 lb (907 kg)]<Insert value>**.
 - 6) Number of Rack Units per Rack: **[38][42][45][52][58][As indicated on Drawings]<Insert number>**.
 - a) Numbering: **[Every][Every five]** rack unit(s), on interior of rack.
 - 7) Threads: **[10-32][12-24][Universal square]**.
 - 8) Vertical and horizontal cable management channels, top and bottom cable troughs, grounding lug[, and a power strip].
 - 9) Base must have minimum four mounting holes for permanent attachment to floor.
 - 10) Top must have provisions for attaching to cable tray or ceiling.
 - 11) Self-leveling.
 - c. Wall-Mounted Racks:
 - 1) Height: **[18 inch (457.2 mm)][22 inch (558.8 mm)][As indicated on Drawings]<Insert value>**.
 - 2) Depth: **[23 inch (584.2 mm)][29 inch (736.6 mm)]<Insert value>**.
 - 3) Load Rating: **[150 lb (65 kg)][200 lb (91 kg)]<Insert value>**.
 - 4) Number of Rack Units per Rack: **[8][12][22][As indicated on Drawings]<Insert number>**.
 - 5) Threads: **[10-32][12-24][Universal square]**.
 - 6) Wall Attachment: Four pre-punched mounting holes.
 - 7) Equipment Access: Integral swing.

C. UL NWIN - 19 Inch Enclosed Equipment Rack :

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Belden Inc.]**
 - b. **[Black Box Corporation]**
 - c. **[Bud Industries, Inc.]**
 - d. **[Chatsworth Products, Inc.]**

- e. [CommScope, Inc]
 - f. [Cooper B-line; brand of Eaton, Electrical Sector]
 - g. [Hoffman; brand of nVent Electrical plc]
 - h. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - i. [Kendall Howard]
 - j. [Leviton Manufacturing Co., Inc.]
 - k. [Liebert; Vertiv Holdings Co.]
 - l. [Middle Atlantic Products; Legrand North America, LLC]
 - m. [Ortronics, Inc.]
 - n. [Panduit Corp]
 - o. [Siemon Co. (The)]
 - p. [Tripp-Lite]
 - q. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Belden Inc.]
 - b. [Black Box Corporation]
 - c. [Bud Industries, Inc.]
 - d. [Chatsworth Products, Inc.]
 - e. [CommScope, Inc]
 - f. [Cooper B-line; brand of Eaton, Electrical Sector]
 - g. [Hoffman; brand of nVent Electrical plc]
 - h. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - i. [Kendall Howard]
 - j. [Leviton Manufacturing Co., Inc.]
 - k. [Liebert; Vertiv Holdings Co.]
 - l. [Middle Atlantic Products; Legrand North America, LLC]
 - m. [Ortronics, Inc.]
 - n. [Panduit Corp]
 - o. [Siemon Co. (The)]
 - p. [Tripp-Lite]
 - q. <Insert manufacturer's name>
3. Listing Criteria:
- a. UL CCN NWIN; including UL 2416.
 - b. Non-Environmental Characteristics: UL 50.
 - c. Environmental Characteristics: UL 50E or UL 2416.
4. Standard Features:
- a. Manufacturer-assembled four-post frame enclosed by side and top panels and front and rear doors, designed for mounting telecommunications equipment.
 - b. Threaded rails designed for mounting telecommunications equipment.
 - c. Width: Compatible with EIA/ECIA 310-E, **19 inch (482.6 mm)** equipment mounting with an opening of **17.72 inch (450 mm)** between rails.
 - d. Frames: Modular units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
 - e. Finish: Manufacturer's standard, baked-polyester powder coat.
 - f. Cable Management:

- 1) Metal, with integral wire retaining fingers.
 - 2) Baked-polyester powder coat finish.
 - 3) Vertical cable management panels have front and rear channels with covers.
 - 4) Horizontal crossover cable manager at top of each relay rack, with minimum height of two rack units each.
- g. Material: **[Extruded steel][Extruded aluminum][Sheet steel][Sheet aluminum]**.
5. Sustainable Design Features:
- a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
6. Other Available Features Required by the Project:
- a. Color: **[Black]<Insert color>**.
 - b. Modular Freestanding Cabinets:
 - 1) Overall Height: **[72 inch (1828.8 mm)][84 inch (2133.6 mm)][As indicated on Drawings]<Insert value>**.
 - 2) Overall Depth: **[23 inch (584.2 mm)][29 inch (736.6 mm)]<Insert value>**.
 - 3) Load Rating: **[3000 lb (1362 kg)]<Insert value>**.
 - 4) Number of Rack Units: **[38][42][45][52][58][As indicated on Drawings]<Insert number>**.
 - a) Numbering: **[Every][Every five]** rack unit(s), on interior of rack.
 - 5) Threads: **[10-32][12-24][Universal square]**.
 - 6) Removable and lockable side and top panels.
 - 7) Hinged and lockable front and rear doors.
 - 8) Adjustable feet for leveling.
 - 9) Screened ventilation openings in roof and rear door.
 - 10) Cable access provisions in roof and base.
 - 11) RBB.
 - 12) **[Rack][Roof]**-mounted, **550 cfm (260 L/s)** fan with filter.
 - 13) Power strip.
 - 14) All cabinets keyed alike.
 - c. Modular Wall Cabinets:
 - 1) Height: **[18 inch (457.2 mm)][22 inch (558.8 mm)][As indicated on Drawings]<Insert value>**.
 - 2) Depth: **[23 inch (584.2 mm)][29 inch (736.6 mm)]<Insert value>**.
 - 3) Load Rating: **[150 lb (65 kg)][200 lb (91 kg)]<Insert value>**.
 - 4) Number of Rack Units: **[8][12][22][As indicated on Drawings]<Insert number>**.

- 5) Threads: **[10-32][12-24][Universal square]**.
- 6) Lockable front **[and rear]** doors.
- 7) Louvered side panels.
- 8) Cable access provisions top and bottom.
- 9) Grounding lug.
- 10) **[Rack][Roof]**-mounted, **250 cfm (118 L/s)** fan.
- 11) Power strip.
- 12) All cabinets keyed alike.

D. UL NWIN - 23 Inch Open Equipment Rack :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Belden Inc.]**
 - b. **[Black Box Corporation]**
 - c. **[CommScope, Inc]**
 - d. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - e. **[Hoffman; brand of nVent Electrical plc]**
 - f. **[Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - g. **[Kendall Howard]**
 - h. **[Leviton Manufacturing Co., Inc.]**
 - i. **[Liebert; Vertiv Holdings Co.]**
 - j. **[Middle Atlantic Products; Legrand North America, LLC]**
 - k. **[Ortronics, Inc.]**
 - l. **[Panduit Corp]**
 - m. **[Siemon Co. (The)]**
 - n. **[Tripp-Lite]**
 - o. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Belden Inc.]**
 - b. **[Black Box Corporation]**
 - c. **[CommScope, Inc]**
 - d. **[Cooper B-line; brand of Eaton, Electrical Sector]**
 - e. **[Hoffman; brand of nVent Electrical plc]**
 - f. **[Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - g. **[Kendall Howard]**
 - h. **[Leviton Manufacturing Co., Inc.]**
 - i. **[Liebert; Vertiv Holdings Co.]**
 - j. **[Middle Atlantic Products; Legrand North America, LLC]**
 - k. **[Ortronics, Inc.]**
 - l. **[Panduit Corp]**
 - m. **[Siemon Co. (The)]**
 - n. **[Tripp-Lite]**
 - o. **<Insert manufacturer's name>**
3. Listing Criteria:

- a. UL CCN NWIN; including UL 2416.
 - b. Non-Environmental Characteristics: UL 50.
 - c. Environmental Characteristics: UL 50E or UL 2416.
4. Standard Features:
 - a. Threaded rails designed for mounting telecommunications equipment.
 - b. Width: Compatible with **23 inch (584.2 mm)** equipment mounting.
 - c. Frames: Modular units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
 - d. Finish: Manufacturer's standard, baked-polyester powder coat.
 - e. Cable Management:
 - 1) Metal, with integral wire retaining fingers.
 - 2) Baked-polyester powder coat finish.
 - 3) Vertical cable management panels have front and rear channels with covers.
 - 4) Horizontal crossover cable manager at top of each relay rack, with minimum height of two rack units each.
 - f. Configuration: **[Two post][and][four post]**.
 - g. Material: **[Extruded steel][Extruded aluminum][Sheet steel][Sheet aluminum]**.
5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
6. Other Available Features Required by the Project:
 - a. Color: **[Black]<Insert color>**.
 - b. Floor-Mounted Racks:
 - 1) Overall Height: **[72 inch (1828.8 mm)][84 inch (2133.6 mm)][As indicated on Drawings]<Insert value>**.
 - 2) Overall Depth: **[23 inch (584.2 mm)][29 inch (736.6 mm)]<Insert value>**.
 - 3) Rail Depth: **[3 inch (76.2 mm)][6 inch (152.4 mm)]<Insert value>**.
 - 4) Two-Post Load Rating: **[200 lb (91 kg)][400 lb (181 kg)]<Insert value>**.
 - 5) Four-Post Load Rating: **[1000 lb (454 kg)][2000 lb (907 kg)]<Insert value>**.
 - 6) Number of Rack Units per Rack: **[38][42][45][52][58][As indicated on Drawings]<Insert number>**.
 - a) Numbering: **[Every][Every five]** rack unit(s), on interior of rack.
 - 7) Threads: **[10-32][12-24][Universal square]**.
 - 8) Vertical and horizontal cable management channels, top and bottom cable troughs,

- grounding lug[, **and a power strip**].
- 9) Base must have minimum four mounting holes for permanent attachment to floor.
- 10) Top must have provisions for attaching to cable tray or ceiling.
- 11) Self-leveling.

c. Wall-Mounted Racks:

- 1) Height: [18 inch (457.2 mm)][22 inch (558.8 mm)][As indicated on Drawings]<Insert value>.
- 2) Depth: [23 inch (584.2 mm)][29 inch (736.6 mm)]<Insert value>.
- 3) Load Rating: [150 lb (65 kg)][200 lb (91 kg)]<Insert value>.
- 4) Number of Rack Units per Rack: [8][12][22][As indicated on Drawings]<Insert number>.
- 5) Threads: [10-32][12-24][Universal square].
- 6) Wall Attachment: Four pre-punched mounting holes.
- 7) Equipment Access: Integral swing.

E. UL NWIN - 23 Inch Enclosed Equipment Rack :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Belden Inc.]
 - b. [Black Box Corporation]
 - c. [CommScope, Inc]
 - d. [Cooper B-line; brand of Eaton, Electrical Sector]
 - e. [Dell Technologies Inc.]
 - f. [Hoffman; brand of nVent Electrical plc]
 - g. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - h. [Kendall Howard]
 - i. [Leviton Manufacturing Co., Inc.]
 - j. [Liebert; Vertiv Holdings Co.]
 - k. [Middle Atlantic Products; Legrand North America, LLC]
 - l. [Ortronics, Inc.]
 - m. [Panduit Corp]
 - n. [Siemon Co. (The)]
 - o. [Tripp-Lite]
 - p. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Belden Inc.]
 - b. [Black Box Corporation]
 - c. [CommScope, Inc]
 - d. [Cooper B-line; brand of Eaton, Electrical Sector]
 - e. [Dell Technologies Inc.]
 - f. [Hoffman; brand of nVent Electrical plc]
 - g. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - h. [Kendall Howard]

- i. [Leviton Manufacturing Co., Inc.]
 - j. [Liebert; Vertiv Holdings Co.]
 - k. [Middle Atlantic Products; Legrand North America, LLC]
 - l. [Ortronics, Inc.]
 - m. [Panduit Corp]
 - n. [Siemon Co. (The)]
 - o. [Tripp-Lite]
 - p. <Insert manufacturer's name>
3. Listing Criteria:
 - a. UL CCN NWIN; including UL 2416.
 - b. Non-Environmental Characteristics: UL 50.
 - c. Environmental Characteristics: UL 50E or UL 2416.
4. Standard Features:
 - a. Manufacturer-assembled four-post frame enclosed by side and top panels and front and rear doors, designed for mounting telecommunications equipment.
 - b. Threaded rails designed for mounting telecommunications equipment.
 - c. Width: Compatible with **23 inch (584.2 mm)** equipment mounting.
 - d. Frames: Modular units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
 - e. Finish: Manufacturer's standard, baked-polyester powder coat.
 - f. Cable Management:
 - 1) Metal, with integral wire retaining fingers.
 - 2) Baked-polyester powder coat finish.
 - 3) Vertical cable management panels have front and rear channels with covers.
 - 4) Horizontal crossover cable manager at top of each relay rack, with minimum height of two rack units each.
 - g. Material: [**Extruded steel**][**Extruded aluminum**][**Sheet steel**][**Sheet aluminum**].
5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide [**third-party-verified**]corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
6. Other Available Features Required by the Project:
 - a. Color: [**Black**]<Insert color>.
 - b. Modular Freestanding Cabinets:
 - 1) Overall Height: [**72 inch (1828.8 mm)**][**84 inch (2133.6 mm)**][**As indicated on**

Drawings]<Insert value>.

- 2) Overall Depth: [23 inch (584.2 mm)][29 inch (736.6 mm)]<Insert value>.
- 3) Load Rating: [3000 lb (1362 kg)]<Insert value>.
- 4) Number of Rack Units: [38][42][45][52][58][As indicated on Drawings]<Insert number>.

a) Numbering: [Every][Every five] rack unit(s), on interior of rack.

- 5) Threads: [10-32][12-24][Universal square].
- 6) Removable and lockable side and top panels.
- 7) Hinged and lockable front and rear doors.
- 8) Adjustable feet for leveling.
- 9) Screened ventilation openings in roof and rear door.
- 10) Cable access provisions in roof and base.
- 11) RBB.
- 12) [Rack][Roof]-mounted, 550 cfm (260 L/s) fan with filter.
- 13) Power strip.
- 14) All cabinets keyed alike.

c. Modular Wall Cabinets:

- 1) Height: [18 inch (457.2 mm)][22 inch (558.8 mm)][As indicated on Drawings]<Insert value>.
- 2) Depth: [23 inch (584.2 mm)][29 inch (736.6 mm)]<Insert value>.
- 3) Load Rating: [150 lb (65 kg)][200 lb (91 kg)]<Insert value>.
- 4) Number of Rack Units: [8][12][22][As indicated on Drawings]<Insert number>.
- 5) Threads: [10-32][12-24][Universal square].
- 6) Lockable front[and rear] doors.
- 7) Louvered side panels.
- 8) Cable access provisions top and bottom.
- 9) Grounding lug.
- 10) [Rack][Roof]-mounted, 250 cfm (118 L/s) fan.
- 11) Power strip.
- 12) All cabinets keyed alike.

2.8 ENCLOSURE-MOUNTED POWER DISTRIBUTION

A. Description: This category covers relocatable power taps and power distribution units.

B. UL XBYS - Enclosure-Mounted Relocatable Power Tap :

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

3. Listing Criteria: UL CCN XBY5; including UL 1363.
4. Standard Features:
 - a. Rocker-type on-off switch, illuminated when in on position.
 - b. LED indicator lights for power and protection status.
 - c. LED indicator lights for reverse polarity and open outlet ground.
5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
6. Other Available Features Required by the Project:
 - a. Wiring Devices: **[Six]<Insert quantity>[5-15R][5-20R]<Insert type>** receptacles.
 - b. Circuit Breaker and Thermal Fusing: **[When protection is lost, circuit opens and cannot be reset][Unit continues to supply power if protection is lost].**
 - c. Cord Length: **[Close-coupled, direct plug-in][15 ft (4.5 m)].**
 - d. Surge Protection: Type 3 SPDs.
 - 1) Peak Single-Impulse Surge Current Rating: **[33][26][13]** kA per phase.
 - 2) Protection modes must be line to neutral, line to ground, and neutral to ground. UL 1449 clamping voltage for all three modes may not be more than **[330 V]<Insert value>**.

C. UL QPQY - Rack-Mounted Power Distribution Center :

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

3. Listing Criteria: UL CCN QPQY; including UL 62368-1 or UL 60950-1, in addition to UL Subject 1801.
4. Standard Features:
 - a. Input Voltage: [120 V][208 V][120/208 V][208Y/120 V][208 V Delta].
 - b. Input Current: [15 A][20 A][30 A].
 - c. Output Receptacle Types and Quantities:
 - 1) 5-15R: [6][8][10][12][14][20].
 - 2) 5-20R: [6][10][12][20].
 - 3) L5-20R: [6][12][24].
 - 4) L5-30R: 6.
 - 5) L6-20R: [1][12][20][24].
 - 6) L6-30R: [1][6].
 - 7) L21-30R: 1.
5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide [third-party-verified] corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
6. Other Available Features Required by the Project:
 - a. Rack transfer switch.
 - b. Switched receptacles.
 - c. Monitoring: [Unit level][Outlet level].
 - d. Sensors:
 - 1) Temperature: [1][3].
 - 2) Humidity.
 - 3) Dew point.
 - 4) Airflow.
 - 5) Plug-and-play dry contact.
 - 6) Door position.
 - 7) Water.
 - 8) Power failure.

PART 3 - EXECUTION

3.1 SELECTION OF ELECTRICAL CABINETS AND ENCLOSURES

- A. Unless more stringent requirements are specified in Contract Documents or manufacturers' written

instructions, comply with NFPA 70 for selection of electrical cabinets and enclosures. Consult Architect for resolution of conflicting requirements.

B. Degree of Protection:

1. Outdoors:

- a. [Type 3R][Type 4][Type 3] unless otherwise indicated.
- b. Locations Exposed to Hosedown: [Type 4][Type 6][Type 6P].
- c. Locations Subject to Potential Flooding: Type 6P.
- d. Locations Aboveground Where Mechanism Must Operate When Ice Covered: Type 3S.
- e. Locations in-Ground or Exposed to Corrosive Agents: [Type 4X][Type 6P][Type 3RX].
- f. Locations in-Ground or Exposed to Corrosive Agents Where Mechanism Must Operate When Ice Covered: Type 3SX.

2. Indoors:

- a. Type 1 unless otherwise indicated.
- b. Damp or Dusty Locations: [Type 12][Type 2][Type 4][Type 5].
- c. Surface Mounted in Kitchens and Other Locations Exposed to Oil or Coolants: Type 12.
- d. Flush Mounted in Kitchens and Other Locations Exposed to Oil or Coolants: [Type 12][Type 12K].
- e. Locations Exposed to Airborne Dust, Lint, Fibers, or Flyings: [Type 4][Type 6].
- f. Locations Exposed to Hosedown: [Type 4][Type 6][Type 6P].
- g. Locations Exposed to Brief Submersion: [Type 6][Type 6P].
- h. Locations Exposed to Prolonged Submersion: Type 6P.
- i. Locations Exposed to Corrosive Agents: [Type 4X][Type 6P].
- j. Locations Exposed to Spraying Oil or Coolants: Type 13.

3.2 INSTALLATION OF ELECTRICAL CABINETS AND ENCLOSURES

A. Comply with manufacturer's published instructions.

B. Reference Standards for Installation: Unless more stringent installation requirements are specified in Contract Documents or manufacturers' published instructions, comply with the following:

1. Electrical Construction: ICC IBC, ICC IFB, NFPA 1, NFPA 70, and NECA NEIS 1.
2. Electrical Safety: NFPA 70E.
3. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
4. Communications Work: BICSI N1.
5. Work in ITE Rooms: NFPA 75.
6. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
7. Cabinets and Cutout Boxes: Article 312 of NFPA 70.
8. Consult Architect for resolution of conflicting requirements.

C. Special Installation Techniques:

1. Mount cabinets and enclosures at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to [center][top][bottom] of box unless otherwise indicated.
2. Do not install cabinets, enclosures, or fittings in contact with concrete or earth.
3. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to ensure a continuous ground path.
4. Identification: Provide labels for cabinets, enclosures, racks and associated electrical equipment.



- a. Identify field-installed conductors, interconnecting wiring, and components.
- b. Provide warning signs.
- c. Label each cabinet, enclosure, and rack with engraved metal or laminated-plastic nameplate.

D. Interfaces with Other Work:

1. Firestop penetrations of rated walls and partitions.
2. Ground and bond RBBs in cabinets, enclosures, and racks.
3. Apply arc-flash hazard warning labels cabinets, enclosures, and racks.
4. Coordinate installation of new products for **<Insert system or product family/category>** with existing conditions.
 - a. **<Insert requirements for transition between new and existing>**.
5. Coordinate with **<Insert Section number and title>** for **<Insert description of interfacing related Work>**.
 - a. **<Insert requirements for transition between this Section and related Work>**.

3.3 FIELD QUALITY CONTROL OF ELECTRICAL CABINETS AND ENCLOSURES

A. Administrant for Electrical Power Tests and Inspections:

1. **[Owner][Tenant]** will engage qualified medium-voltage electrical testing and inspecting agency to administer and perform tests and inspections.
2. Engage qualified medium-voltage electrical testing and inspecting agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].

B. Administrant for Communications Tests and Inspections:

1. **[Owner][Tenant]** will engage qualified communications testing and inspecting agency to administer and perform tests and inspections.
2. Engage qualified communications testing and inspecting agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].

C. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.

D. Tests and Inspections:

1. Perform manufacturer's recommended tests and inspections.

E. Nonconforming Work:

1. Cabinet, enclosure, or rack will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

F. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

3.4 CLEANING

A. Remove construction dust and debris from cabinets, enclosures, and racks.

3.5 PROTECTION

A. Protect coatings and finishes of cabinets, enclosures, and racks from damage and deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 26 27 16 00



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Task	Specification	Specification Description
26 27 16 00	26 09 13 00	Electrical Power Monitoring
26 27 16 00	26 24 19 00	Motor-Control Centers



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SECTION 26 27 19 00 - MULTI-OUTLET ASSEMBLIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Wall-mounted, surface metal raceway multi-outlet assemblies.
2. Wall-mounted, surface nonmetallic raceway multi-outlet assemblies.
3. Floor-mounted, recessed metal raceway multi-outlet assemblies.
4. Indoor service poles.
5. Floor-mounted, enclosure multi-outlet assemblies.
6. Fire-rated, poke-through assemblies.
7. Above-floor service fittings.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
3. Section 260533.13 "Conduits for Electrical Systems" and Section 260533.23 "Surface Raceways for Electrical Systems" for raceways.
4. Section 260533.16 "Boxes and Covers for Electrical Systems" for floor boxes and covers.
5. Section 262726 "Wiring Devices" for receptacles and switches.
6. Section 271513 "Communications Copper Horizontal Cabling" for control-voltage communications outlet devices.

1.2 ACTION SUBMITTALS

A. Product Data:

1. Wall-mounted, surface metal raceway multi-outlet assemblies.
2. Wall-mounted, surface nonmetallic raceway multi-outlet assemblies.
3. Floor-mounted, recessed metal raceway multi-outlet assemblies.
4. Indoor service poles.
5. Floor-mounted, enclosure multi-outlet assemblies.
6. Fire-rated, poke-through assemblies.
7. Above-floor service fittings.

PART 2 - PRODUCTS

2.1 WALL-MOUNTED, SURFACE METAL RACEWAY MULTI-OUTLET ASSEMBLIES

- ##### A. Description:
- Two-piece surface metal raceway, field assembled and wired or with factory-wired multi-outlet harness, including outlets.



- B. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.
- C. General Characteristics:
1. Reference Standards: UL 5 for exposed power raceway and fittings. Multi-outlet assemblies used for communications or data must also comply with UL 5C for exposed communications raceway and fittings, and UL 2024 for communications cable routing.
 2. Provide separate paths for management of telecommunications and power cables.
- D. Source Limitations: Obtain products from single manufacturer designed for use as complete, matching assembly of raceways, receptacles, and switches.
- E. Wall-Mounted, Surface Metal Raceway Power Multi-Outlet Assembly :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Wiremold; Legrand North America, LLC]**
 - c. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Wiremold; Legrand North America, LLC]**
 - c. **<Insert manufacturer's name>**
 3. Options:
 - a. Material: **[Steel][Aluminum]**, with manufacturer's standard finish.
 - b. Color: **<Indicate color>**.
 - c. Power Outlets: **<Indicate receptacle type>** in accordance with Section 262726 "Wiring Devices."
 - d. Power Outlet Spacing: **[6 inch (150 mm)][9 inch (230 mm)][12 inch (300 mm)][18 inch (460 mm)]**.
 - e. Wiring: **[Single circuit][Two circuits, connecting alternating receptacles or switches,]** in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- F. Wall-Mounted, Surface Metal Raceway Power and Communications Multi-Outlet Assembly :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell**

- b. **Incorporated]**
 - b. **[Wiremold; Legrand North America, LLC]**
 - c. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Wiremold; Legrand North America, LLC]**
 - c. **<Insert manufacturer's name>**
- 3. Options:
 - a. Material: **[Steel][Aluminum]**, with manufacturer's standard finish.
 - b. Color: **<Indicate color>**.
 - c. Power Outlets: **<Indicate receptacle type>** in accordance with Section 262726 "Wiring Devices."
 - d. Power Outlet Spacing: **[6 inch (150 mm)][9 inch (230 mm)][12 inch (300 mm)][18 inch (460 mm)]**.
 - e. Power Wiring: **[Single circuit][Two circuits, connecting alternating receptacles or switches,]** in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
 - f. Voice and Data Communication Outlets: **<Indicate quantity>[blank insert with bushed cable opening][8PSJ jacks]** complying with requirements in Section 271500 "Communications Horizontal Cabling."
 - g. A minimum of **[two][four]** four-pair cables in accordance with Section 271513 "Communications Copper Horizontal Cabling" for each outlet.

2.2 WALL-MOUNTED, SURFACE NONMETALLIC RACEWAY MULTI-OUTLET ASSEMBLIES

- A. Description: Two-piece surface nonmetallic raceway, field assembled and wired or with factory-wired multi-outlet harness, including outlets.
- B. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.
- C. General Characteristics:
 - 1. Reference Standards: UL 5A for exposed power raceway and fittings, UL 5C for exposed communications raceway and fittings, and UL 2024 for communications cable routing.
 - 2. Provide separate paths for management of telecommunications and power cables.
- D. Source Limitations: Obtain products from single manufacturer designed for use as complete, matching assembly of raceways, receptacles, and switches.
- E. Wall-Mounted, Surface Nonmetallic Raceway Power Multi-Outlet Assembly :
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:



- a. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Wiremold; Legrand North America, LLC]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Wiremold; Legrand North America, LLC]**
 - c. **<Insert manufacturer's name>**
3. Options:
 - a. Material: **[PVC]<Indicate material>**.
 - b. Color: **<Indicate color>**.
 - c. Power Outlets: **<Indicate receptacle type>** in accordance with Section 262726 "Wiring Devices."
 - d. Power Outlet Spacing: **[6 inch (150 mm)][9 inch (230 mm)][12 inch (300 mm)][18 inch (460 mm)]**.
 - e. Wiring: **[Single circuit][Two circuits, connecting alternating receptacles or switches,]** in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

F. Wall-Mounted, Surface Nonmetallic Raceway Power and Communications Multi-Outlet Assembly :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Wiremold; Legrand North America, LLC]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Wiremold; Legrand North America, LLC]**
 - c. **<Insert manufacturer's name>**
3. Options:
 - a. Material: **[PVC]<Indicate material>**.
 - b. Color: **<Indicate color>**.
 - c. Power Outlets: **<Indicate receptacle type>** in accordance with Section 262726 "Wiring Devices."
 - d. Power Outlet Spacing: **[6 inch (150 mm)][9 inch (230 mm)][12 inch (300 mm)][18 inch (460 mm)]**.

- e. Power Wiring: **[Single circuit][Two circuits, connecting alternating receptacles or switches,]** in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- f. Voice and Data Communication Outlets: **<Indicate quantity>[blank insert with bushed cable opening][8PSJ jacks]** complying with requirements in Section 271500 "Communications Horizontal Cabling."
- g. A minimum of **[two][four]** four-pair cables in accordance with Section 271513 "Communications Copper Horizontal Cabling" for each outlet.

2.3 FLOOR-MOUNTED, RECESSED METAL RACEWAY MULTI-OUTLET ASSEMBLIES

- A. Description: Two-piece flush-mounted, in-floor, metal raceway, with factory-wired multi-outlet harness, for installation flush in floor or under floor finish.
- B. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.
- C. General Characteristics:
 - 1. Reference Standards: UL 5 for exposed power raceway and fittings, UL 5C for exposed communications raceway and fittings, and UL 2024 for communications cable routing.
 - 2. Provide separate paths for management of telecommunications and power cables.
- D. Source Limitations: Obtain products from single manufacturer designed for use as complete, matching assembly of raceways and receptacles.
- E. Floor-Mounted, Recessed Metal Raceway Power Multi-Outlet Assembly :
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Wiremold; Legrand North America, LLC]**
 - c. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Wiremold; Legrand North America, LLC]**
 - c. **<Insert manufacturer's name>**
 - 3. Options:
 - a. Load-Bearing Capacity: **[1000 lb (450 kg)]<Indicate capacity>**.
 - b. Material: **[Steel][Aluminum]**, with manufacturer's standard finish.
 - c. Color: **<Indicate color>**.
 - d. Power Outlets: **<Indicate quantity><Indicate receptacle type>** in accordance with Section 262726 "Wiring Devices" in surface-mounted enclosure capable of mounting



anywhere along length of recessed raceway.

- e. Wiring: **[Single circuit][Two circuits, connecting alternating receptacles,]** in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

F. Floor-Mounted, Recessed Metal Raceway Power and Communications Multi-Outlet Assembly :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Wiremold; Legrand North America, LLC]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Wiremold; Legrand North America, LLC]**
 - c. **<Insert manufacturer's name>**
3. Options:
 - a. Load-Bearing Capacity: **[1000 lb (450 kg)]<Indicate capacity>**.
 - b. Material: **[Steel][Aluminum]**, with manufacturer's standard finish.
 - c. Color: **<Indicate color>**.
 - d. Power Outlets: **<Indicate quantity><Indicate receptacle type>** in accordance with Section 262726 "Wiring Devices" in surface-mounted enclosure capable of mounting anywhere along length of recessed raceway.
 - e. Power Wiring: **[Single circuit][Two circuits, connecting alternating receptacles,]** in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
 - f. Voice and Data Communication Outlets: **<Indicate quantity>[blank insert with bushed cable opening][8PSJ jacks]** complying with requirements in Section 271500 "Communications Horizontal Cabling."
 - g. A minimum of **[two][four]** four-pair cables in accordance with Section 271513 "Communications Copper Horizontal Cabling" for each outlet.

2.4 INDOOR SERVICE POLES

- A. Description: Factory-assembled and -wired, exposed raceway and fittings to route electrical wiring from connections above ceiling to outlets below ceiling.
- B. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.
- C. General Characteristics:
 1. Reference Standards: UL 5 for exposed power raceway and fittings, and UL 2024 for communications raceway and fittings.

2. Listed and labeled in accordance with NFPA 90A for installation in air-handling plenum spaces.
3. Mounting: Ceiling trim flange with concealed bracing arranged for positive connection to above ceiling structural supports; with pole foot and carpet pad attachment.
4. Provide barrier to separate channel for power wiring from channel for voice and data communication cabling.

D. Indoor Service Pole :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Panduit Corp]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Panduit Corp]**
 - c. **<Insert manufacturer's name>**
3. Options:
 - a. Material: **[Aluminum][Steel]**.
 - b. Height: **<Insert height>** below ceiling, and **<Insert height>** above ceiling.
 - c. Finish: **[Manufacturer's standard painted finish and trim combination][Satin-anodized aluminum]**.
 - 1) Color: **[Clear anodized][White][Ivory][Gray][Black]<Insert color>**.
 - d. Power Outlets: **<Indicate quantity><Indicate receptacle type>** in accordance with Section 262726 "Wiring Devices."
 - e. Wiring: **[Single circuit][Two circuits, connecting alternating receptacles,]** in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
 - f. Voice and Data Communication Outlets: **<Indicate quantity>[blank insert with bushed cable opening][8PSJ jacks]** complying with requirements in Section 271500 "Communications Horizontal Cabling."
 - g. A minimum of **[two][four]** four-pair cables in accordance with Section 271513 "Communications Copper Horizontal Cabling" for each outlet.

2.5 FLOOR-MOUNTED ENCLOSURE MULTI-OUTLET ASSEMBLIES

- A. Description: Floor-mounted box with cover enclosing multiple power **[and communications]** outlets in a single assembly.
- B. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.



C. General Characteristics:

1. Reference Standards: UL 514A for metallic boxes; UL 514C for nonmetallic boxes, including scrub-water exclusion requirements; and UL 514D for cover plates.
2. Provide separate paths for management of telecommunications and power cables in accordance with NFPA 76.
3. Compartments: Barrier separates power from voice and data communication cabling.

D. Source Limitations: Obtain products from single manufacturer designed for use as complete, matching assembly of raceways and receptacles.

E. Floor-Mounted Enclosure Multi-Outlet Assembly :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Wiremold; Legrand North America, LLC]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Wiremold; Legrand North America, LLC]**
 - d. **<Insert manufacturer's name>**
3. Options:
 - a. Floor Box and Cover:
 - 1) **[Provide floor boxes classified for use in 1-hour-rated concrete floors. Boxes for floors in contact with earth must be protected with an epoxy paint.]**
 - 2) **[Provide floor boxes classified for use in 1-1/2-hour-rated concrete floors. Boxes for floors in contact with earth must be protected with an epoxy paint.]**
 - 3) **[Provide floor boxes classified for use in 2-hour-rated concrete floors. Boxes for floors in contact with earth must be protected with an epoxy paint.]**
 - 4) **[Provide floor boxes classified for use in 3-hour-rated concrete floors. Boxes for floors in contact with earth must be protected with an epoxy paint.]**
 - 5) **[Provide floor boxes for installation in raised floors.]**
 - 6) **[Provide floor boxes for installation in wood floors.]**
 - 7) Floor boxes for concrete floors must provide a minimum of **4 inch (100 mm)** of adjustment prior to concrete pour and a minimum of **1/2 inch (12.5 mm)** after concrete is set.
 - 8) Provide **[cast-metal][sheet metal][nonmetallic]** floor boxes with **[four][six][eight][10]** gangs.
 - 9) Provide brass or aluminum flanges approved for use on carpet, tile, or wood floor applications. Flanges and cover plates must have a buffed appearance and a

protective finish. Covers must match appearance of floor flanges and provide access to included devices.

- 10) Covers must lay flat on floor surface when open. Provide for cable egress when cover is closed. Provide ADA-compliant covers.
- 11) Provide flanges, mounting brackets, keystones, and accessories for mounting devices and connections indicated on Drawings.

b. Outlets:

- 1) Power Outlets: <Indicate quantity><Indicate receptacle type> in accordance with Section 262726 "Wiring Devices."
- 2) Wiring: [Single circuit][Two circuits, connecting alternating receptacles,] in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- 3) Voice and Data Communication Outlets: <Indicate quantity>[blank insert with bushed cable opening][8PSJ jacks] complying with requirements in Section 271500 "Communications Horizontal Cabling."
- 4) A minimum of [two][four] four-pair cables in accordance with Section 271513 "Communications Copper Horizontal Cabling" for each outlet.

2.6 FIRE-RATED, POKE-THROUGH ASSEMBLIES

- A. Description: Factory-fabricated assembly of below-floor junction box with multichannel, through-floor raceway/firestop unit with receptacles or communications outlets installed below floor surface level.
- B. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.
- C. General Characteristics:
 1. Reference Standards: UL 514A for metallic boxes and UL 514C for nonmetallic boxes, including scrub-water exclusion requirements.
 2. Provide separate paths for management of telecommunications and power cables.
 3. Fire Rating: Provide unit listed and labeled for fire rating of floor-ceiling assembly.
- D. Source Limitations: Obtain products from single manufacturer designed for use as complete, matching assembly of raceways and receptacles.
- E. Fire-Rated, Poke-Through Assembly : [Recessed][Flush][Pedestal] type.
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - b. [Square D; Schneider Electric USA]
 - c. [Wiremold; Legrand North America, LLC]
 - d. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Square D; Schneider Electric USA]**
 - c. **[Wiremold; Legrand North America, LLC]**
 - d. **<Insert manufacturer's name>**
3. Options:
- a. Modular, **[recessed][flush][pedestal]**-type, dual-service units suitable for wiring method used[, **with cover flush with finished floor**].
 - b. Service Plate, Flaps, and Cover: **[Rectangular][Round]**, **[die-cast aluminum][solid brass]** with satin finish.
 - c. Core Size: Selected to fit nominal **[4 inch (100 mm)][6 inch (150 mm)][8 inch (200 mm)][10 inch (250 mm)]** cored holes in floor and matched to floor thickness.
 - d. Closure Plug: Close unused cored opening and reestablish fire rating of floor.
 - e. Feed Conduits: Provide connection points for conduits as indicated on Drawings or required for conductors shown. Provide minimum **[1 inch (25 mm)]<Insert nominal size>** conduits for communications cables.
 - f. Power Outlets: **<Indicate quantity><Indicate receptacle type>** gray finish, unless otherwise indicated, in accordance with Section 262726 "Wiring Devices."
 - g. Telephone and Data Outlets: **<Indicate quantity>[blank cover with bushed cable opening.][modular, keyed, color-coded, 8PSJ jacks in accordance with Section 271513 "Communications Copper Horizontal Cabling."]**
 - h. Audio and Video Outlets: **[Blank cover with bushed cable opening]<Indicate quantity and type>**.

2.7 ABOVE-FLOOR SERVICE FITTINGS

- A. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.
- B. General Characteristics:
 - 1. Reference Standards: UL 514A for metallic boxes and UL 514C for nonmetallic boxes, including scrub-water exclusion requirements.
 - 2. Provide separate paths for management of telecommunications and power cables in compliance with NFPA 76.
 - 3. See Section 260533.16 "Boxes and Covers for Electrical Systems" for more details and requirements for floor boxes.
 - 4. Compartments: Barrier separates power from voice and data communication cabling.
- C. Source Limitations: Obtain products from single manufacturer designed for use as complete, matching assembly of raceways and receptacles.
- D. Pedestal-Type, Above-Floor Service Fitting :
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[Eaton]**

- c. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - d. [Wiremold; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [ABB, Electrification Business]
 - b. [Eaton]
 - c. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - d. [Wiremold; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
- 3. Options:
 - a. Service Plate and Housing: [die-cast aluminum][solid brass] with satin finish.
 - b. Wiring, Raceways, and Compartments: For a minimum of four No. 12 AWG conductors and a minimum of [two][four] four-pair cables in accordance with Section 260533.23 "Surface Raceways for Electrical Systems" and Section 271513 "Communications Copper Horizontal Cabling."
 - c. Power Outlets: <Indicate quantity><Indicate receptacle type> gray finish, unless otherwise indicated, in accordance with Section 262726 "Wiring Devices."
 - d. Communications Outlets: <Indicate quantity>[blank cover with bushed cable opening.][modular, keyed, color-coded, 8PSJ jacks in accordance with Section 271513 "Communications Copper Horizontal Cabling."]

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1 for device mounting heights, except where requirements on Drawings or in this Section are stricter.
- B. Comply with NECA 101 for installation requirements for steel raceways, except where requirements on Drawings or in this Section are stricter.
- C. Comply with NECA 102 for installation requirements for aluminum raceways, except where requirements on Drawings or in this Section are stricter.
- D. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies.
- E. Provide terminations, adapters, boxes, and other fittings required for installation.
- F. Install surface raceway with a minimum **2 inch (50 mm)** radius control at bend points.
- G. Secure metallic surface raceway with screws or other anchor-type devices at intervals not exceeding **48 inch (1200 mm)** and with no fewer than two supports per straight raceway section. Support surface raceway in accordance with manufacturer's instructions. Tape and glue are unacceptable support methods.
- H. Do not install aluminum raceways or fittings in contact with concrete.

- I. Secure nonmetallic surface raceway with screws or other anchor-type devices in each wiring channel at intervals not exceeding **18 inch (460 mm)** and with no fewer than two supports per straight raceway section in each wiring channel. Support nonmetallic surface raceway in accordance with manufacturer's instructions. Tape and glue are unacceptable support methods.
- J. Do not install PVC raceways where ambient temperature exceeds [**122 deg F (50 deg C)**]**<Insert temperature>**. Conductors with insulation rated higher than 75 deg C installed in PVC raceways may not be operated at a temperature greater than 75 deg C.
- K. Comply with Section 260526 "Grounding and Bonding for Electrical Systems."
- L. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and support.
- M. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems" and Section 260533.23 "Surface Raceways for Electrical Systems" for installation of raceways.
- N. Comply with requirements in Section 260533.16 "Boxes and Covers for Electrical Systems" for additional requirements for floor boxes.
- O. Coordination with Other Work:
 - 1. Adjust locations of multi-outlet assemblies to suit arrangement of partitions and furnishings. Locate outlets to avoid blocking by supports, furnishings, and other architectural fixtures.
 - 2. Provide outlets with special requirements, such as GFCI, AFCI, or special environmental requirements, where required by Drawings or to meet codes.
 - 3. Adjust locations of poke-through assembly penetrations to coordinate with locations of structural members, concealed piping, and concealed conduit. Obtain written approval from Architect prior to drilling penetrations in floors other than where dimensioned on architectural Drawings. Comply with requirements in Section 078413 "Penetration Firestopping."

3.2 IDENTIFICATION

- A. Comply with Section 260553 "Identification for Electrical Systems."

END OF SECTION 26 27 19 00



Task	Specification	Specification Description
26 27 19 00	26 05 39 00	Underfloor Raceways For Electrical Systems
26 27 23 00	26 27 26 00	Wiring Devices



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SECTION 26 27 26 00 - WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. General-use switches, dimmer switches, and fan-speed controller switches.
2. General-grade single straight-blade receptacles.
3. General-grade duplex straight-blade receptacles.
4. Hospital-grade straight-blade receptacles.
5. Receptacles with arc-fault and ground-fault protective devices.
6. Locking receptacles.
7. Pin-and-sleeve receptacles.
8. Special-purpose power outlet assemblies.
9. Connectors, cords, and plugs.

B. Products Installed, but Not Furnished, under This Section:

1. **<Insert products identified in "Existing Products to be Modified" Article or "Existing Products to be Removed and Reinstalled" Article>.**

C. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies temperature, humidity, acoustical, and other field conditions applicable to the Work specified in this Section.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies seismic hazard, wind hazard, and other structural load design conditions applicable to the Work specified in this Section.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional coordination, scheduling, sequencing, submittal, and installation requirements applicable to the Work for electrical, communications, and electronic safety and security systems on the Project, including wiring methods.
4. **[Section 013100 "Project Management and Coordination"]<Insert Section number and title>** for preinstallation conference procedures.
5. Section 260526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding referenced by this Section.
6. Section 260533.16 "Boxes and Covers for Electrical Systems" specifies covers and cover plates referenced by this Section.
7. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs referenced by this Section.
8. Section 260923 "Lighting Control Devices" for occupancy sensors, timers, control-voltage switches, and control-voltage dimmers.
9. Section 260936 "Modular Dimming Controls" for multiscene and multipreset dimming controls.
10. Section 260943.16 "Addressable Luminaire Lighting Controls" for network lighting control solid-state devices.
11. Section 260943.23 "Relay-Based Lighting Controls" for network lighting control relay devices.
12. Section 262726.11 "General-Use Switches, Dimmer Switches, and Fan-Speed Controller Switches" for additional wiring device products.
13. Section 262726.31 "General-Grade Single Straight-Blade Receptacles" for additional wiring device products.
14. Section 262726.33 "General-Grade Duplex Straight-Blade Receptacles" for additional wiring device products.

15. Section 262726.35 "Hospital-Grade Straight-Blade Receptacles" for additional wiring device products.
16. Section 262726.37 "Receptacles with Arc-Fault and Ground-Fault Protective Devices" for additional wiring device products.
17. Section 262726.39 "Locking Receptacles" for additional wiring device products.
18. Section 262726.41 "Pin-and-Sleeve Receptacles" for additional wiring device products.
19. Section 262726.43 "Special-Purpose Power Outlet Assemblies" for additional wiring device products.
20. Section 262726.51 "Connectors, Cords, and Plugs" for additional wiring device products.
21. Section 270528 "Pathways for Communications Systems"[**and Section 271100 "Communications Equipment Room Fittings"**] specifies additional requirements for raceway materials, routing, locations, and identification of communications equipment and cabling.

1.2 DEFINITIONS

- A. AFCI: Arc-Fault Circuit Interrupter.
- B. Commercial/Industrial-Use Cord Reel: A cord reel subject to severe use in factories, commercial garages, construction sites, and similar locations requiring a harder service-type cord.
- C. GFCI: Ground-Fault Circuit Interrupter.
- D. UL 1472 Type I Dimmer: Dimmer in which air-gap switch is used to energize preset lighting levels.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at **[Project site]<Insert location>**.
- B. Preinstallation Coordination Meeting(s): For ceiling-mounted cable reels. Conduct meeting **[as videoconference][or][at Project site]<Insert location>** before **<Insert construction activity>**.
 1. Attendees: Installers, fabricators, representatives of manufacturers, and administrators for field tests and inspections. Notify Architect[, **Construction Manager**][, **and Owner's Commissioning Authority**] of scheduled meeting dates.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 1. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing agency, certifying product's compliance with specified listing criteria.
 - a. If listed manufacturer differs from selling manufacturer, indicate relationship between entities on submittal. Clearly indicate which entity warrants product performance and fitness for purpose.
 - b. Listing criteria identified in approval letter must match specified listing criteria. UL label indicating approval of equipment's enclosure is not considered approval of equipment for intended application.
 - c. Product identification in approval letter must match product branding and model numbers in submittal. Approval letters for discontinued or superseded products are not acceptable for submitted product.

2. Include manufacturer's sample extended warranty language.

B. Samples:

1. One for each kind of toggle switch[**and cover plate accessory**] specified, in each finish and color specified.
2. One for each kind of key lock switch[**and cover plate accessory**] specified, in each finish and color specified.
3. One for each kind of maintained-contact switch[**and cover plate accessory**] specified, in each finish and color specified.
4. One for each kind of momentary-contact switch[**and cover plate accessory**] specified, in each finish and color specified.
5. One for each kind of rocker switch[**and cover plate accessory**] specified, in each finish and color specified.
6. One for each kind of dimmer switch[**and cover plate accessory**] specified, in each finish and color specified.
7. One for each kind of fan-speed controller switch[**and cover plate accessory**] specified, in each finish and color specified.
8. One for each kind of single straight-blade receptacle[**and cover plate accessory**] specified, in each finish and color specified.
9. One for each kind of duplex straight-blade receptacle[**and cover plate accessory**] specified, in each finish and color specified.
10. One for each kind of duplex straight-blade receptacle with integral switching means[**and cover plate accessory**] specified, in each finish and color specified.
11. One for each kind of hospital-grade straight-blade receptacle[**and cover plate accessory**] specified, in each finish and color specified.
12. One for each kind of receptacle with AFCI device[**and cover plate accessory**] specified, in each finish and color specified.
13. One for each kind of receptacle with AFCI and GFCI devices[**and cover plate accessory**] specified, in each finish and color specified.
14. One for each kind of receptacle with GFCI device[**and cover plate accessory**] specified, in each finish and color specified.
15. One for each kind of locking receptacle[**and cover plate accessory**] specified, in each finish and color specified.
16. One for each kind of pin-and-sleeve receptacle specified, in each finish and color specified.
17. One for each kind of cord connector specified, in each finish and color specified.

C. Shop Drawings:

1. Wiring diagrams for duplex straight-blade receptacles with integral switching means.

D. Sustainable Design Submittals:

1. Product data for sustainable design features for each type of product.
2. Lighting Control Documentation: Floor plans indicating the following information:
 - a. As-installed locations of switches and dimmers.
 - b. Lighting zones and control strategy for each switch or dimmer, including unoccupied time-delay setting for shut-off and override time-delay setting for shut-off.
 - c. Multilevel or dimming range capability for each switch or dimmer.
 - d. Which switches or dimmers are operated by occupancy sensors, vacancy sensors, daylighting sensors, or time clocks.
3. Record floor plan Drawings indicating as-installed locations of switches and dimmers, indicating lighting zone's each device control, to verify extent of ability of the installed Work to provide occupant control for customizing environment.

4. Record floor plan Drawings indicating as-installed locations of uncontrolled and marked controlled receptacles superimposed on office furniture layout, to verify extent of ability of the installed Work to provide each occupant ability to select at least one uncontrolled receptacle and at least one controlled receptacle for powering workspace equipment. Indicate locations of UL-approved relocatable power taps and power strips, indicating means of securing protection from damage and accessibility for inspection. Indicate locations of temporary extension cords, indicating plan for replacing them with permanent wiring within 90 days.

- E. Field quality-control reports.

1.5 INFORMATIONAL SUBMITTALS

- A. Manufacturer's published instructions.
- B. Field Reports:
 1. Manufacturer's field reports for field quality-control support.

1.6 CLOSEOUT SUBMITTALS

- A. Warranty documentation.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Extra stock material.
- B. Special tools.

1.8 QUALIFICATIONS

- A. Electrical Power Testing (EPT) Technician III: Possessing active NICET EPT Level III certification. Able to manage switching procedures, conduct tests of complex equipment, analyze test and equipment data, plan a job, and lead a team. Has experience performing NFPA 70B, IEEE, and NETA electrical tests.
- B. Electrical Power Testing (EPT) Technician IV: Possessing active NICET EPT Level IV certification. Able to conduct tests of complex metering and relay systems; evaluate tests, test equipment, test results, and power system performance; recommend actions to maintain or improve system performance; and lead multi-team projects.
- C. Electrical Power Testing and Inspecting Agency: Entities possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
 1. On-site electrical testing supervisors must possess active NICET EPT Technician [III][IV] certification.

1.9 WARRANTY FOR DEVICES

- A. Special Installer Extended Warranty: Installer warrants that installed devices perform in accordance with

specified requirements and agrees to repair or replace products that fail to perform as specified within extended-warranty period. Warranty must convey to Owner upon acceptance of the Work.

1. Extended-Warranty Period: **[Two][Three][Four]<Insert number>** years from date of Substantial Completion; full coverage for labor, materials, and equipment.
- B. Special Manufacturer Extended Warranty: Manufacturer warrants that devices perform in accordance with specified requirements and agrees to provide repair or replacement of devices that fail to perform as specified within extended warranty period.
 1. Initial Extended Warranty Period: **[Three][Four][Five]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for labor, materials, and equipment.
 2. Follow-On Extended Warranty Period: **[Eight]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for materials only, free on board **[origin][destination]**, freight prepaid.

1.10 WARRANTY FOR CORD REELS

- A. Special Installer Extended Warranty: Installer warrants that fabricated and installed cord-reel power outlet assemblies perform in accordance with specified requirements and agrees to repair or replace assemblies that fail to perform as specified within extended warranty period.
 1. Extended Warranty Period: **[Two][Three][Four]<Insert number>** years from date of Substantial Completion; full coverage for labor, materials, and equipment.
- B. Special Manufacturer Extended Warranty: Manufacturer warrants that components of cord-reel power outlet assemblies perform in accordance with specified requirements and agrees to provide repair or replacement of components that fail to perform as specified within extended warranty period.
 1. Initial Extended Warranty Period: **[Three][Four][Five]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for labor, materials, and equipment.
 2. Follow-On Extended Warranty Period: **[Eight]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for materials only, free on board **[origin][destination]**, freight prepaid.

PART 2 - PRODUCTS

2.1 EXISTING PRODUCTS TO BE MODIFIED

- A. Basis for Pricing: **<Insert name of manufacturer and model number or series for existing product>**.
- B. Description: **<Insert description of existing product, including special features, options, and finishes that may impact the Work>**.
- C. Accessories: **<Insert accessories included with existing product>**.

2.2 EXISTING PRODUCTS TO BE REMOVED AND REINSTALLED

- A. Basis for Pricing: **<Insert name of manufacturer and model number or series for existing product>**.
- B. Description: **<Insert description of existing product, including special features, options, and**

finishes that may impact the Work>.

- C. Accessories: **<Insert accessories included with existing product>.**

2.3 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2.4 GENERAL-USE SWITCHES, DIMMER SWITCHES, AND FAN-SPEED CONTROLLER SWITCHES

- A. Toggle Switch :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: UL CCN WMUZ and UL 20.
5. Standard Features:
 - a. Device Color: **[Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].**
 - b. Configuration:
 - 1) General-duty, 120-277 V, 15 A, **[single pole][double pole][three way][four way].**
 - 2) General-duty, 120-277 V, 20 A, **[single pole][double pole][three way][four way].**
 - 3) Extra-heavy-duty, 120-277 V, 15 A, **[single pole][double pole][three way][four way].**
 - 4) Extra-heavy-duty, 120-277 V, 20 A, **[single pole][double pole][three way][four way].**
 - 5) Extra-heavy-duty, 120-277 V, 30 A, **[single pole][double pole][three way].**

6. Sustainable Design Features:

- a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
- b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
- c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
- d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
- e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

7. Accessories:

- a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
- b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

B. Toggle Switch with Forked Key Lock :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: UL CEN WMUZ and UL 20.
5. Standard Features:
 - a. Device Color: **[Ivory][White][Gray][Black][As indicated on architectural Drawings].**
 - b. Configuration:
 - 1) 120-277 V, 15 A, **[single pole][double pole][three way][four way].**
 - 2) 120-277 V, 20 A, **[single pole][double pole][three way][four way].**

3) 120-277 V, 30 A, **[single pole][double pole]**.

6. Sustainable Design Features:

- a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
- b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
- c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
- d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
- e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

C. Rocker Switch :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: UL CCN WMUZ and UL 20.
5. Standard Features:
 - a. Device Color: **[Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings]**.
 - b. Configuration:
 - 1) 120-277 V, 15 A, **[single pole][three way][four way]**.
 - 2) 120-277 V, 20 A, **[single pole][double pole][three way][four way]**.

6. Sustainable Design Features:

- a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
- b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
- c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
- d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
- e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

7. Accessories:

- a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
- b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

D. Rocker Switch with Nightlight :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: UL CCN WMUZ and UL 20.
5. Standard Features:
 - a. Device Color: **[Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].**
 - b. Configuration: 120-277 V, 20 A, **[single pole][three way][four way].**

6. Sustainable Design Features:

- a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
- b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
- c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
- d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
- e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

7. Accessories:

- a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
- b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

E. Type I Dimmer Switch :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[GE Lighting; a Savant Company]**
 - c. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - d. **[Leviton Manufacturing Co., Inc.]**
 - e. **[Lutron Electronics Co., Inc]**
 - f. **[Pass & Seymour; Legrand North America, LLC]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[GE Lighting; a Savant Company]**
 - c. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - d. **[Leviton Manufacturing Co., Inc.]**
 - e. **[Lutron Electronics Co., Inc]**
 - f. **[Pass & Seymour; Legrand North America, LLC]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: UL CCN EOYX and UL 1472.
5. Standard Features:

- a. UL 1472 Type I dimmer.
 - b. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - c. Switch Style: [Toggle][Rocker][Push button].
 - d. Dimming Control Style: [Slide][Rotary].
6. Sustainable Design Features:
- a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
7. Accessories:
- a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- F. Air-Gap Fan-Speed Controller Switch :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: UL CCN GQHG and UL 1917.

5. Standard Features:
 - a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
6. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide [third-party-verified]corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
7. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

2.5 GENERAL-GRADE SINGLE STRAIGHT-BLADE RECEPTACLES

- A. Single Straight-Blade Receptacle :
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Leviton Manufacturing Co., Inc.]
 - c. [Pass & Seymour; Legrand North America, LLC]
 - d. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Leviton Manufacturing Co., Inc.]
 - c. [Pass & Seymour; Legrand North America, LLC]
 - d. <Insert manufacturer's name>
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

- a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
4. Standard Features:
 - a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - b. Configuration:
 - 1) General-duty, [NEMA 5-15R][NEMA 5-20R][NEMA 5-30R][NEMA 5-50R].
 - 2) General-duty, smooth face, [NEMA 5-15R][NEMA 5-20R].
 - 3) General-duty, [NEMA 6-15R][NEMA 6-20R][NEMA 6-30R][NEMA 6-50R].
 - 4) General-duty, smooth face, NEMA 6-20R.
 - 5) General-duty, [NEMA 14-30R (Dryer)][NEMA 14-50R (Range)].
 - 6) Heavy-duty, [NEMA 5-30R][NEMA 5-50R].
 - 7) Heavy-duty, [NEMA 6-30R][NEMA 6-50R].
 - 8) Heavy-duty, [NEMA 7-20R][NEMA 7-30R][NEMA 7-50R].
 - 9) Heavy-duty, [NEMA 14-20R][NEMA 14-30R (Dryer)][NEMA 14-50R (Range)][NEMA 14-60R].
 - 10) Heavy-duty, [NEMA 15-20R][NEMA 15-30R][NEMA 15-50R][NEMA 15-60R].
 - 11) Heavy-duty, [NEMA 18-20R][NEMA 18-30R][NEMA 18-50R][NEMA 18-60R].
 - 12) Extra-heavy-duty, [NEMA 5-15R][NEMA 5-20R].
 - 13) Extra-heavy-duty, [NEMA 6-15R][NEMA 6-20R].
5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- B. Tamper-Resistant, Clock Hanger Straight-Blade Receptacle :
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - b. [Pass & Seymour; Legrand North America, LLC]
 - c. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - b. [Pass & Seymour; Legrand North America, LLC]
 - c. <Insert manufacturer's name>
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in



accordance with guide information and standards specified for the following UL product categories:

- a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.

4. Standard Features:

- a. Finish: **[White nylon][Ivory nylon][Brass][Stainless steel][Brushed brass][Nickel plated]**.
- b. Configuration: Recessed, smooth wallplate; **[NEMA 5-15R][NEMA 5-20R]**.

5. Other Available Features Required by the Project:

- a. Has factory-terminated connectors on wiring device pigtails for quick installation.

C. Tamper-Resistant, Floor-Mounted Display Straight-Blade Receptacle :

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

- a. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
- b. **[Pass & Seymour; Legrand North America, LLC]**
- c. **<Insert manufacturer's name>**

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

- a. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
- b. **[Pass & Seymour; Legrand North America, LLC]**
- c. **<Insert manufacturer's name>**

- 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

- a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.

4. Standard Features:

- a. Finish: **[Brushed brass][Nickel plated]**.

5. Other Available Features Required by the Project:

- a. Has factory-terminated connectors on wiring device pigtails for quick installation.

2.6 GENERAL-GRADE DUPLEX STRAIGHT-BLADE RECEPTACLES

A. Duplex Straight-Blade Receptacle :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Leviton Manufacturing Co., Inc.]
 - c. [Pass & Seymour; Legrand North America, LLC]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Leviton Manufacturing Co., Inc.]
 - c. [Pass & Seymour; Legrand North America, LLC]
 - d. <Insert manufacturer's name>
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 - b. Surge Protective Devices: UL 1449, Type 3.
4. Standard Features:
 - a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - b. Configuration:
 - 1) General-duty, [NEMA 5-15R][NEMA 5-20R].
 - 2) General-duty, smooth face, [NEMA 5-15R][NEMA 5-20R].
 - 3) General-duty, [NEMA 6-15R][NEMA 6-20R].
 - 4) General-duty, smooth face, [NEMA 6-15R][NEMA 6-20R].
 - 5) Heavy-duty, [NEMA 5-15R][NEMA 5-20R].
 - 6) Heavy-duty, smooth face, [NEMA 5-15R][NEMA 5-20R].
 - 7) Heavy-duty, [NEMA 6-15R][NEMA 6-20R].
 - 8) Heavy-duty, smooth face, NEMA 6-15R.
 - 9) Heavy-duty, NEMA 7-15R.
 - 10) Extra-heavy-duty, [NEMA 5-15R][NEMA 5-20R].
 - 11) Extra-heavy-duty, smooth face, [NEMA 5-15R][NEMA 5-20R].
 - 12) Extra-heavy-duty, [NEMA 6-15R][NEMA 6-20R].
 - 13) Extra-heavy-duty, smooth face, [NEMA 6-15R][NEMA 6-20R].
5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.



B. Tamper-Resistant Duplex Straight-Blade Receptacle :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Leviton Manufacturing Co., Inc.]**
 - c. **[Pass & Seymour; Legrand North America, LLC]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Leviton Manufacturing Co., Inc.]**
 - c. **[Pass & Seymour; Legrand North America, LLC]**
 - d. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 - b. Surge Protective Devices: UL 1449, Type 3.
4. Standard Features:
 - a. Device Color: **[Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].**
 - b. Configuration:
 - 1) General-duty, **[NEMA 5-15R][NEMA 5-20R].**
 - 2) General-duty, smooth face, **[NEMA 5-15R][NEMA 5-20R].**
 - 3) Heavy-duty, **[NEMA 5-15R][NEMA 5-20R].**
 - 4) Heavy-duty, smooth face, **[NEMA 5-15R][NEMA 5-20R].**
 - 5) Extra-heavy-duty, **[NEMA 5-15R][NEMA 5-20R].**
5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

C. Isolated Ground Duplex Straight-Blade Receptacle :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering**

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

- a. [Leviton Manufacturing Co., Inc.]
 - b. [Pass & Seymour; Legrand North America, LLC]
 - c. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Leviton Manufacturing Co., Inc.]
 - b. [Pass & Seymour; Legrand North America, LLC]
 - c. <Insert manufacturer's name>
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 - b. Surge Protective Devices: UL 1449, Type 3.
 4. Standard Features:
 - a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - b. Configuration:
 - 1) General-duty, [NEMA 5-15R][NEMA 5-20R].
 - 2) General-duty, smooth face, [NEMA 5-15R][NEMA 5-20R].
 - 3) Heavy-duty, [NEMA 5-15R][NEMA 5-20R].
 - 4) Heavy-duty, smooth face, [NEMA 5-15R][NEMA 5-20R].
 - 5) Extra-heavy-duty, [NEMA 5-15R][NEMA 5-20R].
 - 6) Extra heavy-duty, [NEMA 6-15R][NEMA 6-20R].
 5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
 6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- D. Isolated Ground Duplex Straight-Blade Receptacle with Type 3 Surge Protective Device :
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]



- c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 - b. Surge Protective Devices: UL 1449, Type 3.
4. Standard Features:
 - a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - b. Configuration: Heavy-duty, smooth face, [NEMA 5-15R][NEMA 5-20R].
5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- E. Tamper-Resistant Duplex Straight-Blade Receptacle with USB Outlet to Power Class 2 Equipment :
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the

following:

- a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
- a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 - b. Surge Protective Devices: UL 1449, Type 3.
4. Standard Features:
- a. Device Color: **[Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].**
 - b. Configuration:
 - 1) General-duty, **[NEMA 5-15R][NEMA 5-20R]**; two USB-A ports.
 - 2) General-duty, **[NEMA 5-15R][NEMA 5-20R]**; two USB-C ports.
 - 3) General-duty, **[NEMA 5-15R][NEMA 5-20R]**; one USB-A port; one USB-C port.
 - 4) General-duty, smooth face, two USB-A ports.
 - 5) General-duty, smooth face, four USB-A ports.
5. Other Available Features Required by the Project:
- a. Has factory-terminated connectors on wiring device pigtails for quick installation.
6. Accessories:
- a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- F. Wired Full-Controlled Duplex Straight-Blade Receptacle :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Hubbell Lighting; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Pass & Seymour; Legrand North America, LLC]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:



- a. [Hubbell Lighting; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Pass & Seymour; Legrand North America, LLC]
 - d. <Insert manufacturer's name>
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles with Integral Switching Means: UL CCN RTX1 and UL Subject 498B.
4. Standard Features:
 - a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - b. Configuration: [NEMA 5-15R][NEMA 5-20R].
5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

G. Wired Half-Controlled Duplex Straight-Blade Receptacle :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Hubbell Lighting; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Pass & Seymour; Legrand North America, LLC]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Hubbell Lighting; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Pass & Seymour; Legrand North America, LLC]
 - d. <Insert manufacturer's name>
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

- a. Receptacles with Integral Switching Means: UL CCN RTX1 and UL Subject 498B.
- 4. Standard Features:
 - a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - b. Configuration: [NEMA 5-15R][NEMA 5-20R].
- 5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
- 6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

2.7 HOSPITAL-GRADE STRAIGHT-BLADE RECEPTACLES

A. Hospital-Grade, Non-Ferrous Duplex Straight-Blade Receptacle :

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
- 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 - b. Surge Protective Devices: UL 1449, Type 3.
- 4. Standard Features:



- a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - b. Configuration: Extra-heavy-duty, [NEMA 5-15R][NEMA 5-20R].
5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- B. Hospital-Grade, Tamper-Resistant Duplex Straight-Blade Receptacle :
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Leviton Manufacturing Co., Inc.]
 - c. [Pass & Seymour; Legrand North America, LLC]
 - d. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Leviton Manufacturing Co., Inc.]
 - c. [Pass & Seymour; Legrand North America, LLC]
 - d. <Insert manufacturer's name>
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 - b. Surge Protective Devices: UL 1449, Type 3.
 4. Standard Features:
 - a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - b. Configuration:
 - 1) Heavy-duty, [NEMA 5-15R][NEMA 5-20R].
 - 2) Heavy-duty, smooth face, [NEMA 5-15R][NEMA 5-20R].
 - 3) Extra-heavy-duty, [NEMA 5-15R][NEMA 5-20R].
 - 4) Extra-heavy-duty, smooth face, [NEMA 5-15R][NEMA 5-20R].

5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- C. Hospital-Grade, Tamper-Resistant, Nightlight-Type, Lighted Duplex Straight-Blade Receptacle :
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 - b. Surge Protective Devices: UL 1449, Type 3.
 4. Standard Features:
 - a. Device Color: **[Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].**
 - b. Configuration:
 - 1) Heavy-duty, **[NEMA 5-15R][NEMA 5-20R].**
 - 2) Heavy-duty, smooth face, **[NEMA 5-15R][NEMA 5-20R].**
 5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.



6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- D. Hospital-Grade, Tamper-Resistant, Isolated Ground Duplex Straight-Blade Receptacle :
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Leviton Manufacturing Co., Inc.]**
 - b. **[Pass & Seymour; Legrand North America, LLC]**
 - c. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Leviton Manufacturing Co., Inc.]**
 - b. **[Pass & Seymour; Legrand North America, LLC]**
 - c. **<Insert manufacturer's name>**
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 - b. Surge Protective Devices: UL 1449, Type 3.
 4. Standard Features:
 - a. Device Color: **[Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].**
 - b. Configuration:
 - 1) Heavy-duty, **[NEMA 5-15R][NEMA 5-20R].**
 - 2) Heavy-duty, smooth face, **[NEMA 5-15R][NEMA 5-20R].**
 5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
 6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- E. Hospital-Grade, Tamper-Resistant Duplex Straight-Blade Receptacle with USB Outlet to Power Class 2 Equipment :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Pass & Seymour; Legrand North America, LLC]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Pass & Seymour; Legrand North America, LLC]**
 - d. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 - b. Surge Protective Devices: UL 1449, Type 3.
4. Standard Features:
 - a. Device Color: **[Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].**
 - b. Configuration:
 - 1) Heavy-duty, **[NEMA 5-15R][NEMA 5-20R]**; two USB-A ports.
 - 2) Heavy-duty, **[NEMA 5-15R][NEMA 5-20R]**; two USB-C ports.
 - 3) Heavy-duty, **[NEMA 5-15R][NEMA 5-20R]**; one USB-A port; one USB-C port.
5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

2.8 RECEPTACLES WITH ARC-FAULT AND GROUND-FAULT PROTECTIVE DEVICES

A. General-Grade, Tamper-Resistant Duplex Straight-Blade Receptacle with AFCI Device :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering**

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

- a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
- a. Outlet Branch-Circuit Type AFCIs: UL CCN AWBZ, UL 498, UL 1699, and UL Subject 1699A.
4. Standard Features:
- a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - b. Configuration: Heavy-duty, [NEMA 5-15R][NEMA 5-20R].
5. Other Available Features Required by the Project:
- a. Has factory-terminated connectors on wiring device pigtails for quick installation.
6. Accessories:
- a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- B. General-Grade, Tamper-Resistant Duplex Straight-Blade Receptacle with AFCI and GFCI Device :
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Leviton Manufacturing Co., Inc.]
 - c. [Pass & Seymour; Legrand North America, LLC]

- d. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Leviton Manufacturing Co., Inc.]
 - c. [Pass & Seymour; Legrand North America, LLC]
 - d. <Insert manufacturer's name>
- 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Outlet Branch-Circuit Type GFCIs and AFCIs: UL CCN KCXX, UL 498, UL 943, UL 1699, and UL Subject 1699A.
- 4. Standard Features:
 - a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - b. Configuration: Heavy-duty, [NEMA 5-15R][NEMA 5-20R].
- 5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
- 6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- C. General-Grade, Weather-Resistant, Tamper-Resistant Duplex Straight-Blade Receptacle with GFCI Device :
 - 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell

- c. **Incorporated]**
[Leviton Manufacturing Co., Inc.]
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
- 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacle GFCIs: UL CCN KCXS, UL 498, and UL 943.
- 4. Standard Features:
 - a. Device Color: **[Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].**
 - b. Configuration: Heavy-duty, **[NEMA 5-15R][NEMA 5-20R].**
- 5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
- 6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- D. General-Grade, Weather-Resistant, Tamper-Resistant, Nightlight-Type, Lighted Duplex Straight-Blade Receptacle with GFCI Device :
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
 - 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in

accordance with guide information and standards specified for the following UL product categories:

- a. Receptacle GFCIs: UL CCN KCXS, UL 498, and UL 943.
4. Standard Features:
 - a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - b. Configuration: Heavy-duty, [NEMA 5-15R][NEMA 5-20R].
5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- E. Hospital-Grade, Weather-Resistant, Tamper-Resistant, Nightlight-Type, Lighted Duplex Straight-Blade Receptacle with GFCI Device :
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacle GFCIs: UL CCN KCXS, UL 498, and UL 943.
 4. Standard Features:



- a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - b. Configuration: Heavy-duty, [NEMA 5-15R][NEMA 5-20R].
5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- F. Hospital-Grade, Isolated Ground, Weather-Resistant, Tamper-Resistant Duplex Straight-Blade Receptacle with GFCI Device :
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacle GFCIs: UL CCN KCXS, UL 498, and UL 943.
 4. Standard Features:
 - a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - b. Configuration: Heavy-duty, [NEMA 5-15R][NEMA 5-20R].
 5. Other Available Features Required by the Project:

- a. Has factory-terminated connectors on wiring device pigtails for quick installation.
- 6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

2.9 LOCKING RECEPTACLES

A. UL RTRT - NEMA, 125 V, Locking Receptacle :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - c. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - d. **[Leviton Manufacturing Co., Inc.]**
 - e. **[Pass & Seymour; Legrand North America, LLC]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - c. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - d. **[Leviton Manufacturing Co., Inc.]**
 - e. **[Pass & Seymour; Legrand North America, LLC]**
 - f. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
5. Standard Features:
 - a. Device Color: Black with yellow voltage indication on face.
 - b. Configuration: 2 pole, 3 wire, grounding, **[NEMA L5-15R][NEMA L5-20R][NEMA L5-30R]**.

B. UL RTRT - NEMA, 125 V, Isolated Ground Locking Receptacle :

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



- a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
 3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 5. Standard Features:
 - a. Device Color: Black with yellow voltage indication on face.
 - b. Configuration: 2 pole, 3 wire, grounding, [NEMA L5-15R][NEMA L5-20R][NEMA L5-30R].
- C. UL RTRT - NEMA, 250 V, Locking Receptacle :
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>

3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
5. Standard Features:
 - a. Device Color: Black with blue voltage indication on face.
 - b. Configuration:
 - 1) 2 pole, 3 wire, grounding, [NEMA L6-15R][NEMA L6-20R][NEMA L6-30R].
 - 2) 3 pole, 4 wire, grounding, [NEMA L15-20R][NEMA L15-30R].
 - 3) 4 pole, 4 wire, non-grounding, [NEMA L18-20R][NEMA L18-30R].
 - 4) 4 pole, 5 wire, grounding, [NEMA L21-20R][NEMA L21-30R].

D. UL RTRT - NEMA, 250 V, Isolated Ground Locking Receptacle :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
5. Standard Features:
 - a. Device Color: Black with blue voltage indication on face.
 - b. Configuration:
 - 1) 2 pole, 3 wire, grounding, [NEMA L6-15R][NEMA L6-20R][NEMA L6-30R].
 - 2) 3 pole, 4 wire, grounding, [NEMA L15-20R][NEMA L15-30R].

- 3) 4 pole, 5 wire, grounding, [NEMA L21-20R][NEMA L21-30R].

2.10 PIN-AND-SLEEVE RECEPTACLES

A. UL QLIW - C2 Series, 125/250 V, Pin-and-Sleeve Receptacles :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [ABB, Electrification Business]
 - b. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - c. [Crouse-Hinds; brand of Eaton, Electrical Sector]
 - d. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - e. [Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - f. [Leviton Manufacturing Co., Inc.]
 - g. [Pass & Seymour; Legrand North America, LLC]
 - h. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [ABB, Electrification Business]
 - b. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - c. [Crouse-Hinds; brand of Eaton, Electrical Sector]
 - d. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - e. [Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - f. [Leviton Manufacturing Co., Inc.]
 - g. [Pass & Seymour; Legrand North America, LLC]
 - h. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Pin-and-Sleeve Type Receptacles: UL CCN QLIW; including UL 1682.
5. Standard Features:
 - a. Series: UL 1686 Series C2 and IEC 60309-2 Series II.
 - b. Voltage Rating: 125/250 V.
 - c. Configuration:
 - 1) 2 pole, 3 wire, [20 A][30 A, IP67][30 A, IP69k][60 A, IP67][60 A, IP69k][100 A].
 - 2) 3 pole, 4 wire, [20 A][30 A, IP67][30 A, IP69k][60 A, IP67][60 A, IP69k][100 A, IP67][100 A, IP69k].
 - 3) 4 pole, 5 wire, [20 A][30 A, IP67][30 A, IP69k][60 A, IP67][60 A, IP69k][100 A, IP67][100 A, IP69k].

B. UL QLIW - C2 Series, 480 V, Pin-and-Sleeve Receptacles :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB, Electrification Business]**
 - b. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - c. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - d. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - e. **[Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - f. **[Leviton Manufacturing Co., Inc.]**
 - g. **[Pass & Seymour; Legrand North America, LLC]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - c. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - d. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - e. **[Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - f. **[Leviton Manufacturing Co., Inc.]**
 - g. **[Pass & Seymour; Legrand North America, LLC]**
 - h. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Pin-and-Sleeve Type Receptacles: UL CCN QLIW; including UL 1682.
5. Standard Features:
 - a. Series: UL 1686 Series C2 and IEC 60309-2 Series II.
 - b. Voltage Rating: 480 V.
 - c. Configuration:
 - 1) 2 pole, 3 wire, **[20 A][30 A, IP67][30 A, IP69k][60 A, IP67][60 A, IP69k][100 A, IP67][100 A, IP69k].**
 - 2) 3 pole, 4 wire, **[20 A][30 A, IP67][30 A, IP69k][60 A, IP67][60 A, IP69k][100 A, IP67][100 A, IP69k].**
 - 3) 4 pole, 5 wire, **[20 A][30 A, IP67][30 A, IP69k][60 A, IP67][60 A, IP69k][100 A, IP67][100 A, IP69k].**

2.11 SPECIAL-PURPOSE POWER OUTLET ASSEMBLIES

A. Power Outlet Cord Management Assembly :

1. Source Limitations: Obtain all components for each power outlet cord management assembly



- from single manufacturer.
2. General Characteristics: Provide the following specified products with fabricated power outlet cord management assembly:
 - a. Cord Management System:
 - 1) Spring-driven commercial/industrial-use cord reel, **<Insert wire size>** conductors .
 - 2) Cord reel for use in Class I Group D hazardous location .
 - b. Termination Fitting:
 - 1) Owner-furnished fitting.
 - 2) Outdoor-use, watertight, sealed cord connector; **<Insert NEMA configuration><Insert drawing designation>**.
 - 3) **<Insert title of product><Insert drawing designation>** specified in **<Insert Section number and title>**.
 3. Accessories:
 - a. Mounting: **[Ceiling][Wall][Floor]** mounted.
 - b. **<Insert required accessory>**.
 4. Seismic and Wind Performance: Installed product must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:
 - a. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events[**and unit must be fully operational after seismic events**]."
 - b. Component Importance Factor (Ip): **[1.0][1.5]**.
 - c. Component Amplification Factor (ap): **[1.0][2.5]<Insert value>**.
 - d. Component Response Modification Factor (Rp): **[1.5][2.0][2.5][6.0]<Insert value>**.
 - e. Component Overstrength Factor (Qo): **[1.5][2.5]<Insert value>**.
- B. Spring-Driven Commercial/Industrial-Use Cord Reel, No. 14 AWG Conductors :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Eaton]**
 - b. **[Ericson Manufacturing Company]**
 - c. **[Gleason Reel; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Eaton]**
 - b. **[Ericson Manufacturing Company]**
 - c. **[Gleason Reel; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - d. **<Insert manufacturer's name>**
 3. Listing Criteria:

- a. Reference Standards: UL CCN SBCV and UL 355.
4. Standard Features:
- a. Spring take-up retraction mechanism.
 - b. Electrical Rating with Cable: 600 V, [18 A][15 A][12 A][10.5 A][7.5 A].
 - c. Color: [Yellow][Black][White]<Insert color>.
 - d. Enclosure Degree of Protection: [Type 4][Type 4X].
 - e. Ball stop.
 - f. Pivot base.
 - g. Spool Capacity:
 - 1) No. 14 AWG, two wires and equipment ground, [20 ft (6 m)][30 ft (9.1 m)][40 ft (12.2 m)][50 ft (15.2 m)][60 ft (18.3 m)][70 ft (21.3 m)].
 - 2) No. 14 AWG, three wires and equipment ground, [20 ft (6 m)][30 ft (9.1 m)][35 ft (10.7 m)][40 ft (12.2 m)][50 ft (15.2 m)][60 ft (18.3 m)][70 ft (21.3 m)].
 - 3) No. 14 AWG, five wires and equipment ground, [20 ft (6 m)][30 ft (9.1 m)][40 ft (12.2 m)][50 ft (15.2 m)][60 ft (18.3 m)].
 - 4) No. 14 AWG, seven wires and equipment ground, [20 ft (6 m)][30 ft (9.1 m)][40 ft (12.2 m)][50 ft (15.2 m)].
 - 5) No. 14 AWG, nine wires and equipment ground, [20 ft (6 m)][30 ft (9.1 m)].
 - 6) No. 14 AWG, eleven wires and equipment ground, [20 ft (6 m)][60 ft (18.3 m)].
 - 7) No. 14 AWG, two wires and equipment ground, [25 ft (7.6 m)][35 ft (10.7 m)][45 ft (13.7 m)][90 ft (27.4 m)][100 ft (30.5 m)][125 ft (38.1 m)][150 ft (45.7 m)].
 - 8) No. 14 AWG, three wires and equipment ground, [25 ft (7.6 m)][45 ft (13.7 m)][65 ft (19.8 m)][80 ft (24.4 m)][90 ft (27.4 m)][100 ft (30.5 m)][125 ft (38.1 m)][150 ft (45.7 m)].
 - 9) No. 14 AWG, five wires and equipment ground, [25 ft (7.6 m)][35 ft (10.7 m)][45 ft (13.7 m)].
 - 10) No. 14 AWG, seven wires and equipment ground, [25 ft (7.6 m)][35 ft (10.7 m)][45 ft (13.7 m)].
 - 11) No. 14 AWG, nine wires and equipment ground, [25 ft (7.6 m)][50 ft (15.2 m)].
 - 12) No. 14 AWG, eleven wires and equipment ground, [25 ft (7.6 m)][30 ft (9.1 m)].
5. Seismic and Wind Performance: Installed product must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:
- a. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events[**and unit must be fully operational after seismic events**]."
 - b. Component Importance Factor (Ip): [1.0][1.5].
 - c. Component Amplification Factor (ap): [1.0][2.5]<Insert value>.
 - d. Component Response Modification Factor (Rp): [1.5][2.0][2.5][6.0]<Insert value>.
 - e. Component Overstrength Factor (Ωo): [1.5][2.5]<Insert value>.
- C. Spring-Driven Commercial/Industrial-Use Cord Reel, No. 12 AWG Conductors :
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Appleton; Emerson Electric Co., Automation Solutions]
 - b. [Ericson Manufacturing Company]
 - c. [Gleason Reel; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - d. [Reelcraft Industries Inc]

- e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Appleton; Emerson Electric Co., Automation Solutions]
 - b. [Ericson Manufacturing Company]
 - c. [Gleason Reel; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - d. [Reelcraft Industries Inc]
 - e. <Insert manufacturer's name>
3. Listing Criteria:
 - a. Reference Standards: UL CCN SBCV and UL 355.
4. Standard Features:
 - a. Spring take-up retraction mechanism.
 - b. Electrical Rating with Cable: 600 V, [25 A][20 A][16 A][14 A].
 - c. Color: [Yellow][Black][White]<Insert color>.
 - d. Enclosure Degree of Protection: [Type 4][Type 4X].
 - e. Ball stop.
 - f. Pivot base.
 - g. Spool Capacity:
 - 1) No. 12 AWG, two wires and equipment ground, [20 ft (6 m)][25 ft (7.6 m)][30 ft (9.1 m)][40 ft (12.2 m)][50 ft (15.2 m)][60 ft (18.3 m)].
 - 2) No. 12 AWG, three wires and equipment ground, [20 ft (6 m)][25 ft (7.6 m)][30 ft (9.1 m)][40 ft (12.2 m)][45 ft (13.7 m)][50 ft (15.2 m)][60 ft (18.3 m)][100 ft (30.5 m)].
 - 3) No. 12 AWG, five wires and equipment ground, [20 ft (6 m)][30 ft (9.1 m)][40 ft (12.2 m)].
 - 4) No. 12 AWG, seven wires and equipment ground, [20 ft (6 m)][30 ft (9.1 m)].
 - 5) No. 12 AWG, two wires and equipment ground, [35 ft (10.7 m)][45 ft (13.7 m)][70 ft (21.3 m)][80 ft (24.4 m)][90 ft (27.4 m)][100 ft (30.5 m)][125 ft (38.1 m)][150 ft (45.7 m)].
 - 6) No. 12 AWG, three wires and equipment ground, [35 ft (10.7 m)][70 ft (21.3 m)][80 ft (24.4 m)][90 ft (27.4 m)][125 ft (38.1 m)].
 - 7) No. 12 AWG, four wires and equipment ground, [20 ft (6 m)][30 ft (9.1 m)][40 ft (12.2 m)].
 - 8) No. 12 AWG, five wires and equipment ground, [25 ft (7.6 m)][35 ft (10.7 m)][45 ft (13.7 m)].
 - 9) No. 12 AWG, seven wires and equipment ground, [25 ft (7.6 m)][40 ft (12.2 m)].
5. Seismic and Wind Performance: Installed product must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:
 - a. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events[**and unit must be fully operational after seismic events**]."
 - b. Component Importance Factor (Ip): [1.0][1.5].
 - c. Component Amplification Factor (ap): [1.0][2.5]<Insert value>.
 - d. Component Response Modification Factor (Rp): [1.5][2.0][2.5][6.0]<Insert value>.
 - e. Component Overstrength Factor (Qo): [1.5][2.5]<Insert value>.

D. Spring-Driven Cord Reel for Use in Class I Group D Hazardous Locations :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Appleton; Emerson Electric Co., Automation Solutions]**
 - b. **[Conductix-Wampfler USA; Delachaux Group]**
 - c. **[KH Industries, Inc.]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Appleton; Emerson Electric Co., Automation Solutions]**
 - b. **[Conductix-Wampfler USA; Delachaux Group]**
 - c. **[KH Industries, Inc.]**
 - d. **<Insert manufacturer's name>**
3. Listing Criteria:
 - a. Reference Standards: UL CCN SAOX and UL 355.
4. Standard Features:
 - a. Spring take-up retraction mechanism.
 - b. Electrical Rating with Cable: 600 V, **[35 A][25 A][20 A][18 A][15 A]**.
 - c. Color: **[Yellow][Black][White]<Insert color>**.
 - d. Enclosure Degree of Protection: **[Type 4][Type 4X]**.
 - e. Ball stop.
 - f. Pivot base.
 - g. Spool Capacity:
 - 1) No. 14 AWG, two wires and equipment ground, **[20 ft (6 m)][30 ft (9.1 m)][50 ft (15.2 m)]**.
 - 2) No. 14 AWG, three wires and equipment ground, **[20 ft (6 m)][30 ft (9.1 m)][50 ft (15.2 m)]**.
 - 3) No. 12 AWG, two wires and equipment ground, **[30 ft (9.1 m)][50 ft (15.2 m)]**.
 - 4) No. 14 AWG, two wires and equipment ground, **[40 ft (12.2 m)][60 ft (18.3 m)][70 ft (21.3 m)]**.
 - 5) No. 14 AWG, three wires and equipment ground, **[40 ft (12.2 m)][60 ft (18.3 m)]**.
 - 6) No. 12 AWG, two wires and equipment ground, **[20 ft (6 m)][40 ft (12.2 m)][60 ft (18.3 m)]**.
 - 7) No. 12 AWG, three wires and equipment ground, **[20 ft (6 m)][30 ft (9.1 m)][40 ft (12.2 m)][50 ft (15.2 m)]**.
 - 8) No. 10 AWG, two wires and equipment ground, **[20 ft (6 m)][30 ft (9.1 m)][40 ft (12.2 m)]**.
 - 9) No. 10 AWG, three wires and equipment ground, **[20 ft (6 m)][30 ft (9.1 m)][40 ft (12.2 m)]**.
5. Seismic and Wind Performance: Installed product must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:
 - a. Withstand Requirement: Unit must remain in place without separation of parts when

subjected to specified criteria during seismic events[**and unit must be fully operational after seismic events**]."

- b. Component Importance Factor (Ip): **[1.0][1.5]**.
- c. Component Amplification Factor (ap): **[1.0][2.5]<Insert value>**.
- d. Component Response Modification Factor (Rp): **[1.5][2.0][2.5][6.0]<Insert value>**.
- e. Component Overstrength Factor (Ωo): **[1.5][2.5]<Insert value>**.

2.12 CONNECTORS, CORDS, AND PLUGS

A. Outdoor-Use, Watertight, Sealed Cord Connector :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Ericson Manufacturing Company]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Ericson Manufacturing Company]**
 - b. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Reference Standards: UL CCN AXUT and UL 498.
4. Standard Features:
 - a. Configuration:
 - 1) NEMA 5-15[**with diagnostic LED indicator**].
 - 2) NEMA 5-20[**with diagnostic LED indicator**].
 - 3) NEMA 6-15.
 - 4) NEMA 6-20.
 - 5) NEMA L5-15.
 - 6) NEMA L5-20[**with diagnostic LED indicator**].
 - 7) NEMA L5-30.
 - 8) NEMA L6-15.
 - 9) NEMA L6-20.
 - 10) NEMA L6-30.
 - 11) NEMA L7-15.
 - 12) NEMA L7-20.
 - 13) NEMA L7-30.
 - 14) NEMA L14-20.
 - 15) NEMA L14-30.
 - 16) NEMA L15-20.
 - 17) NEMA L15-30.
 - 18) NEMA L16-20.

- 19) NEMA L16-30.
- 20) NEMA L17-30.
- 21) NEMA L18-30.

2.13 MAINTENANCE MATERIAL ITEMS FOR STRAIGHT-BLADE RECEPTACLES

- A. Extra Stock Material: Furnish to Owner extra materials[, **from same production run,**] that match products installed and that are packaged with protective covering for storage and identified with labels describing contents. [**Include the following:**]
 - 1. SPD Receptacles: Equal to [10]<Insert number> percent of quantity installed for each kind specified, but no fewer than [one]<Insert number> units.
 - 2. Controlled Receptacles: Equal to [10]<Insert number> percent of quantity installed for each kind specified, but no fewer than [one]<Insert number> units.
- B. Special Tools: Furnish to Owner proprietary equipment, keys, and software required to operate, maintain, repair, adjust, or implement future changes to controlled receptacles, that are packaged with protective covering for storage on-site and identified with labels describing contents.

2.14 MAINTENANCE MATERIAL ITEMS FOR CONNECTORS, CORDS, AND PLUGS

- A. Extra Stock Material: Furnish to Owner extra materials[, **from same production run,**] that match products installed and that are packaged with protective covering for storage and identified with labels describing contents. [**Include the following:**]
 - 1. Cord Connectors: [One]<Insert number> of each kind.
- B. Special Tools: Furnish to Owner proprietary equipment, keys, and software required to operate, maintain, repair, adjust, or implement future changes to cord connectors, that are packaged with protective covering for storage on-site and identified with labels describing contents.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Receptacles:
 - 1. Verify that receptacles to be procured and installed for Owner-furnished equipment are compatible with mating attachment plugs on equipment.
- B. Cord Reels:
 - 1. Examine roughing-in for cord reel mounting and power connections to verify actual locations of mounts and power connections before cord reel installation.
 - 2. Examine walls, floors, and ceilings for suitable conditions where cord reel will be installed.
 - 3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 SELECTION OF CONTROLLED AND UNCONTROLLED RECEPTACLES

- A. Private and Open Office Spaces:



1. Uncontrolled Receptacles at Workstations: Coordinate final locations of receptacles with furniture plan such that at least one uncontrolled receptacle is selected for installation not greater than 6 ft. (1.8 m) from each workstation.
2. Controlled Receptacles at Workstations: Coordinate final locations of receptacles with furniture plan such that at least one controlled receptacle is selected for installation not greater than 6 ft. (1.8 m) from each workstation.
3. Contact Architect for resolution of discrepancies between these requirements and Drawings.

3.3 SELECTION OF GFCI RECEPTACLES

- A. Healthcare Facilities: Unless protection of downstream branch-circuit wiring, cord sets, and power-supply cords is required by NFPA 70 or NFPA 99, provide non-feed-through GFCI receptacles.

3.4 INSTALLATION OF SWITCHES

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:
 1. Electrical Construction: ICC IBC, ICC IFB, NFPA 1, NFPA 70, and NECA NEIS 1.
 2. Electrical Safety: NFPA 70E.
 3. Life Safety and Means of Egress Work: NFPA 101.
 4. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
 5. Wiring Devices: NECA NEIS 130.
 6. Mounting Heights: NECA NEIS 1.
 7. Consult Architect for resolution of conflicting requirements.
- C. Interfaces with Other Work:
 1. Identification:
 - a. Identify cover or cover plate for device with panelboard identification and circuit number.
 - b. Mark cover or cover plate using hot, stamped, or engraved machine printing with [black][white][red]-filled lettering, and provide durable wire markers or tags inside device box or outlet box.
 - c. Provide warning signs and arc-flash hazard warning labels for electrical equipment.
 - d. Healthcare Facilities: Distinctively identify covers or cover plates of device boxes and outlet boxes that are supplied from life safety and critical branch power supplies following facility's standard practice.
 2. Coordinate installation of new products for <Insert system or product group> with existing conditions.
 - a. <Insert requirements for transition between new and existing>.
 3. Coordinate with <Insert Section number and title> for <Insert description of interfacing related Work>.
 - a. <Insert requirements for transition between this Section and related Work>.

3.5 INSTALLATION OF STRAIGHT-BLADE RECEPTACLES

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:
 - 1. Electrical Construction: ICC IBC, ICC IFB, NFPA 1, NFPA 70, and NECA NEIS 1.
 - 2. Electrical Safety: NFPA 70E.
 - 3. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
 - 4. Work in ITE Rooms: NFPA 75.
 - 5. Work in Health Care Facilities: NFPA 99 and Article 517 of NFPA 70.
 - 6. Work in Confined Spaces: NFPA 350.
 - 7. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
 - 8. Installing and Maintaining Wiring Devices: NECA NEIS 130.
 - 9. Mounting Heights: Unless otherwise indicated in the Contract Documents, comply with mounting heights recommended in NECA NEIS 1.
 - 10. Receptacle Orientation: Unless otherwise indicated in the Contract Documents, orient receptacle to match configuration diagram in NEMA WD 6.
 - a. Hospital-Grade Receptacle Orientation: Orient receptacle with ground pin or neutral pin at top.
 - 11. Consult Architect for resolution of conflicting requirements.
- C. Interfaces with Other Work:
 - 1. Identification: Provide labels for receptacles and associated electrical equipment.
 - a. Identify field-installed conductors, interconnecting wiring, and components.
 - b. Label each enclosure with engraved metal or laminated-plastic nameplate.
 - 1) Identify cover or cover plate for device with panelboard identification and circuit number.
 - 2) Mark cover or cover plate using hot, stamped, or engraved machine printing with [black][white][red]-filled lettering, and provide durable wire markers or tags inside device box or outlet box.
 - c. Provide warning signs and arc-flash hazard warning labels for electrical equipment.
 - d. Healthcare Facilities: Distinctively identify covers or cover plates of device boxes and outlet boxes that are supplied from life safety and critical branch power supplies following facility's standard practice.
 - 2. Do not install Type 3 SPD, including surge-protected relocatable taps and power strips, on branch circuit downstream of GFCI device.
 - 3. Coordinate installation of new products for **<Insert system or product group>** with existing conditions.
 - a. **<Insert requirements for transition between new and existing>**.
 - 4. Coordinate with **<Insert Section number and title>** for **<Insert description of interfacing related Work>**.
 - a. **<Insert requirements for transition between this Section and related Work>**.



3.6 INSTALLATION OF LOCKING RECEPTACLES

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:
 - 1. Electrical Construction: ICC IBC, ICC IFB, NFPA 1, NFPA 70, and NECA NEIS 1.
 - 2. Electrical Safety: NFPA 70E.
 - 3. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
 - 4. Work in ITE Rooms: NFPA 75.
 - 5. Work in Health Care Facilities: NFPA 99 and Article 517 of NFPA 70.
 - 6. Work in Confined Spaces: NFPA 350.
 - 7. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
 - 8. Installing and Maintaining Wiring Devices: NECA NEIS 130.
 - 9. Mounting Heights: Unless otherwise indicated in the Contract Documents, comply with mounting heights recommended in NECA NEIS 1.
 - 10. Receptacle Orientation: Unless otherwise indicated in the Contract Documents, orient receptacle to match configuration diagram in NEMA WD 6.
 - 11. Consult Architect for resolution of conflicting requirements.
- C. Interfaces with Other Work:
 - 1. Identification: Provide labels for receptacles and associated electrical equipment.
 - a. Identify field-installed conductors, interconnecting wiring, and components.
 - b. Label each enclosure with engraved metal or laminated-plastic nameplate.
 - 1) Identify cover or cover plate for device with panelboard identification and circuit number.
 - 2) Mark cover or cover plate using hot, stamped, or engraved machine printing with [black][white][red]-filled lettering, and provide durable wire markers or tags inside device box or outlet box.
 - c. Provide warning signs and arc-flash hazard warning labels for electrical equipment.
 - d. Healthcare Facilities: Distinctively identify covers or cover plates of device boxes and outlet boxes that are supplied from life safety and critical branch power supplies following facility's standard practice.
 - 2. Coordinate installation of new products for **<Insert system or product group>** with existing conditions.
 - a. **<Insert requirements for transition between new and existing>.**
 - 3. Coordinate with **<Insert Section number and title>** for **<Insert description of interfacing related Work>**.
 - a. **<Insert requirements for transition between this Section and related Work>.**

3.7 INSTALLATION OF PIN-AND-SLEEVE RECEPTACLES

- A. Comply with manufacturer's published instructions.

- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:
1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
 2. Electrical Safety: NFPA 70E.
 3. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
 4. Work in ITE Rooms: NFPA 75.
 5. Work in Health Care Facilities: NFPA 99 and Article 517 of NFPA 70.
 6. Work in Confined Spaces: NFPA 350.
 7. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
 8. Installing and Maintaining Wiring Devices: NECA NEIS 130.
 9. Mounting Heights: Unless otherwise indicated in the Contract Documents, comply with mounting heights recommended in NECA NEIS 1.
 10. Receptacle Orientation: Unless otherwise indicated in the Contract Documents, orient receptacle to match configuration diagram in UL 1686.
 11. Consult Architect for resolution of conflicting requirements.
- C. Interfaces with Other Work:
1. Identification: Provide labels for receptacles and associated electrical equipment.
 - a. Identify field-installed conductors, interconnecting wiring, and components.
 - b. Label each enclosure with engraved metal or laminated-plastic nameplate.
 - 1) Identify cover or cover plate for device with panelboard identification and circuit number.
 - 2) Mark cover or cover plate using hot, stamped, or engraved machine printing with [black][white][red]-filled lettering, and provide durable wire markers or tags inside device box or outlet box.
 - c. Provide warning signs and arc-flash hazard warning labels for electrical equipment.
 - d. Healthcare Facilities: Distinctively identify covers or cover plates of device boxes and outlet boxes that are supplied from life safety and critical branch power supplies following facility's standard practice.
 2. Coordinate installation of new products for **<Insert system or product group>** with existing conditions.
 - a. **<Insert requirements for transition between new and existing>**.
 3. Coordinate with **<Insert Section number and title>** for **<Insert description of interfacing related Work>**.
 - a. **<Insert requirements for transition between this Section and related Work>**.

3.8 INSTALLATION OF CORD REELS AND FITTINGS

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:
1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
 2. Electrical Maintenance: NFPA 70B.
 3. Electrical Safety: NFPA 70E.

4. Hot Work: NFPA 51B.
5. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
6. Work in Confined Spaces: NFPA 350.
7. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.

C. Special Techniques:

1. **<Insert more stringent installation requirements that supplement or supersede manufacturers' instructions>.**

D. Interfaces with Other Work:

1. Coordinate installation of new products for **<Insert system or product group>** with existing conditions.
 - a. **<Insert requirements for transition between new and existing>.**
2. Coordinate with **<Insert Section number and title>** for **<Insert description of interfacing related Work>.**
 - a. **<Insert requirements for transition between this Section and related Work>.**

3.9 INSTALLATION OF CONNECTORS, CORDS, AND PLUGS

A. Comply with manufacturer's published instructions.

B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:

1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
2. Electrical Maintenance: NFPA 70B.
3. Electrical Safety: NFPA 70E.
4. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
5. Work in ITE Rooms: NFPA 75.
6. Work in Health Care Facilities: NFPA 99 and Article 517 of NFPA 70.
7. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
8. Consult Architect for resolution of conflicting requirements.

C. Special Techniques:

1. **<Insert more stringent installation requirements that supplement or supersede listed standards and manufacturers' instructions>.**

D. Interfaces with Other Work:

1. Coordinate with Section 262726.43 "Special-Purpose Power Outlet Assemblies" for installation of connectors and cords on fabricated power-outlet cord management assemblies.
2. Coordinate installation of new products for **<Insert system or product group>** with existing conditions.
 - a. **<Insert requirements for transition between new and existing>.**
3. Coordinate with **<Insert Section number and title>** for **<Insert description of interfacing**

related Work>.

- a. <Insert requirements for transition between this Section and related Work>.

3.10 FIELD QUALITY CONTROL OF SWITCHES

A. Administrant for Electrical Power Tests and Inspections:

1. [Owner][Tenant] will engage qualified medium-voltage electrical testing and inspecting agency to administer and perform tests and inspections.
2. Engage qualified medium-voltage electrical testing and inspecting agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].

B. Acceptance Testing Preparation:

1. <Insert requirements>.

C. Field tests and inspections must be witnessed by [Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>.

D. Tests and Inspections:

1. Perform tests and inspections in accordance with manufacturers' published instructions.
2. <Insert tests and inspections>.

E. Nonconforming Work:

1. Unit will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

F. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

G. Manufacturer Services: Engage factory-authorized service representative to [support][supervise] field tests and inspections.

1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.

3.11 FIELD QUALITY CONTROL OF STRAIGHT-BLADE RECEPTACLES

A. Administrant for Electrical Power Tests and Inspections:

1. [Owner][Tenant] will engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
2. Engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.

4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].
 - B. Acceptance Testing Preparation:
 1. **<Insert requirements>**.
 - C. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.
 - D. Tests and Inspections:
 1. Insert and remove test plug to verify that device is securely mounted.
 2. Verify polarity of hot and neutral pins.
 3. Measure line voltage.
 4. Measure percent voltage drop.
 5. Measure grounding circuit continuity; impedance must be not greater than 2 ohms.
 6. Healthcare Facilities: Test straight-blade receptacles in patient care spaces with receptacle pin tension test instrument in accordance with NFPA 99. Retention force of ground pin must be not less than 115 g (4 oz).
 7. Perform additional installation and maintenance inspections and diagnostic tests in accordance with NECA NEIS 130 and manufacturers' published instructions.
 8. **<Insert tests and inspections>**.
 - E. Nonconforming Work:
 1. Device will be considered defective if it does not pass tests and inspections.
 2. Remove and replace defective units and retest.
 - F. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.
 - G. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.
 1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.
- 3.12 FIELD QUALITY CONTROL OF LOCKING RECEPTACLES
- A. Adminstrant for Low-Voltage Electrical Tests and Inspections:
 1. **[Owner][Tenant]** will engage qualified low-voltage electrical testing and inspecting agency to administer and perform tests and inspections.
 2. Engage qualified low-voltage electrical testing and inspecting agency to administer and perform tests and inspections.
 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
 4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].
 - B. Acceptance Testing Preparation:

1. <Insert requirements>.
 - C. Field tests and inspections must be witnessed by [Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>.
 - D. Tests and Inspections:
 1. Insert and remove test plug to verify that device is securely mounted.
 2. Verify polarity of hot and neutral pins.
 3. Measure line voltage.
 4. Measure percent voltage drop.
 5. Measure grounding circuit continuity; impedance must be not greater than 2 ohms.
 6. Perform additional installation and maintenance inspections and diagnostic tests in accordance with NECA NEIS 130 and manufacturers' published instructions.
 7. <Insert tests and inspections>.
 - E. Nonconforming Work:
 1. Device will be considered defective if it does not pass tests and inspections.
 2. Remove and replace defective units and retest.
 - F. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.
 - G. Manufacturer Services: Engage factory-authorized service representative to [support][supervise] field tests and inspections.
 1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.
- 3.13 FIELD QUALITY CONTROL OF PIN-AND-SLEEVE RECEPTACLES
- A. Adminstrant for Low-Voltage Electrical Tests and Inspections:
 1. [Owner][Tenant] will engage qualified low-voltage electrical testing and inspecting agency to administer and perform tests and inspections.
 2. Engage qualified low-voltage electrical testing and inspecting agency to administer and perform tests and inspections.
 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
 4. Administer and perform tests and inspections[with assistance of factory-authorized service representative].
 - B. Acceptance Testing Preparation:
 1. <Insert requirements>.
 - C. Field tests and inspections must be witnessed by [Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>.
 - D. Tests and Inspections:
 1. Insert and remove test plug to verify that device is securely mounted.
 2. Measure line voltage.

3. Measure percent voltage drop.
4. Measure ground impedance, which must be not greater than 2 ohms.
5. Perform additional installation and maintenance inspections and diagnostic tests in accordance with NECA NEIS 130 and manufacturers' published instructions.
6. **<Insert tests and inspections>.**

E. Nonconforming Work:

1. Device will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

F. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

G. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.

1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.

3.14 FIELD QUALITY CONTROL OF CORD REELS AND FITTINGS

A. Adminstrant for Electrical Power Tests and Inspections:

1. **[Owner][Tenant]** will engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
2. Engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].

B. Acceptance Testing Preparation:

1. **<Insert requirements>.**

C. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>.**

D. Tests and Inspections:

1. Perform tests and inspections indicated in manufacturer's published instructions.
2. **<Insert Project-specific test or inspection>.**

E. Nonconforming Work:

1. Components and assemblies will be considered defective if they do not pass tests and inspections.
2. Remove and replace defective units and retest.

F. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

- G. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.
1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.

3.15 FIELD QUALITY CONTROL OF CONNECTORS, CORDS, AND PLUGS

- A. Administrant for Electrical Power Tests and Inspections:
1. **[Owner][Tenant]** will engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
 2. Engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
 4. Administer and perform tests and inspections **[with assistance of factory-authorized service representative]**.
- B. Acceptance Testing Preparation:
1. **<Insert requirements>**.
- C. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.
- D. Tests and Inspections:
1. Perform tests and inspections indicated in manufacturer's published instructions.
 2. **<Insert Project-specific test or inspection>**.
- E. Nonconforming Work:
1. Unit will be considered defective if it does not pass tests and inspections.
 2. Remove and replace defective units and retest.
- F. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.
- G. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.
1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.

3.16 SYSTEM STARTUP FOR SWITCHES

- A. Perform startup service.
1. Complete installation and startup checks in accordance with manufacturer's published instructions.
 2. **<Insert startup steps if any>**.

- B. Manufacturer Services: Engage factory-authorized service representative to [support][supervise] system startup.
 - 1. Manufacturer's Field Reports for System Startup Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.

3.17 ADJUSTING

- A. Occupancy Adjustments for Controlled Receptacles: When requested within [12]<Insert number> months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to [two]<Insert number> visits to the Project during other-than-normal occupancy hours for this purpose.
- B. Cord Reels and Fittings: Adjust spring mechanisms and moving parts of cord reels and fittings to function smoothly, and lubricate as recommended in writing by manufacturer.

3.18 PROTECTION

- A. Devices:
 - 1. Schedule and sequence installation to minimize risk of contamination of wires and cables, devices, device boxes, outlet boxes, covers, and cover plates by plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other materials.
 - 2. After installation, protect wires and cables, devices, device boxes, outlet boxes, covers, and cover plates from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.
- B. Cord Reels and Fittings:
 - 1. After installation, protect cord reels and fittings from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.
- C. Connectors, Cords, and Plugs:
 - 1. After installation, protect connectors, cords, and plugs from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 26 27 26 00

SECTION 26 27 26 00A - GENERAL-USE SWITCHES, DIMMER SWITCHES, AND FAN-SPEED CONTROLLER SWITCHES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. General-use switches.
2. General-use dimmer switches.
3. General-use fan-speed controller switches.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies temperature, humidity, acoustical, and other field conditions applicable to the Work specified in this Section.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies seismic hazard, wind hazard, and other structural load design conditions applicable to the Work specified in this Section.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional coordination, scheduling, sequencing, submittal, and installation requirements applicable to the Work for electrical, communications, and electronic safety and security systems on Project, including wiring methods.
4. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs referenced by this Section.
5. Section 260923 "Lighting Control Devices" specifies occupancy sensors, timers, control-voltage switches, and control-voltage dimmers referenced by this Section.
6. Section 260936 "Modular Dimming Controls" specifies multiscene and multipreset dimming controls referenced by this Section.
7. Section 260943.16 "Addressable Luminaire Lighting Controls" specifies network lighting control solid-state devices referenced by this Section.
8. Section 260943.23 "Relay-Based Lighting Controls" specifies network lighting control relay devices referenced by this Section.
9. Section 270528 "Pathways for Communications Systems"[and **Section 271100 "Communications Equipment Room Fittings"**] specifies additional requirements for raceway materials, routing, locations, and identification of communications equipment and cabling.

1.2 DEFINITIONS

- A. Type I Dimmer: Dimmer in which air-gap switch is used to energize preset lighting levels.
- B. Type II Dimmer: Dimmer with air-gap switch that opens and closes load circuit at minimum output voltage setting only.
- C. Type IIa Dimmer: Dimmer with air-gap switch that opens and closes load circuit at maximum output voltage setting only.
- D. Type III Dimmer: Dimmer incorporating solid-state components providing preestablished rectified output settings.

- E. Type IV Dimmer: Dimmer not covered by UL 1472 Types I through III.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing agency, certifying product's compliance with specified listing criteria.
 - a. If listed manufacturer differs from selling manufacturer, indicate relationship between entities on submittal. Clearly indicate which entity warrants product performance and fitness for purpose.
 - b. Listing criteria identified in approval letter must match specified listing criteria. UL label indicating approval of equipment's enclosure is not considered approval of equipment for intended application.
 - c. Product identification in approval letter must match product branding and model numbers in submittal. Approval letters for discontinued or superseded products are not acceptable for submitted product.
 - 2. Include manufacturer's sample extended warranty language.
- B. Samples: For each type of product requiring samples for source quality control.
- C. Sustainable Design Submittals:
 - 1. Product data for sustainable design features for each type of product.
 - 2. Lighting Control Documentation: Floor plans indicating the following information:
 - a. As-installed locations of switches and dimmers.
 - b. Lighting zones and control strategy for each switch or dimmer, including unoccupied time-delay setting for shut-off and override time-delay setting for shut-off.
 - c. Multilevel or dimming range capability for each switch or dimmer.
 - d. Which switches or dimmers are operated by occupancy sensors, vacancy sensors, daylighting sensors, or time clocks.
- D. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

- A. Manufacturer's published instructions.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Extra stock material.

1.6 QUALIFICATIONS

- A. Electrical Power Testing (EPT) Technician III: Possessing active NICET EPT Level III certification. Able to manage switching procedures; conduct tests of complex equipment; analyze test and equipment

data; plan a job; and lead a team. Has experience performing NFPA 70B, IEEE, and NETA electrical tests.

- B. Electrical Power Testing (EPT) Technician IV: Possessing active NICET EPT Level IV certification. Able to conduct tests of complex metering and relay systems; evaluate tests, test equipment, test results, and power system performance; recommend actions to maintain or improve system performance; and lead multi-team projects.
- C. Electrical Power Testing and Inspecting Agency: Entities possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
 - 1. On-site electrical testing supervisors must possess active NICET EPT Technician [III][IV] certification.

PART 2 - PRODUCTS

2.1 EXISTING PRODUCTS TO BE MODIFIED

- A. Basis for Pricing: **<Insert name of manufacturer; model number or series for existing product>.**
- B. Description: **<Insert description of existing product, including special features, options, and finishes that may impact Work>.**
- C. Accessories: **<Insert accessories included with existing product>.**

2.2 EXISTING PRODUCTS TO BE REMOVED AND REINSTALLED

- A. Basis for Pricing: **<Insert name of manufacturer; model number or series for existing product>.**
- B. Description: **<Insert description of existing product, including special features, options, and finishes that may impact Work>.**
- C. Accessories: **<Insert accessories included with existing product>.**

2.3 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2.4 GENERAL-USE SWITCHES

- A. Description: Snap switches intended for mounting in device boxes.
- B. Source Quality Control:
 - 1. Samples for Initial Selection: One for each kind of general-use switch[**and cover plate accessory**] in each specified rating, size, finish, and color.

C. Toggle Switch :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: UL CCN WMUZ and UL 20.
5. Standard Features:
 - a. Device Color: **[Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].**
 - b. Configuration:
 - 1) General-duty, 120-277 V, 15 A, **[single pole][double pole][three way][four way].**
 - 2) General-duty, 120-277 V, 20 A, **[single pole][double pole][three way][four way].**
 - 3) Extra-heavy-duty, 120-277 V, 15 A, **[single pole][double pole][three way][four way].**
 - 4) Extra-heavy-duty, 120-277 V, 20 A, **[single pole][double pole][three way][four way].**
 - 5) Extra-heavy-duty, 120-277 V, 30 A, **[single pole][double pole][three way].**
6. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard

- development organization, is publicly available for product.
- e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
7. Accessories:
- a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- D. Toggle Switch with Pilot Light :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: UL CCN WMUZ and UL 20.
 5. Standard Features:
 - a. Device Color: **[Ivory][Red][Clear]**.
 - b. Configuration:
 - 1) Illuminated when load off, 120-277 V, 15 A, **[single pole][three way]**.
 - 2) Illuminated when load off, 120-277 V, 20 A, **[single pole][three way]**.
 - 3) Illuminated when load on, 120-277 V, 15 A, **[single pole][double pole][three way]**.
 - 4) Illuminated when load on, 120-277 V, 20 A, **[single pole][double pole][three way]**.
 - 5) Illuminated when load on, 120-277 V, 30 A, **[single pole][double pole]**.
 6. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.



- c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
- d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
- e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

7. Accessories:

- a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
- b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

E. Toggle Switch with Forked Key Lock :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: UL CCN WMUZ and UL 20.
5. Standard Features:
 - a. Device Color: **[Ivory][White][Gray][Black][As indicated on architectural Drawings].**
 - b. Configuration:
 - 1) 120-277 V, 15 A, **[single pole][double pole][three way][four way].**
 - 2) 120-277 V, 20 A, **[single pole][double pole][three way][four way].**
 - 3) 120-277 V, 30 A, **[single pole][double pole].**
6. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability

- report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
- b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
- c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
- d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
- e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

F. Toggle Switch with Barrel Key Lock :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: UL CCN WMUZ and UL 20.
5. Standard Features:
 - a. Configuration: 120-277 V, 20 A, **[single pole][single pole, key removable in off position only][double pole][three way][four way]**.
6. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.

**General-Use Switches, Dimmer Switches, and Fan-Speed
Controller Switches**



- d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
- e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

G. Maintained-Contact, Center-Off, Toggle Switch :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: UL CCN WMUZ and UL 20.
5. Standard Features:
 - a. Device Color: **[Ivory][White][Brown][As indicated on architectural Drawings].**
 - b. Configuration:
 - 1) Single pole, double throw, 120-277 V, **[15 A][20 A].**
 - 2) Double pole, double throw, 120-277 V, **[15 A][20 A][30 A].**
6. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.

- e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
- H. Momentary-Contact, Center-Off, Toggle Switch :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: UL CCN WMUZ and UL 20.
 5. Standard Features:
 - a. Device Color: **[Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].**
 - b. Configuration: Single pole, double throw, 120-277 V, **[15 A][20 A].**
 6. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
- I. Momentary-Contact, Center-Off, Toggle Switch with Forked Key Lock :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: UL CCN WMUZ and UL 20.
 5. Standard Features:
 - a. Device Color: **[Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings]**.
 - b. Configuration: Single pole, double throw, 120-277 V, **[15 A][20 A]**.
 6. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
- J. Rocker Switch :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: UL CCN WMUZ and UL 20.
5. Standard Features:
- a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - b. Configuration:
 - 1) 120-277 V, 15 A, [single pole][three way][four way].
 - 2) 120-277 V, 20 A, [single pole][double pole][three way][four way].
6. Sustainable Design Features:
- a. Corporate Sustainability Report: Provide [third-party-verified]corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
7. Accessories:
- a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

K. Rocker Switch with Nightlight :

1. Manufacturers: Subject to compliance with requirements, [provide products by the
General-Use Switches, Dimmer Switches, and Fan-Speed

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

- a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: UL CCN WMUZ and UL 20.
5. Standard Features:
- a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - b. Configuration: 120-277 V, 20 A, [single pole][three way][four way].
6. Sustainable Design Features:
- a. Corporate Sustainability Report: Provide [third-party-verified]corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
7. Accessories:
- a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

L. Rocker Switch with Pilot Light :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: UL CCN WMUZ and UL 20.
5. Standard Features:
 - a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - b. Configuration:
 - 1) Illuminated when load on, 120-277 V, 20 A, [single pole][three way].
 - 2) Illuminated when load off, 120-277 V, 20 A, [single pole].
6. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide [third-party-verified]corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
7. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.

**General-Use Switches, Dimmer Switches, and Fan-Speed
Controller Switches**



- b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

2.5 GENERAL-USE DIMMER SWITCHES

- A. Description: Line-voltage dimmers intended for mounting in flush device boxes or on outlet box covers (wall box).
- B. Source Quality Control:
1. Samples for Initial Selection: One for each kind of general-use dimmer switch[**and cover plate accessory**] in each specified rating, size, finish, and color.
- C. Type I Dimmer Switch :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[GE Lighting; a Savant Company]**
 - c. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - d. **[Leviton Manufacturing Co., Inc.]**
 - e. **[Lutron Electronics Co., Inc]**
 - f. **[Pass & Seymour; Legrand North America, LLC]**
 - g. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[GE Lighting; a Savant Company]**
 - c. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - d. **[Leviton Manufacturing Co., Inc.]**
 - e. **[Lutron Electronics Co., Inc]**
 - f. **[Pass & Seymour; Legrand North America, LLC]**
 - g. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: UL CCN EOYX and UL 1472.
 5. Standard Features:
 - a. UL 1472 Type I dimmer.
 - b. Device Color: **[Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].**
 - c. Switch Style: **[Toggle][Rocker][Push-button].**
 - d. Dimming Control Style: **[Slide][Rotary].**

6. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

7. Accessories:

- a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
- b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

D. Type II Dimmer Switch :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[GE Lighting; a Savant Company]**
 - c. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - d. **[Leviton Manufacturing Co., Inc.]**
 - e. **[Lutron Electronics Co., Inc]**
 - f. **[Pass & Seymour; Legrand North America, LLC]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[GE Lighting; a Savant Company]**
 - c. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - d. **[Leviton Manufacturing Co., Inc.]**
 - e. **[Lutron Electronics Co., Inc]**
 - f. **[Pass & Seymour; Legrand North America, LLC]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: UL CCN EOYX and UL 1472.
5. Standard Features:



- a. UL 1472 Type II dimmer.
- b. Switch Style: Air-gap switch at dimmer control end of travel at minimum output voltage.
- c. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
- d. Dimming Control Style: [Slide][Rotary].

6. Sustainable Design Features:

- a. Corporate Sustainability Report: Provide [third-party-verified]corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
- b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
- c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
- d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
- e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

7. Accessories:

- a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
- b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

E. Type IIa Dimmer Switch :

- 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [GE Lighting; a Savant Company]
 - c. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - d. [Leviton Manufacturing Co., Inc.]
 - e. [Lutron Electronics Co., Inc]
 - f. [Pass & Seymour; Legrand North America, LLC]
 - g. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [GE Lighting; a Savant Company]
 - c. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - d. [Leviton Manufacturing Co., Inc.]

- e. [Lutron Electronics Co., Inc]
 - f. [Pass & Seymour; Legrand North America, LLC]
 - g. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: UL CCN EOYX and UL 1472.
 5. Standard Features:
 - a. UL 1472 Type IIa dimmer.
 - b. Switch Style: Air-gap switch at dimmer control end of travel at maximum output voltage.
 - c. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - d. Dimming Control Style: [Slide][Rotary].
 6. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide [third-party-verified]corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
 7. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- F. Type III Dimmer Switch :
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [GE Lighting; a Savant Company]
 - c. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - d. [Leviton Manufacturing Co., Inc.]
 - e. [Lutron Electronics Co., Inc]
 - f. [Pass & Seymour; Legrand North America, LLC]
 - g. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the

**General-Use Switches, Dimmer Switches, and Fan-Speed
Controller Switches**

following:

- a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[GE Lighting; a Savant Company]**
 - c. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - d. **[Leviton Manufacturing Co., Inc.]**
 - e. **[Lutron Electronics Co., Inc]**
 - f. **[Pass & Seymour; Legrand North America, LLC]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: UL CCN EOYX and UL 1472.
 5. Standard Features:
 - a. UL 1472 Type III dimmer.
 - b. Device Color: **[Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].**
 - c. Switch Style: **[Momentary toggle][Momentary rocker][Push-button].**
 - d. Dimming Control Style: **[Momentary toggle][Momentary rocker][Push-button].**
 - e. Network connection to provide programmable presets, scenes, and time-clock.
 6. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
 7. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- G. Type IV Dimmer Switch :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **<Insert, in separate subparagraphs, manufacturer's name>.**

2. Source Limitations: Obtain products from single manufacturer.
3. Listing Criteria: UL CCN EOYX and UL 1472.
4. Standard Features:
 - a. UL 1472 Type IV dimmer.
 - b. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
5. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
6. Other Available Features Required by Project:
 - a. Switch Style: **<Insert characteristics>**.
 - b. Dimming Control Style: **<Insert characteristics>**.
 - c. **<Insert other characteristics>**.
7. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

2.6 GENERAL-USE FAN-SPEED CONTROLLER SWITCHES

- A. Description: Semiconductor, capacitive-type, and inductive-type fan-speed controllers for regulating speed of fan motor, including starting and stopping of fan motor, intended for mounting in flush device boxes or on outlet box covers (wall box).
- B. Source Quality Control:
 1. Samples for Initial Selection: One for each kind of general-use fan-speed controller switch[**and cover plate accessory**] in each specified rating, size, finish, and color.
- C. Air-Gap Fan-Speed Controller Switch :
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the**

following]:

- a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: UL CCN GQHG and UL 1917.
5. Standard Features:
- a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
6. Sustainable Design Features:
- a. Corporate Sustainability Report: Provide [third-party-verified]corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
7. Accessories:
- a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- D. Solid-State Fan-Speed Controller Switch :
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering

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

- a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. <Insert manufacturer's name>
 3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: UL CCN GQHG and UL 1917.
 5. Standard Features:
 - a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 6. Sustainable Design Features:
 - a. Corporate Sustainability Report: Provide [third-party-verified]corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
 7. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

2.7 MAINTENANCE MATERIAL ITEMS

- A. Extra Stock Material: Furnish to Owner extra materials[, **from same production run,**] that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.[**Include the following:**]
 1. Extra Keys for Key Lock Switches: [One]<Insert number> of each kind.

**General-Use Switches, Dimmer Switches, and Fan-Speed
Controller Switches**



PART 3 - EXECUTION**3.1 INSTALLATION**

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:
 - 1. Electrical Construction: ICC IBC, ICC IFB, NFPA 1, NFPA 70, and NECA NEIS 1.
 - 2. Electrical Safety: NFPA 70E.
 - 3. Life Safety and Means of Egress Work: NFPA 101.
 - 4. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
 - 5. Wiring Devices: NECA NEIS 130.
 - 6. Mounting Heights: NECA NEIS 1.
 - 7. Consult Architect for resolution of conflicting requirements.
- C. Identification:
 - 1. Identify cover or cover plate for device with panelboard identification and circuit number.
 - a. Mark cover or cover plate using hot, stamped, or engraved machine printing with **[black][white][red]**-filled lettering, and provide durable wire markers or tags inside device box or outlet box.
 - b. Healthcare Facilities: Distinctively identify covers or cover plates of device boxes and outlet boxes that are supplied from life safety and critical branch power supplies following facility's standard practice.
- D. Interfaces with Other Work:
 - 1. Coordinate installation of new products for **<Insert system or product group>** with existing conditions.
 - a. **<Insert requirements for transition between new and existing>**.
 - 2. Coordinate with **<Insert Section number and title>** for **<Insert description of interfacing related Work>**.
 - a. **<Insert requirements for transition between this Section and related Work>**.

3.2 FIELD QUALITY CONTROL

- A. Adminstrant for Electrical Power Tests and Inspections:
 - 1. **[Owner][Tenant]** will engage qualified medium-voltage electrical testing and inspecting agency to administer and perform tests and inspections.
 - 2. Engage qualified medium-voltage electrical testing and inspecting agency to administer and perform tests and inspections.
 - 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
 - 4. Administer and perform tests and inspections[**with assistance of factory-authorized service**

representative].

- B. Acceptance Testing Preparation:
 - 1. **<Insert requirements>.**
- C. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>.**
- D. Tests and Inspections:
 - 1. Perform manufacturer's recommended tests and inspections.
 - 2. **<Insert tests and inspections>.**
- E. Nonconforming Work:
 - 1. Unit will be considered defective if it does not pass tests and inspections.
 - 2. Remove and replace defective units and retest.
- F. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.
- G. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.
 - 1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at Project site.

3.3 SYSTEM STARTUP

- A. Perform startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's published instructions.
 - 2. **<Insert startup steps if any>.**
- B. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** system startup.
 - 1. Manufacturer's Field Reports for System Startup Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at Project site.

3.4 PROTECTION

- A. Schedule and sequence installation to minimize risk of contamination of wires and cables, devices, device boxes, outlet boxes, covers, and cover plates by plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other materials.
- B. After installation, protect wires and cables, devices, device boxes, outlet boxes, covers, and cover plates from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.



26 - Electrical

END OF SECTION 26 27 26 00A

SECTION 26 27 26 00B - GENERAL-GRADE SINGLE STRAIGHT-BLADE RECEPTACLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Single straight-blade receptacles for plugs and attachment plugs.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. Section 260526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding referenced by this Section.
5. Section 260533.16 "Boxes and Covers for Electrical Systems" specifies covers and cover plates referenced by this Section.
6. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs referenced by this Section.
7. Section 262726.33 "General-Grade Duplex Straight-Blade Receptacles" for duplex receptacles.
8. Section 262726.35 "Hospital-Grade Straight-Blade Receptacles" for hospital-grade receptacles.
9. Section 262726.37 "Receptacles with Arc-Fault and Ground-Fault Protective Devices" for AFCI and GFCI receptacles.
10. Section 262726.39 "Locking Receptacles" for locking receptacles.
11. Section 262726.41 "Pin-and-Sleeve Receptacles" for pin-and-sleeve receptacles.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing agency, certifying product's compliance with specified listing criteria.
 - a. If listed manufacturer differs from selling manufacturer, indicate relationship between entities on submittal. Clearly indicate which entity warrants product performance and fitness for purpose.
 - b. Listing criteria identified in approval letter must match specified listing criteria. UL label indicating approval of equipment's enclosure is not considered approval of equipment for intended application.
 - c. Product identification in approval letter must match product branding and model numbers in submittal. Approval letters for discontinued or superseded products are unacceptable for submitted product.

- B. Samples: One for each kind of single straight-blade receptacle[**and cover plate accessory**] specified, in each finish and color specified.

- C. Field quality-control reports.

1.3 INFORMATIONAL SUBMITTALS

- A. Manufacturer's published instructions.
- B. Field Reports:
 - 1. Manufacturer's field reports for field quality-control support.

1.4 QUALIFICATIONS

- A. Electrical Power Testing (EPT) Technician III: Possessing active NICET EPT Level III certification. Able to manage switching procedures, conduct tests of complex equipment, analyze test and equipment data, plan a job, and lead a team. Has experience performing NFPA 70B, IEEE, and NETA electrical tests.
- B. Electrical Power Testing (EPT) Technician IV: Possessing active NICET EPT Level IV certification. Able to conduct tests of complex metering and relay systems; evaluate tests, test equipment, test results, and power system performance; recommend actions to maintain or improve system performance; and lead multi-team projects.
- C. Electrical Power Testing and Inspecting Agency: Entities possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
 - 1. On-site electrical testing supervisors must possess active NICET EPT Technician [III][IV] certification.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2.2 SINGLE STRAIGHT-BLADE RECEPTACLES FOR PLUGS AND ATTACHMENT PLUGS

- A. Single Straight-Blade Receptacle :
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**

- d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 4. Standard Features:
 - a. Device Color: **[Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].**
 - b. Configuration:
 - 1) General-duty, **[NEMA 5-15R][NEMA 5-20R][NEMA 5-30R][NEMA 5-50R].**
 - 2) General-duty, smooth face, **[NEMA 5-15R][NEMA 5-20R].**
 - 3) General-duty, **[NEMA 6-15R][NEMA 6-20R][NEMA 6-30R][NEMA 6-50R].**
 - 4) General-duty, smooth face, NEMA 6-20R.
 - 5) General-duty, **[NEMA 14-30R (Dryer)][NEMA 14-50R (Range)].**
 - 6) Heavy-duty, **[NEMA 5-30R][NEMA 5-50R].**
 - 7) Heavy-duty, **[NEMA 6-30R][NEMA 6-50R].**
 - 8) Heavy-duty, **[NEMA 7-20R][NEMA 7-30R][NEMA 7-50R].**
 - 9) Heavy-duty, **[NEMA 14-20R][NEMA 14-30R (Dryer)][NEMA 14-50R (Range)][NEMA 14-60R].**
 - 10) Heavy-duty, **[NEMA 15-20R][NEMA 15-30R][NEMA 15-50R][NEMA 15-60R].**
 - 11) Heavy-duty, **[NEMA 18-20R][NEMA 18-30R][NEMA 18-50R][NEMA 18-60R].**
 - 12) Extra-heavy-duty, **[NEMA 5-15R][NEMA 5-20R].**
 - 13) Extra-heavy-duty, **[NEMA 6-15R][NEMA 6-20R].**
 5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
 6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- B. Tamper-Resistant Single Straight-Blade Receptacle :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering**



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

- a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
- a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
4. Standard Features:
- a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - b. Configuration:
 - 1) General-duty, [NEMA 5-15R][NEMA 5-20R].
 - 2) General-duty, smooth face, [NEMA 5-15R][NEMA 5-20R].
5. Other Available Features Required by the Project:
- a. Has factory-terminated connectors on wiring device pigtails for quick installation.
6. Accessories:
- a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- C. Weather-Resistant Single Straight-Blade Receptacle :
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]

- b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 4. Standard Features:
 - a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - b. Configuration: Heavy-duty, [NEMA 5-15R][NEMA 5-20R].
 5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
 6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- D. Isolated Ground Single Straight-Blade Receptacle :
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - b. [Leviton Manufacturing Co., Inc.]
 - c. [Pass & Seymour; Legrand North America, LLC]
 - d. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:



- a. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - b. [Leviton Manufacturing Co., Inc.]
 - c. [Pass & Seymour; Legrand North America, LLC]
 - d. <Insert manufacturer's name>
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
4. Standard Features:
 - a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - b. Configuration: Extra-Heavy-duty, [NEMA 5-15R][NEMA 5-20R].
5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

E. Weather-Resistant, Isolated Ground Single Straight-Blade Receptacle :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - b. [Leviton Manufacturing Co., Inc.]
 - c. [Pass & Seymour; Legrand North America, LLC]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - b. [Leviton Manufacturing Co., Inc.]
 - c. [Pass & Seymour; Legrand North America, LLC]
 - d. <Insert manufacturer's name>
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

- a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 4. Standard Features:
 - a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - b. Configuration:
 - 1) Heavy-duty, NEMA 5-30R.
 - 2) Heavy-duty, NEMA 6-30R.
 - 3) Extra-heavy-duty, [NEMA 5-15R][NEMA 5-20R].
 - 4) Extra-heavy-duty, [NEMA 6-15R][NEMA 6-20R].
 5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
 6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- F. Tamper-Resistant, Clock Hanger Straight-Blade Receptacle :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - b. [Pass & Seymour; Legrand North America, LLC]
 - c. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - b. [Pass & Seymour; Legrand North America, LLC]
 - c. <Insert manufacturer's name>
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 4. Standard Features:
 - a. Finish: [White nylon][Ivory nylon][Brass][Stainless steel][Brushed brass][Nickel plated].
 - b. Configuration: Recessed, smooth wallplate; [NEMA 5-15R][NEMA 5-20R].



5. Other Available Features Required by the Project:

- a. Has factory-terminated connectors on wiring device pigtails for quick installation.

G. Tamper-Resistant, Floor-Mounted Display Straight-Blade Receptacle :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Pass & Seymour; Legrand North America, LLC]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Pass & Seymour; Legrand North America, LLC]**
 - c. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
4. Standard Features:
 - a. Configuration: NEMA 5-15R.
 - b. Finish: **[Brushed brass][Nickel plated]**.
5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.

H. Tamper-Resistant, Pop-Up Countertop Straight-Blade Receptacle :

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

- a. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **<Insert manufacturer's name>**
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 4. Standard Features:
 - a. Finish: **[Brushed aluminum][Brushed brass][Brushed nickel][Polished chrome][Bronze matte powder coat][Black matte powder coat][White matte powder coat]**.
 - b. Configuration:
 - 1) Surface Mount: **[NEMA 5-15R][NEMA 5-20R]**.
 - 2) Flush Mount: **[NEMA 5-15R][NEMA 5-20R]**.
 5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
- I. Tamper-Resistant, Pop-Out Wall Straight-Blade Receptacle :
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Pass & Seymour; Legrand North America, LLC]**
 - b. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Pass & Seymour; Legrand North America, LLC]**
 - b. **<Insert manufacturer's name>**
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 4. Standard Features:
 - a. Color: **[White][Magnesium][Graphite]**.
 - b. Configuration:
 - 1) 1-Gang; **[three single NEMA 5-15R][two single NEMA 5-20R]**.
 - 2) 2-Gang; three single NEMA 5-15R, with space in enclosure for additional device.



5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that receptacles to be procured and installed for Owner-furnished equipment are compatible with mating attachment plugs on equipment.

3.2 INSTALLATION OF GENERAL-GRADE SINGLE STRAIGHT-BLADE RECEPTACLES

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:
 1. Electrical Construction: ICC IBC, ICC IFB, NFPA 1, NFPA 70, and NECA NEIS 1.
 2. Electrical Safety: NFPA 70E.
 3. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
 4. Work in ITE Rooms: NFPA 75.
 5. Work in Health Care Facilities: NFPA 99 and Article 517 of NFPA 70.
 6. Work in Confined Spaces: NFPA 350.
 7. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
 8. Installing and Maintaining Wiring Devices: NECA NEIS 130.
 9. Mounting Heights: Unless otherwise indicated in Contract Documents, comply with mounting heights recommended in NECA NEIS 1.
 10. Receptacle Orientation: Unless otherwise indicated in Contract Documents, orient receptacle to match configuration diagram in NEMA WD 6.
 11. Consult Architect for resolution of conflicting requirements.
- C. Interfaces with Other Work:
 1. Identification: Provide labels for receptacles and associated electrical equipment.
 - a. Identify field-installed conductors, interconnecting wiring, and components.
 - b. Label each enclosure with engraved metal or laminated-plastic nameplate.
 - 1) Identify cover or cover plate for device with panelboard identification and circuit number.
 - 2) Mark cover or cover plate using hot, stamped, or engraved machine printing with [black][white][red]-filled lettering, and provide durable wire markers or tags inside device box or outlet box.
 - c. Provide warning signs and arc-flash hazard warning labels for electrical equipment.
 - d. Healthcare Facilities: Distinctively identify covers or cover plates of device boxes and outlet boxes that are supplied from life safety and critical branch power supplies following facility's standard practice.
 2. Do not install Type 3 SPD, including surge-protected relocatable taps and power strips, on branch

3. circuit downstream of GFCI device.
3. Coordinate installation of new products for **<Insert system or product group>** with existing conditions.
 - a. **<Insert requirements for transition between new and existing>**.
4. Coordinate with **<Insert Section number and title>** for **<Insert description of interfacing related Work>**.
 - a. **<Insert requirements for transition between this Section and related Work>**.

3.3 FIELD QUALITY CONTROL

- A. Administrant for Electrical Power Tests and Inspections:
 1. **[Owner][Tenant]** will engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
 2. Engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
 4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].
- B. Acceptance Testing Preparation:
 1. **<Insert requirements>**.
- C. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.
- D. Tests and Inspections:
 1. Insert and remove test plug to verify that device is securely mounted.
 2. Verify polarity of hot and neutral pins.
 3. Measure line voltage.
 4. Measure percent voltage drop.
 5. Measure grounding circuit continuity; impedance must be not greater than 2 ohms.
 6. Healthcare Facilities: Test straight-blade receptacles in patient care spaces with receptacle pin tension test instrument in accordance with NFPA 99. Retention force of ground pin must be not less than 115 g (4 oz).
 7. Perform additional installation and maintenance inspections and diagnostic tests in accordance with NECA NEIS 130 and manufacturers' published instructions.
 8. **<Insert tests and inspections>**.
- E. Nonconforming Work:
 1. Device will be considered defective if it does not pass tests and inspections.
 2. Remove and replace defective units and retest.
- F. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.
- G. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.



1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.

3.4 PROTECTION

- A. Schedule and sequence installation to minimize risk of contamination of wires and cables, devices, device boxes, outlet boxes, covers, and cover plates by plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other materials.
- B. After installation, protect wires and cables, devices, device boxes, outlet boxes, covers, and cover plates from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 26 27 26 00B

SECTION 26 27 26 00C - GENERAL-GRADE DUPLEX STRAIGHT-BLADE RECEPTACLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Duplex straight-blade receptacles.
2. Duplex straight-blade receptacles with integral switching means.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. Section 260526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding referenced by this Section.
5. Section 260533.16 "Boxes and Covers for Electrical Systems" specifies covers and cover plates referenced by this Section.
6. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs referenced by this Section.
7. Section 262726.31 "General-Grade Single Straight-Blade Receptacles" for single receptacles.
8. Section 262726.35 "Hospital-Grade Straight-Blade Receptacles" for hospital-grade receptacles.
9. Section 262726.37 "Receptacles with Arc-Fault and Ground-Fault Protective Devices" for AFCI and GFCI receptacles.
10. Section 262726.39 "Locking Receptacles" for twist-locking receptacles.
11. Section 262726.41 "Pin-and-Sleeve Receptacles" for pin-and-sleeve receptacles.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing agency, certifying product's compliance with specified listing criteria.
 - a. If listed manufacturer differs from selling manufacturer, indicate relationship between entities on submittal. Clearly indicate which entity warrants product performance and fitness for purpose.
 - b. Listing criteria identified in approval letter must match specified listing criteria. UL label indicating approval of equipment's enclosure is not considered approval of equipment for intended application.
 - c. Product identification in approval letter must match product branding and model numbers in submittal. Approval letters for discontinued or superseded products are unacceptable for submitted product.
2. Include manufacturer's sample extended warranty language.

- B. Samples:
 - 1. One for each kind of duplex straight-blade receptacle[**and cover plate accessory**] specified, in each finish and color specified.
 - 2. One for each kind of duplex straight-blade receptacle with integral switching means[**and cover plate accessory**] specified, in each finish and color specified.
- C. Shop Drawings:
 - 1. Wiring diagrams for duplex straight-blade receptacles with integral switching means.
- D. Sustainable Design Submittals:
 - 1. Record floor plan Drawings indicating as-installed locations of uncontrolled and marked controlled receptacles superimposed on office furniture layout, to verify extent of ability of the installed Work to provide each occupant ability to select at least one uncontrolled receptacle and at least one controlled receptacle for powering workspace equipment. Indicate locations of UL-approved relocatable power taps and power strips, indicating means of securing protection from damage and accessibility for inspection. Indicate locations of temporary extension cords, indicating plan for replacing them with permanent wiring within 90 days.
- E. Field quality-control reports.

1.3 INFORMATIONAL SUBMITTALS

- A. Manufacturer's published instructions.
- B. Field Reports:
 - 1. Manufacturer's field reports for field quality-control support.

1.4 CLOSEOUT SUBMITTALS

- A. Warranty documentation.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Extra stock material.
- B. Special tools.

1.6 QUALIFICATIONS

- A. Electrical Power Testing (EPT) Technician III: Possessing active NICET EPT Level III certification. Able to manage switching procedures, conduct tests of complex equipment, analyze test and equipment data, plan a job, and lead a team. Has experience performing NFPA 70B, IEEE, and NETA electrical tests.
- B. Electrical Power Testing (EPT) Technician IV: Possessing active NICET EPT Level IV certification. Able to conduct tests of complex metering and relay systems; evaluate tests, test equipment, test results, and

power system performance; recommend actions to maintain or improve system performance; and lead multi-team projects.

- C. Electrical Power Testing and Inspecting Agency: Entities possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
1. On-site electrical testing supervisors must possess active NICET EPT Technician [III][IV] certification.

1.7 WARRANTY

- A. Special Manufacturer Extended Warranty: Manufacturer warrants that devices perform in accordance with specified requirements and agrees to provide repair or replacement of devices that fail to perform as specified within extended warranty period.
1. Initial Extended Warranty Period: **[Three][Four][Five]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for labor, materials, and equipment.
 2. Follow-On Extended Warranty Period: **[Eight]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for materials only, free on board **[origin][destination]**, freight prepaid.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2.2 DUPLEX STRAIGHT-BLADE RECEPTACLES

- A. Duplex Straight-Blade Receptacle :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell**

- c. **Incorporated]**
[Leviton Manufacturing Co., Inc.]
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
- 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 - b. Surge Protective Devices: UL 1449, Type 3.
- 4. Standard Features:
 - a. Device Color: **[Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].**
 - b. Configuration:
 - 1) General-duty, **[NEMA 5-15R][NEMA 5-20R].**
 - 2) General-duty, smooth face, **[NEMA 5-15R][NEMA 5-20R].**
 - 3) General-duty, **[NEMA 6-15R][NEMA 6-20R].**
 - 4) General-duty, smooth face, **[NEMA 6-15R][NEMA 6-20R].**
 - 5) Heavy-duty, **[NEMA 5-15R][NEMA 5-20R].**
 - 6) Heavy-duty, smooth face, **[NEMA 5-15R][NEMA 5-20R].**
 - 7) Heavy-duty, **[NEMA 6-15R][NEMA 6-20R].**
 - 8) Heavy-duty, smooth face, **NEMA 6-15R.**
 - 9) Heavy-duty, **NEMA 7-15R.**
 - 10) Extra-heavy-duty, **[NEMA 5-15R][NEMA 5-20R].**
 - 11) Extra-heavy-duty, smooth face, **[NEMA 5-15R][NEMA 5-20R].**
 - 12) Extra-heavy-duty, **[NEMA 6-15R][NEMA 6-20R].**
 - 13) Extra-heavy-duty, smooth face, **[NEMA 6-15R][NEMA 6-20R].**
- 5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
- 6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- B. Nightlight-Type, Lighted Duplex Straight-Blade Receptacle :
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Leviton Manufacturing Co., Inc.]**
 - b. **[Pass & Seymour; Legrand North America, LLC]**
 - c. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert**

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

- a. **[Leviton Manufacturing Co., Inc.]**
 - b. **[Pass & Seymour; Legrand North America, LLC]**
 - c. **<Insert manufacturer's name>**
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 - b. Surge Protective Devices: UL 1449, Type 3.
 4. Standard Features:
 - a. Device Color: **[Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].**
 - b. Configuration: General-duty, **[NEMA 5-15R][NEMA 5-20R].**
 5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
 6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- C. Tamper-Resistant Duplex Straight-Blade Receptacle :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**

3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 - b. Surge Protective Devices: UL 1449, Type 3.
4. Standard Features:
 - a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - b. Configuration:
 - 1) General-duty, [NEMA 5-15R][NEMA 5-20R].
 - 2) General-duty, smooth face, [NEMA 5-15R][NEMA 5-20R].
 - 3) Heavy-duty, [NEMA 5-15R][NEMA 5-20R].
 - 4) Heavy-duty, smooth face, [NEMA 5-15R][NEMA 5-20R].
 - 5) Extra-heavy-duty, [NEMA 5-15R][NEMA 5-20R].
5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

D. Recessed, Tamper-Resistant Duplex Straight-Blade Receptacle :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>

3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 - b. Surge Protective Devices: UL 1449, Type 3.
 4. Standard Features:
 - a. Device Color: **[Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].**
 - b. Configuration:
 - 1) General-duty, **[NEMA 5-15R][NEMA 5-20R].**
 - 2) General-duty, smooth face, **[NEMA 5-15R][NEMA 5-20R].**
 5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
 6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- E. Weather-Resistant Duplex Straight-Blade Receptacle :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:



- a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
- b. Surge Protective Devices: UL 1449, Type 3.

4. Standard Features:

- a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
- b. Configuration:
 - 1) General-duty, [NEMA 5-15R][NEMA 5-20R].
 - 2) Heavy-duty, [NEMA 5-15R][NEMA 5-20R].
 - 3) Heavy-duty, smooth face, [NEMA 5-15R][NEMA 5-20R].
 - 4) Extra-heavy-duty, [NEMA 5-15R][NEMA 5-20R].

5. Other Available Features Required by the Project:

- a. Has factory-terminated connectors on wiring device pigtails for quick installation.

6. Accessories:

- a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
- b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

F. Weather-Resistant, Tamper-Resistant Duplex Straight-Blade Receptacle :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.

- b. Surge Protective Devices: UL 1449, Type 3.
 4. Standard Features:
 - a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - b. Configuration:
 - 1) General-duty, [NEMA 5-15R][NEMA 5-20R].
 - 2) General-duty, smooth face, [NEMA 5-15R][NEMA 5-20R].
 - 3) Heavy-duty, smooth face, [NEMA 5-15R][NEMA 5-20R].
 5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
 6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- G. Isolated Ground Duplex Straight-Blade Receptacle :
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Leviton Manufacturing Co., Inc.]**
 - c. **[Pass & Seymour; Legrand North America, LLC]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Leviton Manufacturing Co., Inc.]**
 - c. **[Pass & Seymour; Legrand North America, LLC]**
 - d. **<Insert manufacturer's name>**
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 - b. Surge Protective Devices: UL 1449, Type 3.
 4. Standard Features:
 - a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance



with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].

b. Configuration:

- 1) General-duty, [NEMA 5-15R][NEMA 5-20R].
- 2) General-duty, smooth face, [NEMA 5-15R][NEMA 5-20R].
- 3) Heavy-duty, [NEMA 5-15R][NEMA 5-20R].
- 4) Heavy-duty, smooth face, [NEMA 5-15R][NEMA 5-20R].
- 5) Extra-heavy-duty, [NEMA 5-15R][NEMA 5-20R].
- 6) Extra heavy-duty, [NEMA 6-15R][NEMA 6-20R].

5. Other Available Features Required by the Project:

a. Has factory-terminated connectors on wiring device pigtails for quick installation.

6. Accessories:

- a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
- b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

H. Tamper-Resistant, Isolated Ground Duplex Straight-Blade Receptacle :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Leviton Manufacturing Co., Inc.]**
 - c. **[Pass & Seymour; Legrand North America, LLC]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Leviton Manufacturing Co., Inc.]**
 - c. **[Pass & Seymour; Legrand North America, LLC]**
 - d. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 - b. Surge Protective Devices: UL 1449, Type 3.
4. Standard Features:
 - a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on

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6. Accessories:

- a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
- b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

J. Duplex Straight-Blade Receptacle with Type 3 Surge Protective Device :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 - b. Surge Protective Devices: UL 1449, Type 3.
4. Standard Features:
 - a. Device Color: **[Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].**
 - b. Configuration: Heavy-duty, smooth face, **[NEMA 5-15R][NEMA 5-20R].**
5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

K. Tamper-Resistant Duplex Straight-Blade Receptacle with Type 3 Surge Protective Device :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 - b. Surge Protective Devices: UL 1449, Type 3.
4. Standard Features:
 - a. Device Color: **[Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings]**.
 - b. Configuration: Heavy-duty, smooth face, **[NEMA 5-15R][NEMA 5-20R]**.
5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

L. Isolated Ground Duplex Straight-Blade Receptacle with Type 3 Surge Protective Device :

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



- a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 - b. Surge Protective Devices: UL 1449, Type 3.
4. Standard Features:
 - a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - b. Configuration: Heavy-duty, smooth face, [NEMA 5-15R][NEMA 5-20R].
5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- M. Tamper-Resistant Duplex Straight-Blade Receptacle with USB Outlet to Power Class 2 Equipment :
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 - b. Surge Protective Devices: UL 1449, Type 3.
4. Standard Features:
 - a. Device Color: **[Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].**
 - b. Configuration:
 - 1) General-duty, **[NEMA 5-15R][NEMA 5-20R]**; two USB-A ports.
 - 2) General-duty, **[NEMA 5-15R][NEMA 5-20R]**; two USB-C ports.
 - 3) General-duty, **[NEMA 5-15R][NEMA 5-20R]**; one USB-A port; one USB-C port.
 - 4) General-duty, smooth face, two USB-A ports.
 - 5) General-duty, smooth face, four USB-A ports.
5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

2.3 DUPLEX STRAIGHT-BLADE RECEPTACLES WITH INTEGRAL SWITCHING MEANS

A. Wired Full-Controlled Duplex Straight-Blade Receptacle :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Hubbell Lighting; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Pass & Seymour; Legrand North America, LLC]**
 - d. **<Insert manufacturer's name>**



2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Hubbell Lighting; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Pass & Seymour; Legrand North America, LLC]**
 - d. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles with Integral Switching Means: UL CCN RTXI and UL Subject 498B.
4. Standard Features:
 - a. Device Color: **[Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].**
 - b. Configuration: **[NEMA 5-15R][NEMA 5-20R].**
5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

B. Wired Half-Controlled Duplex Straight-Blade Receptacle :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Hubbell Lighting; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Pass & Seymour; Legrand North America, LLC]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Hubbell Lighting; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Pass & Seymour; Legrand North America, LLC]**
 - d. **<Insert manufacturer's name>**

3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles with Integral Switching Means: UL CCN RTX1 and UL Subject 498B.
 4. Standard Features:
 - a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - b. Configuration: [NEMA 5-15R][NEMA 5-20R].
 5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
 6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- C. Wireless Full-Controlled Duplex Straight-Blade Receptacle :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Lutron Electronics Co., Inc]**
 - c. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Lutron Electronics Co., Inc]**
 - c. **<Insert manufacturer's name>**
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles with Integral Switching Means: UL CCN RTX1 and UL Subject 498B.
 4. Standard Features:
 - a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - b. Configuration: [NEMA 5-15R][NEMA 5-20R].



5. Other Available Features Required by the Project:

- a. Has factory-terminated connectors on wiring device pigtails for quick installation.

6. Accessories:

- a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
- b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

D. Wireless Half-Controlled Duplex Straight-Blade Receptacle :

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

- a. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
- b. **[Lutron Electronics Co., Inc]**
- c. **<Insert manufacturer's name>**

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

- a. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
- b. **[Lutron Electronics Co., Inc]**
- c. **<Insert manufacturer's name>**

3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

- a. Receptacles with Integral Switching Means: UL CCN RTX1 and UL Subject 498B.

4. Standard Features:

- a. Device Color: **[Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].**
- b. Configuration: **[NEMA 5-15R][NEMA 5-20R].**

5. Other Available Features Required by the Project:

- a. Has factory-terminated connectors on wiring device pigtails for quick installation.

6. Accessories:

- a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
- b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

2.4 MAINTENANCE MATERIAL ITEMS

- A. Extra Stock Material: Furnish to Owner extra materials[, **from same production run,**] that match products installed and that are packaged with protective covering for storage and identified with labels describing contents. [**Include the following:**]
1. SPD Receptacles: Equal to [10]<Insert number> percent of quantity installed for each kind specified, but no fewer than [one]<Insert number> units.
 2. Controlled Receptacles: Equal to [10]<Insert number> percent of quantity installed for each kind specified, but no fewer than [one]<Insert number> units.
- B. Special Tools: Furnish to Owner proprietary equipment, keys, and software required to operate, maintain, repair, adjust, or implement future changes to controlled receptacles, that are packaged with protective covering for storage on-site and identified with labels describing contents.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that receptacles to be procured and installed for Owner-furnished equipment are compatible with mating attachment plugs on equipment.

3.2 SELECTION OF CONTROLLED AND UNCONTROLLED RECEPTACLES

- A. Private and Open Office Spaces:
1. Uncontrolled Receptacles at Workstations: Coordinate final locations of receptacles with furniture plan such that at least one uncontrolled receptacle is selected for installation not greater than 6 ft. (1.8 m) from each workstation.
 2. Controlled Receptacles at Workstations: Coordinate final locations of receptacles with furniture plan such that at least one controlled receptacle is selected for installation not greater than 6 ft. (1.8 m) from each workstation.
 3. Contact Architect for resolution of discrepancies between these requirements and Drawings.

3.3 INSTALLATION

- A. Comply with manufacturer's instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:
1. Electrical Construction: ICC IBC, ICC IFB, NFPA 1, NFPA 70, and NECA NEIS 1.
 2. Electrical Safety: NFPA 70E.
 3. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
 4. Work in ITE Rooms: NFPA 75.
 5. Work in Health Care Facilities: NFPA 99 and Article 517 of NFPA 70.
 6. Work in Confined Spaces: NFPA 350.
 7. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
 8. Installing and Maintaining Wiring Devices: NECA NEIS 130.
 9. Mounting Heights: Unless otherwise indicated in the Contract Documents, comply with mounting heights recommended in NECA NEIS 1.



10. Receptacle Orientation: Unless otherwise indicated in the Contract Documents, orient receptacle to match configuration diagram in NEMA WD 6.
11. Consult Architect for resolution of conflicting requirements.

C. Interfaces with Other Work:

1. Identification: Provide labels for receptacles and associated electrical equipment.
 - a. Identify field-installed conductors, interconnecting wiring, and components.
 - b. Label each enclosure with engraved metal or laminated-plastic nameplate.
 - 1) Identify cover or cover plate for device with panelboard identification and circuit number.
 - 2) Mark cover or cover plate using hot, stamped, or engraved machine printing with **[black][white][red]**-filled lettering, and provide durable wire markers or tags inside device box or outlet box.
 - c. Provide warning signs and arc-flash hazard warning labels for electrical equipment.
 - d. Healthcare Facilities: Distinctively identify covers or cover plates of device boxes and outlet boxes that are supplied from life safety and critical branch power supplies following facility's standard practice.
2. Do not install Type 3 SPD, including surge-protected relocatable taps and power strips, on branch circuit downstream of GFCI device.
3. Coordinate installation of new products for **<Insert system or product group>** with existing conditions.
 - a. **<Insert requirements for transition between new and existing>.**
4. Coordinate with **<Insert Section number and title>** for **<Insert description of interfacing related Work>**.
 - a. **<Insert requirements for transition between this Section and related Work>.**

3.4 FIELD QUALITY CONTROL

A. Administrant for Electrical Power Tests and Inspections:

1. **[Owner][Tenant]** will engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
2. Engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].

B. Acceptance Testing Preparation:

1. **<Insert requirements>.**

C. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.

D. Tests and Inspections:

1. Insert and remove test plug to verify that device is securely mounted.
2. Verify polarity of hot and neutral pins.
3. Measure line voltage.
4. Measure percent voltage drop.
5. Measure grounding circuit continuity; impedance must be not greater than 2 ohms.
6. Healthcare Facilities: Test straight-blade receptacles in patient care spaces with receptacle pin tension test instrument in accordance with NFPA 99. Retention force of ground pin must be not less than 115 g (4 oz).
7. Perform additional installation and maintenance inspections and diagnostic tests in accordance with NECA NEIS 130 and manufacturers' instructions.
8. **<Insert tests and inspections>**.

E. Nonconforming Work:

1. Device will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

F. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

G. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.

1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.

3.5 ADJUSTING

- A. Occupancy Adjustments for Controlled Receptacles: When requested within **[12]<Insert number>** months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to **[two]<Insert number>** visits to the Project during other-than-normal occupancy hours for this purpose.

3.6 PROTECTION

- A. Schedule and sequence installation to minimize risk of contamination of wires and cables, devices, device boxes, outlet boxes, covers, and cover plates by plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other materials.
- B. After installation, protect wires and cables, devices, device boxes, outlet boxes, covers, and cover plates from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 26 27 26 00C



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SECTION 26 27 26 00D - HOSPITAL-GRADE STRAIGHT-BLADE RECEPTACLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Hospital-grade straight-blade receptacles.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. Section 260526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding referenced by this Section.
5. Section 260533.16 "Boxes and Covers for Electrical Systems" specifies covers and cover plates referenced by this Section.
6. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs referenced by this Section.
7. Section 262726.31 "General-Grade Single Straight-Blade Receptacles" for single receptacles.
8. Section 262726.33 "General-Grade Duplex Straight-Blade Receptacles" for duplex receptacles that are not hospital grade.
9. Section 262726.37 "Receptacles with Arc-Fault and Ground-Fault Protective Devices" for AFCI and GFCI receptacles.
10. Section 262726.39 "Locking Receptacles" for twist-locking receptacles.
11. Section 262726.41 "Pin-and-Sleeve Receptacles" for pin-and-sleeve receptacles.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing agency, certifying product's compliance with specified listing criteria.
 - a. If listed manufacturer differs from selling manufacturer, indicate relationship between entities on submittal. Clearly indicate which entity warrants product performance and fitness for purpose.
 - b. Listing criteria identified in approval letter must match specified listing criteria. UL label indicating approval of equipment's enclosure is not considered approval of equipment for intended application.
 - c. Product identification in approval letter must match product branding and model numbers in submittal. Approval letters for discontinued or superseded products are unacceptable for submitted product.
2. Include manufacturer's sample extended warranty language.

- B. Samples: One for each kind of hospital-grade straight-blade receptacle[**and cover plate accessory**] specified, in each finish and color specified.
- C. Field quality-control reports.

1.3 INFORMATIONAL SUBMITTALS

- A. Manufacturer's published instructions.
- B. Field Reports:
 - 1. Manufacturer's field reports for field quality-control support.

1.4 CLOSEOUT SUBMITTALS

- A. Warranty documentation.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Extra stock material.

1.6 QUALIFICATIONS

- A. Electrical Power Testing (EPT) Technician III: Possessing active NICET EPT Level III certification. Able to manage switching procedures, conduct tests of complex equipment, analyze test and equipment data, plan a job, and lead a team. Has experience performing NFPA 70B, IEEE, and NETA electrical tests.
- B. Electrical Power Testing (EPT) Technician IV: Possessing active NICET EPT Level IV certification. Able to conduct tests of complex metering and relay systems; evaluate tests, test equipment, test results, and power system performance; recommend actions to maintain or improve system performance; and lead multi-team projects.
- C. Electrical Power Testing and Inspecting Agency: Entities possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
 - 1. On-site electrical testing supervisors must possess active NICET EPT Technician [III][IV] certification.

1.7 WARRANTY

- A. Special Manufacturer Extended Warranty: Manufacturer warrants that devices perform in accordance with specified requirements and agrees to provide repair or replacement of devices that fail to perform as specified within extended warranty period.
 - 1. Initial Extended Warranty Period: [Three][Four][Five]<Insert number> years from date of Substantial Completion; [full][prorated] coverage for labor, materials, and equipment.
 - 2. Follow-On Extended Warranty Period: [Eight]<Insert number> years from date of Substantial Completion; [full][prorated] coverage for materials only, free on board [origin][destination],

freight prepaid.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2.2 HOSPITAL-GRADE STRAIGHT-BLADE RECEPTACLES

- A. Hospital-Grade Single Straight-Blade Receptacle :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 - b. Surge Protective Devices: UL 1449, Type 3.
4. Standard Features:
 - a. Device Color: **[Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].**
 - b. Configuration:
 - 1) Extra-heavy-duty, **[NEMA 5-15R][NEMA 5-20R].**



- 2) Extra-heavy-duty, **[NEMA 6-15R][NEMA 6-20R]**.
5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- B. Hospital-Grade, Isolated Ground Single Straight-Blade Receptacle :
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Pass & Seymour; Legrand North America, LLC]**
 - c. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Pass & Seymour; Legrand North America, LLC]**
 - c. **<Insert manufacturer's name>**
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 - b. Surge Protective Devices: UL 1449, Type 3.
 4. Standard Features:
 - a. Device Color: Orange **[in accordance with NEMA WD 1]**.
 - b. Configuration:
 - 1) Heavy-duty, NEMA 5-20R.
 - 2) Extra-heavy-duty, **[NEMA 5-15R][NEMA 5-20R]**.
 5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
 6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.

- b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- C. Hospital-Grade Duplex Straight-Blade Receptacle :
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
 - 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 - b. Surge Protective Devices: UL 1449, Type 3.
 - 4. Standard Features:
 - a. Device Color: **[Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].**
 - b. Configuration:
 - 1) Heavy-duty, **[NEMA 5-15R][NEMA 5-20R].**
 - 2) Heavy-duty, smooth face, **[NEMA 5-15R][NEMA 5-20R].**
 - 3) Extra-heavy-duty, **[NEMA 5-15R][NEMA 5-20R].**
 - 4) Extra-heavy-duty, smooth face, **[NEMA 5-15R][NEMA 5-20R].**
 - 5) Extra-heavy-duty, **[NEMA 6-15R][NEMA 6-20R].**
 - 5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
 - 6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

D. Hospital-Grade, Non-Ferrous Duplex Straight-Blade Receptacle :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 - b. Surge Protective Devices: UL 1449, Type 3.
4. Standard Features:
 - a. Device Color: **[Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings]**.
 - b. Configuration: Extra-heavy-duty, **[NEMA 5-15R][NEMA 5-20R]**.
5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

E. Hospital-Grade, Nightlight-Type, Lighted Duplex Straight-Blade Receptacle :

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

- a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
- a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 - b. Surge Protective Devices: UL 1449, Type 3.
4. Standard Features:
- a. Device Color: **[Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].**
 - b. Configuration:
 - 1) Heavy-duty, **[NEMA 5-15R][NEMA 5-20R].**
 - 2) Heavy-duty, smooth face, **[NEMA 5-15R][NEMA 5-20R].**
 - 3) Extra-heavy-duty, **[NEMA 5-15R][NEMA 5-20R].**
 - 4) Extra-heavy-duty, smooth face, **[NEMA 5-15R][NEMA 5-20R].**
5. Other Available Features Required by the Project:
- a. Has factory-terminated connectors on wiring device pigtails for quick installation.
6. Accessories:
- a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- F. Hospital-Grade, Power-Indicating-Type, Lighted Duplex Straight-Blade Receptacle :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell**

- c. **Incorporated]**
[Leviton Manufacturing Co., Inc.]
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
- 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 - b. Surge Protective Devices: UL 1449, Type 3.
- 4. Standard Features:
 - a. Device Color: **[Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].**
 - b. Configuration:
 - 1) Extra-heavy-duty, **[NEMA 5-15R][NEMA 5-20R].**
 - 2) Extra-heavy-duty, smooth face, **[NEMA 5-15R][NEMA 5-20R].**
- 5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
- 6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- G. Hospital-Grade, Isolated Ground Duplex Straight-Blade Receptacle :
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Leviton Manufacturing Co., Inc.]**
 - b. **[Pass & Seymour; Legrand North America, LLC]**
 - c. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert**

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

- a. **[Leviton Manufacturing Co., Inc.]**
 - b. **[Pass & Seymour; Legrand North America, LLC]**
 - c. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
- a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 - b. Surge Protective Devices: UL 1449, Type 3.
4. Standard Features:
- a. Device Color: **[Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].**
 - b. Configuration:
 - 1) Heavy-duty, **[NEMA 5-15R][NEMA 5-20R].**
 - 2) Heavy-duty, smooth face, **[NEMA 5-15R][NEMA 5-20R].**
 - 3) Heavy-duty, NEMA 6-20R.
 - 4) Extra-heavy-duty, **[NEMA 5-15R][NEMA 5-20R].**
 - 5) Extra-heavy-duty, smooth face, **[NEMA 5-15R][NEMA 5-20R].**
 - 6) Extra-heavy-duty, NEMA 6-20R.
5. Other Available Features Required by the Project:
- a. Has factory-terminated connectors on wiring device pigtails for quick installation.
6. Accessories:
- a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- H. Hospital-Grade, Tamper-Resistant Duplex Straight-Blade Receptacle :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:



- a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 - b. Surge Protective Devices: UL 1449, Type 3.
4. Standard Features:
 - a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - b. Configuration:
 - 1) Heavy-duty, [NEMA 5-15R][NEMA 5-20R].
 - 2) Heavy-duty, smooth face, [NEMA 5-15R][NEMA 5-20R].
 - 3) Extra-heavy-duty, [NEMA 5-15R][NEMA 5-20R].
 - 4) Extra-heavy-duty, smooth face, [NEMA 5-15R][NEMA 5-20R].
5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- I. Hospital-Grade, Tamper-Resistant, Nightlight-Type, Lighted Duplex Straight-Blade Receptacle :
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]

- b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 - b. Surge Protective Devices: UL 1449, Type 3.
 4. Standard Features:
 - a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - b. Configuration:
 - 1) Heavy-duty, [NEMA 5-15R][NEMA 5-20R].
 - 2) Heavy-duty, smooth face, [NEMA 5-15R][NEMA 5-20R].
 5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
 6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- J. Hospital-Grade, Tamper-Resistant, Power-Indicating-Type, Lighted Duplex Straight-Blade Receptacle :
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]



- e. <Insert manufacturer's name>
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 - b. Surge Protective Devices: UL 1449, Type 3.
4. Standard Features:
 - a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - b. Configuration: Heavy-duty, [NEMA 5-15R][NEMA 5-20R].
5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- K. Hospital-Grade, Tamper-Resistant, Isolated Ground Duplex Straight-Blade Receptacle :
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Leviton Manufacturing Co., Inc.]
 - b. [Pass & Seymour; Legrand North America, LLC]
 - c. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Leviton Manufacturing Co., Inc.]
 - b. [Pass & Seymour; Legrand North America, LLC]
 - c. <Insert manufacturer's name>
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 - b. Surge Protective Devices: UL 1449, Type 3.
 4. Standard Features:

- a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - b. Configuration:
 - 1) Heavy-duty, [NEMA 5-15R][NEMA 5-20R].
 - 2) Heavy-duty, smooth face, [NEMA 5-15R][NEMA 5-20R].
5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- L. Hospital-Grade Duplex Straight-Blade Receptacle with Type 3 Surge Protective Device :
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Leviton Manufacturing Co., Inc.]
 - c. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Leviton Manufacturing Co., Inc.]
 - c. <Insert manufacturer's name>
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 - b. Surge Protective Devices: UL 1449, Type 3.
 4. Standard Features:
 - a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - b. Configuration: Heavy-duty, smooth face, [NEMA 5-15R][NEMA 5-20R].
 5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.



6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- M. Hospital-Grade, Tamper-Resistant Duplex Straight-Blade Receptacle with Type 3 Surge Protective Device :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Leviton Manufacturing Co., Inc.]**
 - b. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Leviton Manufacturing Co., Inc.]**
 - b. **<Insert manufacturer's name>**
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 - b. Surge Protective Devices: UL 1449, Type 3.
 4. Standard Features:
 - a. Device Color: **[Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].**
 - b. Configuration: Heavy-duty, smooth face, **[NEMA 5-15R][NEMA 5-20R].**
 5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
 6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- N. Hospital-Grade, Isolated Ground Duplex Straight-Blade Receptacle with Type 3 Surge Protective Device :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the**

following]:

- a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Leviton Manufacturing Co., Inc.]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Leviton Manufacturing Co., Inc.]**
 - c. **<Insert manufacturer's name>**
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 - b. Surge Protective Devices: UL 1449, Type 3.
 4. Standard Features:
 - a. Device Color: **[Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].**
 - b. Configuration: Heavy-duty, **[NEMA 5-15R][NEMA 5-20R].**
 5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
 6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- O. Hospital-Grade, Tamper-Resistant Duplex Straight-Blade Receptacle with USB Outlet to Power Class 2 Equipment :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Pass & Seymour; Legrand North America, LLC]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:



- a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Pass & Seymour; Legrand North America, LLC]
 - d. <Insert manufacturer's name>
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 - b. Surge Protective Devices: UL 1449, Type 3.
4. Standard Features:
 - a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - b. Configuration:
 - 1) Heavy-duty, [NEMA 5-15R][NEMA 5-20R]; two USB-A ports.
 - 2) Heavy-duty, [NEMA 5-15R][NEMA 5-20R]; two USB-C ports.
 - 3) Heavy-duty, [NEMA 5-15R][NEMA 5-20R]; one USB-A port; one USB-C port.
5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

2.3 MAINTENANCE MATERIAL ITEMS

- A. Extra Stock Material: Furnish to Owner extra materials[, **from same production run,**] that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.[**Include the following:**]
 1. SPD Receptacles: Equal to [10]<Insert number> percent of quantity installed for each kind specified, but no fewer than [one]<Insert number> units.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that receptacles to be procured and installed for Owner-furnished equipment are compatible with mating attachment plugs on equipment.

3.2 INSTALLATION

- A. Comply with manufacturer's instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:
 - 1. Electrical Construction: ICC IBC, ICC IFB, NFPA 1, NFPA 70, and NECA NEIS 1.
 - 2. Electrical Safety: NFPA 70E.
 - 3. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
 - 4. Work in ITE Rooms: NFPA 75.
 - 5. Work in Health Care Facilities: NFPA 99 and Article 517 of NFPA 70.
 - 6. Work in Confined Spaces: NFPA 350.
 - 7. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
 - 8. Installing and Maintaining Wiring Devices: NECA NEIS 130.
 - 9. Mounting Heights: Unless otherwise indicated in Contract Documents, comply with mounting heights recommended in NECA NEIS 1.
 - 10. Receptacle Orientation: Unless otherwise indicated in Contract Documents, orient receptacle to match configuration diagram in NEMA WD 6.
 - a. Hospital-Grade Receptacle Orientation: Orient receptacle with ground pin or neutral pin at top.
 - 11. Consult Architect for resolution of conflicting requirements.
- C. Interfaces with Other Work:
 - 1. Identification: Provide labels for receptacles and associated electrical equipment.
 - a. Identify field-installed conductors, interconnecting wiring, and components.
 - b. Label each enclosure with engraved metal or laminated-plastic nameplate.
 - 1) Identify cover or cover plate for device with panelboard identification and circuit number.
 - 2) Mark cover or cover plate using hot, stamped, or engraved machine printing with **[black][white][red]**-filled lettering, and provide durable wire markers or tags inside device box or outlet box.
 - c. Provide warning signs and arc-flash hazard warning labels for electrical equipment.
 - d. Healthcare Facilities: Distinctively identify covers or cover plates of device boxes and outlet boxes that are supplied from life safety and critical branch power supplies following facility's standard practice.
 - 2. Do not install Type 3 SPD, including surge-protected relocatable taps and power strips, on branch circuit downstream of GFCI device.
 - 3. Coordinate installation of new products for **<Insert system or product group>** with existing conditions.
 - a. **<Insert requirements for transition between new and existing>**.
 - 4. Coordinate with **<Insert Section number and title>** for **<Insert description of interfacing related Work>**.
 - a. **<Insert requirements for transition between this Section and related Work>**.

3.3 FIELD QUALITY CONTROL

- A. Administrant for Electrical Power Tests and Inspections:
1. **[Owner][Tenant]** will engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
 2. Engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
 4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].
- B. Acceptance Testing Preparation:
1. **<Insert requirements>**.
- C. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.
- D. Tests and Inspections:
1. Insert and remove test plug to verify that device is securely mounted.
 2. Verify polarity of hot and neutral pins.
 3. Measure line voltage.
 4. Measure percent voltage drop.
 5. Measure grounding circuit continuity; impedance must be not greater than 2 ohms.
 6. Healthcare Facilities: Test straight-blade receptacles in patient care spaces with receptacle pin tension test instrument in accordance with NFPA 99. Retention force of ground pin must be not less than 115 g (4 oz).
 7. Perform additional installation and maintenance inspections and diagnostic tests in accordance with NECA NEIS 130 and manufacturers' instructions.
 8. **<Insert tests and inspections>**.
- E. Nonconforming Work:
1. Device will be considered defective if it does not pass tests and inspections.
 2. Remove and replace defective units and retest.
- F. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.
- G. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.
1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.

3.4 PROTECTION

- A. Schedule and sequence installation to minimize risk of contamination of wires and cables, devices, device boxes, outlet boxes, covers, and cover plates by plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other materials.



- B. After installation, protect wires and cables, devices, device boxes, outlet boxes, covers, and cover plates from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 26 27 26 00D



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SECTION 26 27 26 00E - RECEPTACLES WITH ARC-FAULT AND GROUND-FAULT PROTECTIVE DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Receptacles with AFCI devices.
2. Receptacles with both AFCI and GFCI devices.
3. Receptacles with GFCI devices.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. Section 260526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding referenced by this Section.
5. Section 260533.16 "Boxes and Covers for Electrical Systems" specifies covers and cover plates referenced by this Section.
6. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs referenced by this Section.
7. Section 262726.31 "General-Grade Single Straight-Blade Receptacles" for single receptacles.
8. Section 262726.33 "General-Grade Duplex Straight-Blade Receptacles" for duplex receptacles that are not hospital grade.
9. Section 262726.35 "Hospital-Grade Straight-Blade Receptacles" for hospital-grade receptacles.
10. Section 262726.39 "Locking Receptacles" for twist-locking receptacles.
11. Section 262726.41 "Pin-and-Sleeve Receptacles" for pin-and-sleeve receptacles.

1.2 DEFINITIONS

- A. AFCI: Arc-Fault Circuit Interrupter.
- B. GFCI: Ground-Fault Circuit Interrupter.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing agency, certifying product's compliance with specified listing criteria.
 - a. If listed manufacturer differs from selling manufacturer, indicate relationship between entities on submittal. Clearly indicate which entity warrants product performance and

- fitness for purpose.
- b. Listing criteria identified in approval letter must match specified listing criteria. UL label indicating approval of equipment's enclosure is not considered approval of equipment for intended application.
- c. Product identification in approval letter must match product branding and model numbers in submittal. Approval letters for discontinued or superseded products are unacceptable for submitted product.

2. Include manufacturer's sample extended warranty language.

B. Samples:

- 1. One for each kind of receptacles with AFCI devices[**and cover plate accessory**] specified, in each finish and color specified.
- 2. One for each kind of receptacles with AFCI and GFCI devices[**and cover plate accessory**] specified, in each finish and color specified.
- 3. One for each kind of receptacles with GFCI devices[**and cover plate accessory**] specified, in each finish and color specified.

C. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

A. Manufacturer's published instructions.

B. Field Reports:

- 1. Manufacturer's field reports for field quality-control support.

1.5 WARRANTY

A. Special Manufacturer Extended Warranty: Manufacturer warrants that devices perform in accordance with specified requirements and agrees to provide repair or replacement of devices that fail to perform as specified within extended warranty period.

- 1. Initial Extended Warranty Period: [**Three**][**Four**][**Five**]**<Insert number>** years from date of Substantial Completion; [**full**][**prorated**] coverage for labor, materials, and equipment.
- 2. Follow-On Extended Warranty Period: [**Eight**]**<Insert number>** years from date of Substantial Completion; [**full**][**prorated**] coverage for materials only, free on board [**origin**][**destination**], freight prepaid.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2.2 RECEPTACLES WITH AFCI DEVICES

A. General-Grade, Tamper-Resistant Duplex Straight-Blade Receptacle with AFCI Device :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Outlet Branch-Circuit Type AFCIs: UL CCN AWBZ, UL 498, UL 1699, and UL Subject 1699A.
4. Standard Features:
 - a. Device Color: **[Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].**
 - b. Configuration: Heavy-duty, **[NEMA 5-15R][NEMA 5-20R].**
5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

B. Hospital-Grade, Tamper-Resistant Duplex Straight-Blade Receptacle with AFCI Device :

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



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

- a. [Leviton Manufacturing Co., Inc.]
 - b. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Leviton Manufacturing Co., Inc.]
 - b. <Insert manufacturer's name>
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Outlet Branch-Circuit Type AFCIs: UL CCN AWBZ, UL 498, UL 1699, and UL Subject 1699A.
 4. Standard Features:
 - a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - b. Configuration: Heavy-duty, [NEMA 5-15R][NEMA 5-20R].
 5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
 6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

2.3 RECEPTACLES WITH BOTH AFCI AND GFCI DEVICES

A. General-Grade, Tamper-Resistant Duplex Straight-Blade Receptacle with AFCI and GFCI Device :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]

- e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Outlet Branch-Circuit Type GFCIs and AFCIs: UL CCN KCXX, UL 498, UL 943, UL 1699, and UL Subject 1699A.
4. Standard Features:
 - a. Device Color: **[Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].**
 - b. Configuration: Heavy-duty, **[NEMA 5-15R][NEMA 5-20R].**
5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

2.4 RECEPTACLES WITH GFCI DEVICES

A. General-Grade Duplex Straight-Blade Receptacle with GFCI Device :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**



2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacle GFCIs: UL CCN KCXS, UL 498, and UL 943.
4. Standard Features:
 - a. Device Color: **[Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings]**.
 - b. Configuration: Heavy-duty, **[NEMA 5-15R][NEMA 5-20R]**.
5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

B. General-Grade, Nightlight-Type, Lighted Duplex Straight-Blade Receptacle with GFCI Device :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**

- b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacle GFCIs: UL CCN KCXS, UL 498, and UL 943.
 4. Standard Features:
 - a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - b. Configuration: Heavy-duty, [NEMA 5-15R][NEMA 5-20R].
 5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
 6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- C. General-Grade, Tamper-Resistant Duplex Straight-Blade Receptacle with GFCI Device :
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>



3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacle GFCIs: UL CCN KCXS, UL 498, and UL 943.
 4. Standard Features:
 - a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - b. Configuration: Heavy-duty, [NEMA 5-15R][NEMA 5-20R].
 5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
 6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- D. General-Grade, Tamper-Resistant, Nightlight-Type, Lighted Duplex Straight-Blade Receptacle with GFCI Device :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

- a. Receptacle GFCIs: UL CCN KCXS, UL 498, and UL 943.
 4. Standard Features:
 - a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - b. Configuration: Heavy-duty, [NEMA 5-15R][NEMA 5-20R].
 5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
 6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- E. General-Grade, Weather-Resistant Duplex Straight-Blade Receptacle with GFCI Device :
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacle GFCIs: UL CCN KCXS, UL 498, and UL 943.
 4. Standard Features:
 - a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on



- architectural Drawings].**
- b. Configuration: Heavy-duty, **[NEMA 5-15R][NEMA 5-20R]**.
5. Other Available Features Required by the Project:
- a. Has factory-terminated connectors on wiring device pigtails for quick installation.
6. Accessories:
- a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- F. General-Grade, Weather-Resistant, Tamper-Resistant Duplex Straight-Blade Receptacle with GFCI Device :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacle GFCIs: UL CCN KCXS, UL 498, and UL 943.
 4. Standard Features:
 - a. Device Color: **[Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].**
 - b. Configuration: Heavy-duty, **[NEMA 5-15R][NEMA 5-20R]**.
 5. Other Available Features Required by the Project:

- a. Has factory-terminated connectors on wiring device pigtails for quick installation.
6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- G. General-Grade, Weather-Resistant, Tamper-Resistant, Nightlight-Type, Lighted Duplex Straight-Blade Receptacle with GFCI Device :
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacle GFCIs: UL CCN KCXS, UL 498, and UL 943.
 4. Standard Features:
 - a. Device Color: **[Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].**
 - b. Configuration: Heavy-duty, **[NEMA 5-15R][NEMA 5-20R].**
 5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
 6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth



- finish and color matching wiring device; from same manufacturer as wiring device.
- b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- H. General-Grade, Isolated Ground, Tamper-Resistant Duplex Straight-Blade Receptacle with GFCI Device :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacle GFCIs: UL CCN KCXS, UL 498, and UL 943.
 4. Standard Features:
 - a. Device Color: **[Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].**
 - b. Configuration: Heavy-duty, **[NEMA 5-15R][NEMA 5-20R].**
 5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
 6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- I. General-Grade, Isolated Ground, Weather-Resistant, Tamper-Resistant Duplex Straight-Blade

Receptacle with GFCI Device :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacle GFCIs: UL CCN KCXS, UL 498, and UL 943.
 4. Standard Features:
 - a. Device Color: **[Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings]**.
 - b. Configuration: Heavy-duty, **[NEMA 5-15R][NEMA 5-20R]**.
 5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
 6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- J. Hospital-Grade Duplex Straight-Blade Receptacle with GFCI Device :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:



- a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacle GFCIs: UL CCN KCXS, UL 498, and UL 943.
4. Standard Features:
 - a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - b. Configuration: Heavy-duty, [NEMA 5-15R][NEMA 5-20R].
5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- K. Hospital-Grade, Nightlight-Type, Lighted Duplex Straight-Blade Receptacle with GFCI Device :
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]

- e. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
- 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacle GFCIs: UL CCN KCXS, UL 498, and UL 943.
- 4. Standard Features:
 - a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - b. Configuration: Heavy-duty, [NEMA 5-15R][NEMA 5-20R].
- 5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
- 6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- L. Hospital-Grade, Tamper-Resistant, Nightlight-Type, Lighted Duplex Straight-Blade Receptacle with GFCI Device :
 - 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:



- a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacle GFCIs: UL CCN KCXS, UL 498, and UL 943.
4. Standard Features:
 - a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - b. Configuration: Heavy-duty, [NEMA 5-15R][NEMA 5-20R].
5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- M. Hospital-Grade, Weather-Resistant, Tamper-Resistant Duplex Straight-Blade Receptacle with GFCI Device :
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]

- d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacle GFCIs: UL CCN KCXS, UL 498, and UL 943.
4. Standard Features:
 - a. Device Color: **[Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].**
 - b. Configuration: Heavy-duty, **[NEMA 5-15R][NEMA 5-20R].**
5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- N. Hospital-Grade, Weather-Resistant, Tamper-Resistant, Nightlight-Type, Lighted Duplex Straight-Blade Receptacle with GFCI Device :
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product



categories:

- a. Receptacle GFCIs: UL CCN KCXS, UL 498, and UL 943.
4. Standard Features:
 - a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - b. Configuration: Heavy-duty, [NEMA 5-15R][NEMA 5-20R].
5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- O. Hospital-Grade, Isolated Ground, Tamper-Resistant Duplex Straight-Blade Receptacle with GFCI Device :
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacle GFCIs: UL CCN KCXS, UL 498, and UL 943.

4. Standard Features:
 - a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].
 - b. Configuration: Heavy-duty, [NEMA 5-15R][NEMA 5-20R].
 5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
 6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- P. Hospital-Grade, Isolated Ground, Weather-Resistant, Tamper-Resistant Duplex Straight-Blade Receptacle with GFCI Device :
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacle GFCIs: UL CCN KCXS, UL 498, and UL 943.
 4. Standard Features:
 - a. Device Color: [Ivory][White][Gray][Brown][Black][Red][Yellow][Orange][in accordance with NEMA WD 1][Blue][Green][Office White][Almond][Light Almond][As indicated on architectural Drawings].

- b. Configuration: Heavy-duty, **[NEMA 5-15R][NEMA 5-20R]**.
- 5. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
- 6. Accessories:
 - a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that receptacles to be procured and installed for Owner-furnished equipment are compatible with mating attachment plugs on equipment.

3.2 SELECTION OF GFCI RECEPTACLES

- A. Healthcare Facilities: Unless protection of downstream branch-circuit wiring, cord sets, and power-supply cords is required by NFPA 70 or NFPA 99, provide non-feed-through GFCI receptacles.

3.3 INSTALLATION

- A. Comply with manufacturer's instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:
 - 1. Electrical Construction: ICC IBC, ICC IFB, NFPA 1, NFPA 70, and NFPA 70E.
 - 2. Electrical Safety: NFPA 70E.
 - 3. Grounding and Bonding: NFPA 70E and Article 250 of NFPA 70.
 - 4. Work in ITE Rooms: NFPA 75.
 - 5. Work in Health Care Facilities: NFPA 99 and Article 517 of NFPA 70.
 - 6. Work in Confined Spaces: NFPA 350.
 - 7. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
 - 8. Installing and Maintaining Wiring Devices: NFPA 70E 130.
 - 9. Mounting Heights: Unless otherwise indicated in the Contract Documents, comply with mounting heights recommended in NFPA 70E 1.
 - 10. Receptacle Orientation: Unless otherwise indicated in the Contract Documents, orient receptacle to match configuration diagram in NFPA 70E 6.
 - a. Hospital-Grade Receptacle Orientation: Orient receptacle with ground pin or neutral pin at top.
 - 11. Consult Architect for resolution of conflicting requirements.

C. Interfaces with Other Work:

1. Identification: Provide labels for receptacles and associated electrical equipment.
 - a. Identify field-installed conductors, interconnecting wiring, and components.
 - b. Label each enclosure with engraved metal or laminated-plastic nameplate.
 - 1) Identify cover or cover plate for device with panelboard identification and circuit number.
 - 2) Mark cover or cover plate using hot, stamped, or engraved machine printing with **[black][white][red]**-filled lettering, and provide durable wire markers or tags inside device box or outlet box.
 - c. Provide warning signs and arc-flash hazard warning labels for electrical equipment.
 - d. Healthcare Facilities: Distinctively identify covers or cover plates of device boxes and outlet boxes that are supplied from life safety and critical branch power supplies following facility's standard practice.
2. Do not install Type 3 SPD, including surge-protected relocatable taps and power strips, on branch circuit downstream of GFCI device.
3. Coordinate installation of new products for **<Insert system or product group>** with existing conditions.
 - a. **<Insert requirements for transition between new and existing>**.
4. Coordinate with **<Insert Section number and title>** for **<Insert description of interfacing related Work>**.
 - a. **<Insert requirements for transition between this Section and related Work>**.

3.4 FIELD QUALITY CONTROL

A. Administrant for Electrical Power Tests and Inspections:

1. **[Owner][Tenant]** will engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
2. Engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections **[with assistance of factory-authorized service representative]**.

B. Acceptance Testing Preparation:

1. **<Insert requirements>**.

C. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.

D. Tests and Inspections:

1. Insert and remove test plug to verify that device is securely mounted.

2. Verify polarity of hot and neutral pins.
3. Measure line voltage.
4. Measure percent voltage drop.
5. Measure grounding circuit continuity; impedance must be not greater than 2 ohms.
6. Healthcare Facilities: Test straight-blade receptacles in patient care spaces with receptacle pin tension test instrument in accordance with NFPA 99. Retention force of ground pin must be not less than 115 g (4 oz).
7. Perform additional installation and maintenance inspections and diagnostic tests in accordance with NECA NEIS 130 and manufacturers' instructions.
8. **<Insert tests and inspections>.**

E. Nonconforming Work:

1. Device will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

F. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

G. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.

1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.

3.5 PROTECTION

- A. Schedule and sequence installation to minimize risk of contamination of wires and cables, devices, device boxes, outlet boxes, covers, and cover plates by plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other materials.
- B. After installation, protect wires and cables, devices, device boxes, outlet boxes, covers, and cover plates from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 26 27 26 00E

SECTION 26 27 26 00F - LOCKING RECEPTACLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Locking receptacles.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies temperature, humidity, acoustical, and other field conditions applicable to the Work specified in this Section.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies seismic hazard, wind hazard, and other structural design conditions applicable to the Work specified in this Section.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional abbreviations, definitions, submittals, qualifications, testing agencies, and other requirements applicable to the Work for electrical, communications, and electronic safety and security systems on Project, including wiring methods.
4. Section 260553 "Identification for Electrical Systems" specifies equipment identification products installed by this Section.
5. Section 262726.31 "General-Grade Single Straight-Blade Receptacles" specifies single receptacles.
6. Section 262726.33 "General-Grade Duplex Straight-Blade Receptacles" specifies duplex receptacles that are not hospital grade.
7. Section 262726.35 "Hospital-Grade Straight-Blade Receptacles" specifies hospital-grade receptacles.
8. Section 262726.37 "Receptacles with Arc-Fault and Ground-Fault Protective Devices" specifies AFCI and GFCI receptacles.
9. Section 262726.41 "Pin-and-Sleeve Receptacles" specifies pin-and-sleeve receptacles.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product. In addition to information identified in Section 013300 "Submittal Procedures," submit the following:

1. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing agency, certifying product's compliance with specified listing criteria.
2. Include manufacturer's sample extended warranty language.

B. Samples: For each type of product that requires samples for source quality control.

C. Field quality-control reports.

1.3 INFORMATIONAL SUBMITTALS

A. Manufacturer's published instructions.

B. Field Reports:

1. Manufacturer's field reports for field quality-control support.

1.4 CLOSEOUT SUBMITTALS

- A. Warranty documentation.

1.5 QUALIFICATIONS

- A. Low-Voltage Electrical Testing and Inspecting Agency: Entities possessing active credentials from qualified electrical testing laboratory recognized by authorities having jurisdiction.
 1. On-site electrical testing supervisors must have documented certification and experience with testing electrical equipment in accordance with NETA testing standards.

1.6 WARRANTY

- A. Special Installer Extended Warranty: Installer warrants that installed devices perform in accordance with specified requirements and agrees to repair or replace products that fail to perform as specified within extended-warranty period. Warranty must convey to Owner upon acceptance of the Work.
 1. Extended-Warranty Period: **[Two][Three][Four]<Insert number>** years from date of Substantial Completion; full coverage for labor, materials, and equipment.
- B. Special Manufacturer Extended Warranty: Manufacturer warrants that products perform in accordance with specified requirements and agrees to provide repair or replacement of products that fail to perform as specified within extended-warranty period. Warranty must convey to Owner upon acceptance of the Work.
 1. Initial Extended-Warranty Period: **[Three][Four][Five]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for labor, materials, and equipment.
 2. Follow-On Extended-Warranty Period: **[Eight]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for materials only, free on board **[origin][destination]**, freight prepaid.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2.2 LOCKING RECEPTACLES

- A. Description: Receptacles that require two motions, insertion and rotation, to fully mate attachment plugs.
- B. Source Quality Control:

1. Samples: One for each kind of locking receptacle[**and cover plate accessory**] specified, in each finish and color specified.
- C. UL RTRT - NEMA, 125 V, Locking Receptacle :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 5. Standard Features:
 - a. Device Color: Black with yellow voltage indication on face.
 - b. Configuration: 2 pole, 3 wire, grounding, **[NEMA L5-15R][NEMA L5-20R][NEMA L5-30R]**.
- D. UL RTRT - NEMA, 125 V, Isolated Ground Locking Receptacle :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the

following:

- a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 5. Standard Features:
 - a. Device Color: Black with yellow voltage indication on face.
 - b. Configuration: 2 pole, 3 wire, grounding, **[NEMA L5-15R][NEMA L5-20R][NEMA L5-30R]**.

E. UL RTRT - NEMA, 125/250 V, Locking Receptacle :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
5. Standard Features:

- a. Device Color: Black with orange voltage indication on face.
- b. Configuration:
 - 1) 3 pole, 3 wire, non-grounding, [NEMA L10-20R][NEMA L10-30R].
 - 2) 3 pole, 4 wire, grounding, [NEMA L14-20R][NEMA L14-30R].

F. UL RTRT - NEMA, 125/250 V, Isolated Ground Locking Receptacle :

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
- 3. Source Limitations: Obtain products from single manufacturer.
- 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
- 5. Standard Features:
 - a. Device Color: Black with orange voltage indication on face.
 - b. Configuration: 3 pole, 4 wire, grounding, [NEMA L14-20R][NEMA L14-30R].

G. UL RTRT - NEMA, 250 V, Locking Receptacle :

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
5. Standard Features:
 - a. Device Color: Black with blue voltage indication on face.
 - b. Configuration:
 - 1) 2 pole, 3 wire, grounding, **[NEMA L6-15R][NEMA L6-20R][NEMA L6-30R]**.
 - 2) 3 pole, 4 wire, grounding, **[NEMA L15-20R][NEMA L15-30R]**.
 - 3) 4 pole, 4 wire, non-grounding, **[NEMA L18-20R][NEMA L18-30R]**.
 - 4) 4 pole, 5 wire, grounding, **[NEMA L21-20R][NEMA L21-30R]**.

H. UL RTRT - NEMA, 250 V, Isolated Ground Locking Receptacle :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Pass & Seymour; Legrand North America, LLC]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in

accordance with guide information and standards specified for the following UL product categories:

- a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.

5. Standard Features:

- a. Device Color: Black with blue voltage indication on face.
- b. Configuration:
 - 1) 2 pole, 3 wire, grounding, [NEMA L6-15R][NEMA L6-20R][NEMA L6-30R].
 - 2) 3 pole, 4 wire, grounding, [NEMA L15-20R][NEMA L15-30R].
 - 3) 4 pole, 5 wire, grounding, [NEMA L21-20R][NEMA L21-30R].

I. UL RTRT - NEMA, 277 V, Locking Receptacle :

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
- 3. Source Limitations: Obtain products from single manufacturer.
- 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
- 5. Standard Features:
 - a. Device Color: Black with gray voltage indication on face.
 - b. Configuration: 2 pole, 3 wire, grounding, [NEMA L7-15R][NEMA L7-20R][NEMA L7-30R].

J. UL RTRT - NEMA, 480 V, Locking Receptacle :

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

following]:

- a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
- a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
5. Standard Features:
- a. Device Color: Black with red voltage indication on face.
 - b. Configuration:
 - 1) 2 pole, 3 wire, grounding, [NEMA L8-20R][NEMA L8-30R].
 - 2) 3 pole, 4 wire, grounding, [NEMA L16-20R][NEMA L16-30R].
 - 3) 4 pole, 4 wire, non-grounding, [NEMA L19-20R][NEMA L19-30R].
 - 4) 4 pole, 5 wire, grounding, [NEMA L22-20R][NEMA L22-30R].

K. UL RTRT - NEMA, 600 V, Locking Receptacle :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - b. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Pass & Seymour; Legrand North America, LLC]
 - e. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
5. Standard Features:
 - a. Device Color: Black with black voltage indication on face.
 - b. Configuration:
 - 1) 2 pole, 3 wire, grounding, 50 A.
 - 2) 3 pole, 4 wire, grounding, 50 A.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that receptacles to be procured and installed for Owner-furnished equipment are compatible with mating attachment plugs on equipment.

3.2 INSTALLATION

- A. Comply with manufacturer's published instructions.
- B. Reference Standards:
 1. Unless more stringent requirements are specified in the Contract Documents or manufacturer's published instructions, comply with installation instructions in NECA NEIS 130.
 2. Mounting Heights: Unless otherwise indicated in the Contract Documents, comply with mounting heights recommended in NECA NEIS 1.
 3. Receptacle Orientation: Unless otherwise indicated in the Contract Documents, orient receptacle to match configuration diagram in NEMA WD 6.
 4. Consult Architect for resolution of conflicting requirements.
- C. Identification:
 1. Identify cover or cover plate for device with panelboard identification and circuit number.
 - a. Mark cover or cover plate using hot, stamped, or engraved machine printing with [black][white][red]-filled lettering, and provide durable wire markers or tags inside device box or outlet box.
 - b. Healthcare Facilities: Distinctively identify covers or cover plates of device boxes and outlet boxes that are supplied from life safety and critical branch power supplies following

facility's standard practice.

D. Interfaces with Other Work:

1. Coordinate installation of new products for **<Insert system or product group>** with existing conditions.
 - a. **<Insert requirements for transition between new and existing>**.
2. Coordinate with **<Insert Section number and title>** for **<Insert description of interfacing related Work>**.
 - a. **<Insert requirements for transition between this Section and related Work>**.

3.3 FIELD QUALITY CONTROL

A. Administrant for Low-Voltage Electrical Tests and Inspections:

1. **[Owner][Tenant]** will engage qualified low-voltage electrical testing and inspecting agency to administer and perform tests and inspections.
2. Engage qualified low-voltage electrical testing and inspecting agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections **[with assistance of factory-authorized service representative]**.

B. Acceptance Testing Preparation:

1. **<Insert requirements>**.

C. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.

D. Tests and Inspections:

1. Insert and remove test plug to verify that device is securely mounted.
2. Verify polarity of hot and neutral pins.
3. Measure line voltage.
4. Measure percent voltage drop.
5. Measure grounding circuit continuity; impedance must be not greater than 2 ohms.
6. Perform additional installation and maintenance inspections and diagnostic tests in accordance with NECA NEIS 130 and manufacturer's published instructions.
7. **<Insert tests and inspections>**.

E. Nonconforming Work:

1. Device will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

F. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

G. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** field

tests and inspections.

1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at Project site.

3.4 PROTECTION

- A. Schedule and sequence installation to minimize risk of contamination of wires and cables, devices, device boxes, outlet boxes, covers, and cover plates by plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other materials.
- B. After installation, protect wires and cables, devices, device boxes, outlet boxes, covers, and cover plates from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 26 27 26 00F



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SECTION 26 27 26 00G - PIN-AND-SLEEVE RECEPTACLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pin-and-sleeve type receptacles.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies temperature, humidity, acoustical, and other field conditions applicable to the Work specified in this Section.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies seismic hazard, wind hazard, and other structural design conditions applicable to the Work specified in this Section.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional abbreviations, definitions, submittals, qualifications, testing agencies, and other requirements applicable to the Work for electrical, communications, and electronic safety and security systems on the Project, including wiring methods.
4. Section 260553 "Identification for Electrical Systems" specifies equipment identification products installed by this Section.
5. Section 262726.31 "General-Grade Single Straight-Blade Receptacles" specifies single receptacles.
6. Section 262726.33 "General-Grade Duplex Straight-Blade Receptacles" specifies duplex receptacles that are not hospital grade.
7. Section 262726.35 "Hospital-Grade Straight-Blade Receptacles" specifies hospital-grade receptacles.
8. Section 262726.37 "Receptacles with Arc-Fault and Ground-Fault Protective Devices" specifies AFCI and GFCI receptacles.
9. Section 262726.39 "Locking Receptacles" specifies twist-locking receptacles.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product. In addition to information identified in Section 013300 "Submittal Procedures," submit the following:

1. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing agency, certifying product's compliance with specified listing criteria.
2. Include manufacturer's sample extended warranty language.

B. Samples: For each type of product that requires samples for source quality control.

C. Field quality-control reports.

1.3 INFORMATIONAL SUBMITTALS

A. Manufacturer's published instructions.

B. Field Reports:

1. Manufacturer's field reports for field quality-control support.

1.4 CLOSEOUT SUBMITTALS

- A. Warranty documentation.

1.5 QUALIFICATIONS

- A. Low-Voltage Electrical Testing and Inspecting Agency: Entities possessing active credentials from qualified electrical testing laboratory recognized by authorities having jurisdiction.
 1. On-site electrical testing supervisors must have documented certification and experience with testing electrical equipment in accordance with NETA testing standards.

1.6 WARRANTY

- A. Special Installer Extended Warranty: Installer warrants that installed devices perform in accordance with specified requirements and agrees to repair or replace products that fail to perform as specified within extended-warranty period. Warranty must convey to Owner upon acceptance of the Work.
 1. Extended-Warranty Period: **[Two][Three][Four]<Insert number>** years from date of Substantial Completion; full coverage for labor, materials, and equipment.
- B. Special Manufacturer Extended Warranty: Manufacturer warrants that products perform in accordance with specified requirements and agrees to provide repair or replacement of products that fail to perform as specified within extended-warranty period. Warranty must convey to Owner upon acceptance of the Work.
 1. Initial Extended-Warranty Period: **[Three][Four][Five]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for labor, materials, and equipment.
 2. Follow-On Extended-Warranty Period: **[Eight]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for materials only, free on board **[origin][destination]**, freight prepaid.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2.2 PIN-AND-SLEEVE TYPE RECEPTACLES

- A. Description: Pin-and-sleeve type receptacles and other outlet devices intended for direct connection to wiring systems recognized by NFPA 70.
- B. Source Quality Control:

1. Samples: One for each kind of pin-and-sleeve receptacle specified, in each finish and color specified.
- C. UL QLIW - C2 Series, 125 V, Pin-and-Sleeve Receptacles :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**
 - b. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - c. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - d. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - e. **[Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - f. **[Leviton Manufacturing Co., Inc.]**
 - g. **[Pass & Seymour; Legrand North America, LLC]**
 - h. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB, Electrification Business]**
 - b. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - c. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - d. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - e. **[Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - f. **[Leviton Manufacturing Co., Inc.]**
 - g. **[Pass & Seymour; Legrand North America, LLC]**
 - h. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Pin-and-Sleeve Type Receptacles: UL CCN QLIW; including UL 1682.
 5. Standard Features:
 - a. Series: UL 1686 Series C2 and IEC 60309-2 Series II.
 - b. Voltage Rating: 125 V.
 - c. Configuration: 2 pole, 3 wire, **[20 A][30 A, IP67][30 A, IP69k][60 A, IP67][60 A, IP69k][100 A]**.
- D. UL QLIW - C2 Series, 125/250 V, Pin-and-Sleeve Receptacles :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB, Electrification Business]**

- b. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - c. [Crouse-Hinds; brand of Eaton, Electrical Sector]
 - d. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - e. [Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - f. [Leviton Manufacturing Co., Inc.]
 - g. [Pass & Seymour; Legrand North America, LLC]
 - h. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [ABB, Electrification Business]
 - b. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - c. [Crouse-Hinds; brand of Eaton, Electrical Sector]
 - d. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - e. [Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - f. [Leviton Manufacturing Co., Inc.]
 - g. [Pass & Seymour; Legrand North America, LLC]
 - h. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
- a. Pin-and-Sleeve Type Receptacles: UL CCN QLIW; including UL 1682.
5. Standard Features:
- a. Series: UL 1686 Series C2 and IEC 60309-2 Series II.
 - b. Voltage Rating: 125/250 V.
 - c. Configuration:
 - 1) 2 pole, 3 wire, [20 A][30 A, IP67][30 A, IP69k][60 A, IP67][60 A, IP69k][100 A].
 - 2) 3 pole, 4 wire, [20 A][30 A, IP67][30 A, IP69k][60 A, IP67][60 A, IP69k][100 A, IP67][100 A, IP69k].
 - 3) 4 pole, 5 wire, [20 A][30 A, IP67][30 A, IP69k][60 A, IP67][60 A, IP69k][100 A, IP67][100 A, IP69k].
- E. UL QLIW - C2 Series, 250 V, Pin-and-Sleeve Receptacles :
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
- a. [ABB, Electrification Business]
 - b. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - c. [Crouse-Hinds; brand of Eaton, Electrical Sector]
 - d. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - e. [Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated]

- f. [Leviton Manufacturing Co., Inc.]
 - g. [Pass & Seymour; Legrand North America, LLC]
 - h. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [ABB, Electrification Business]
 - b. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - c. [Crouse-Hinds; brand of Eaton, Electrical Sector]
 - d. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - e. [Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - f. [Leviton Manufacturing Co., Inc.]
 - g. [Pass & Seymour; Legrand North America, LLC]
 - h. <Insert manufacturer's name>
 3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Pin-and-Sleeve Type Receptacles: UL CCN QLIW; including UL 1682.
 5. Standard Features:
 - a. Series: UL 1686 Series C2 and IEC 60309-2 Series II.
 - b. Voltage Rating: 250 V.
 - c. Configuration: 3 pole, 4 wire, [20 A][30 A, IP67][30 A, IP69k][60 A, IP67][60 A, IP69k][100 A, IP67][100 A, IP69k].
- F. UL QLIW - C2 Series, 480 V, Pin-and-Sleeve Receptacles :
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [ABB, Electrification Business]
 - b. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - c. [Crouse-Hinds; brand of Eaton, Electrical Sector]
 - d. [Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - e. [Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - f. [Leviton Manufacturing Co., Inc.]
 - g. [Pass & Seymour; Legrand North America, LLC]
 - h. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [ABB, Electrification Business]
 - b. [Arrow Hart, Wiring Devices; Eaton, Electrical Sector]
 - c. [Crouse-Hinds; brand of Eaton, Electrical Sector]

- d. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - e. **[Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - f. **[Leviton Manufacturing Co., Inc.]**
 - g. **[Pass & Seymour; Legrand North America, LLC]**
 - h. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
- a. Pin-and-Sleeve Type Receptacles: UL CCN QLIW; including UL 1682.
5. Standard Features:
- a. Series: UL 1686 Series C2 and IEC 60309-2 Series II.
 - b. Voltage Rating: 480 V.
 - c. Configuration:
 - 1) 2 pole, 3 wire, **[20 A][30 A, IP67][30 A, IP69k][60 A, IP67][60 A, IP69k][100 A]**.
 - 2) 3 pole, 4 wire, **[20 A][30 A, IP67][30 A, IP69k][60 A, IP67][60 A, IP69k][100 A, IP67][100 A, IP69k]**.
 - 3) 4 pole, 5 wire, **[20 A][30 A, IP67][30 A, IP69k][60 A, IP67][60 A, IP69k][100 A, IP67][100 A, IP69k]**.

G. UL QLIW - C2 Series, 600 V, Pin-and-Sleeve Receptacles :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
- a. **[ABB, Electrification Business]**
 - b. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - c. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - d. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - e. **[Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - f. **[Leviton Manufacturing Co., Inc.]**
 - g. **[Pass & Seymour; Legrand North America, LLC]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[ABB, Electrification Business]**
 - b. **[Arrow Hart, Wiring Devices; Eaton, Electrical Sector]**
 - c. **[Crouse-Hinds; brand of Eaton, Electrical Sector]**
 - d. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - e. **[Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - f. **[Leviton Manufacturing Co., Inc.]**
 - g. **[Pass & Seymour; Legrand North America, LLC]**

- h. <Insert manufacturer's name>
- 3. Source Limitations: Obtain products from single manufacturer.
- 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Pin-and-Sleeve Type Receptacles: UL CCN QLIW; including UL 1682.
- 5. Standard Features:
 - a. Series: UL 1686 Series C2 and IEC 60309-2 Series II.
 - b. Voltage Rating: 600 V.
 - c. Configuration: 3 pole, 4 wire, [20 A][30 A, IP67][30 A, IP69k][60 A, IP67][60 A, IP69k][100 A, IP67][100 A, IP69k].

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that receptacles to be procured and installed for Owner-furnished equipment are compatible with mating attachment plugs on equipment.

3.2 INSTALLATION

- A. Comply with manufacturer's published instructions.
- B. Reference Standards:
 - 1. Unless more stringent requirements are specified in the Contract Documents or manufacturer's published instructions, comply with installation instructions in NECA NEIS 130.
 - 2. Mounting Heights: Unless otherwise indicated in the Contract Documents, comply with mounting heights recommended in NECA NEIS 1.
 - 3. Receptacle Orientation: Unless otherwise indicated in the Contract Documents, orient receptacle to match configuration diagram in UL 1686.
 - 4. Consult Architect for resolution of conflicting requirements.
- C. Identification:
 - 1. Identify cover or cover plate for device with panelboard identification and circuit number.
 - a. Mark cover or cover plate using hot, stamped, or engraved machine printing with [black][white][red]-filled lettering, and provide durable wire markers or tags inside device box or outlet box.
 - b. Healthcare Facilities: Distinctively identify covers or cover plates of device boxes and outlet boxes that are supplied from life safety and critical branch power supplies following facility's standard practice.
- D. Interfaces with Other Work:
 - 1. Coordinate installation of new products for <Insert system or product group> with existing conditions.

- a. <Insert requirements for transition between new and existing>.
2. Coordinate with <Insert Section number and title> for <Insert description of interfacing related Work>.
- a. <Insert requirements for transition between this Section and related Work>.

3.3 FIELD QUALITY CONTROL

- A. Administrant for Low-Voltage Electrical Tests and Inspections:
 1. [Owner][Tenant] will engage qualified low-voltage electrical testing and inspecting agency to administer and perform tests and inspections.
 2. Engage qualified low-voltage electrical testing and inspecting agency to administer and perform tests and inspections.
 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
 4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].
- B. Acceptance Testing Preparation:
 1. <Insert requirements>.
- C. Field tests and inspections must be witnessed by [Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>.
- D. Tests and Inspections:
 1. Insert and remove test plug to verify that device is securely mounted.
 2. Measure line voltage.
 3. Measure percent voltage drop.
 4. Measure ground impedance, which must be not greater than 2 ohms.
 5. Perform additional installation and maintenance inspections and diagnostic tests in accordance with NECA NEIS 130 and manufacturer's published instructions.
 6. <Insert tests and inspections>.
- E. Nonconforming Work:
 1. Device will be considered defective if it does not pass tests and inspections.
 2. Remove and replace defective units and retest.
- F. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.
- G. Manufacturer Services: Engage factory-authorized service representative to [support][supervise] field tests and inspections.
 1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.



3.4 PROTECTION

- A. Schedule and sequence installation to minimize risk of contamination of wires and cables, devices, device boxes, outlet boxes, covers, and cover plates by plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other materials.
- B. After installation, protect wires and cables, devices, device boxes, outlet boxes, covers, and cover plates from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 26 27 26 00G



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SECTION 26 27 26 00H - SPECIAL-PURPOSE POWER OUTLET ASSEMBLIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fabricated power outlet cord management assemblies.
2. Fabricated pendant push-button station fittings.
3. Spring-driven commercial/industrial-use cord reels.
4. Motor-driven cord reels.
5. Motor-driven cable management systems.
6. Cord reels for use in hazardous locations.
7. Pendant push-button stations and components.
8. Pendant relocatable power taps.

B. Products Installed, but Not Furnished, under This Section:

1. **<Insert products identified in "Existing Products to be Modified" Article or "Existing Products to be Removed and Reinstalled" Article>.**

C. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. **[Section 013100 "Project Management and Coordination"]<Insert Section number and title>** for preinstallation conference procedures.
5. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs referenced by this Section.
6. Section 262726.51 "Connectors, Cords, and Plugs" for connectors, cords, and strain-relief cord grips.
7. Section 270528 "Pathways for Communications Systems" specifies additional requirements for raceway materials, routing, locations, and identification of communications equipment and cabling.

1.2 DEFINITIONS

- A. Commercial/Industrial-Use Cord Reel: A cord reel subject to severe use in factories, commercial garages, construction sites, and similar locations requiring a harder service type cord.
- B. General-Use Cord Reel: A cord reel that is acceptable for residential applications, and marked for use either indoors or outdoors. General-use outdoor cord reels are intended to be stored indoors when not in use.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at **[the Project site]<Insert location>**.
- B. Preinstallation Coordination Meeting(s): For ceiling-mounted cable reels. Conduct meeting **[as videoconference][or][at the Project site]<Insert location>** before **<Insert construction activity>**.
 - 1. Attendees: Installers, fabricators, representatives of manufacturers, and administrators for field tests and inspections. Notify Architect[, **Construction Manager**][, and **Owner's Commissioning Authority**] of scheduled meeting dates.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing agency, certifying product's compliance with specified listing criteria.
 - a. If listed manufacturer differs from selling manufacturer, indicate relationship between entities on submittal. Clearly indicate which entity warrants product performance and fitness for purpose.
 - b. Listing criteria identified in approval letter must match specified listing criteria. UL label indicating approval of equipment's enclosure is not considered approval of equipment for intended application.
 - c. Product identification in approval letter must match product branding and model numbers in submittal. Approval letters for discontinued or superseded products are unacceptable for submitted product.
 - 2. Include manufacturer's sample extended warranty language.
- B. Field quality-control reports.

1.5 INFORMATIONAL SUBMITTALS

- A. Manufacturer's published instructions.
- B. Field Reports:
 - 1. Manufacturer's field reports for field quality-control support.

1.6 CLOSEOUT SUBMITTALS

- A. Warranty documentation.

1.7 QUALIFICATIONS

- A. Electrical Power Testing (EPT) Technician III: Possessing active NICET EPT Level III certification. Able to manage switching procedures, conduct tests of complex equipment, analyze test and equipment data, plan a job, and lead a team. Has experience performing NFPA 70B, IEEE, and NETA electrical tests.

- B. Electrical Power Testing (EPT) Technician IV: Possessing active NICET EPT Level IV certification. Able to conduct tests of complex metering and relay systems; evaluate tests, test equipment, test results, and power system performance; recommend actions to maintain or improve system performance; and lead multi-team projects.
- C. Electrical Power Testing and Inspecting Agency: Entities possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
 - 1. On-site electrical testing supervisors must possess active NICET EPT Technician [III][IV] certification.

1.8 WARRANTY

- A. Special Installer Extended Warranty: Installer warrants that fabricated and installed cord-reel power outlet assemblies perform in accordance with specified requirements and agrees to repair or replace assemblies that fail to perform as specified within extended warranty period.
 - 1. Extended Warranty Period: **[Two][Three][Four]<Insert number>** years from date of Substantial Completion; full coverage for labor, materials, and equipment.
- B. Special Manufacturer Extended Warranty: Manufacturer warrants that components of cord-reel power outlet assemblies perform in accordance with specified requirements and agrees to provide repair or replacement of components that fail to perform as specified within extended warranty period.
 - 1. Initial Extended Warranty Period: **[Three][Four][Five]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for labor, materials, and equipment.
 - 2. Follow-On Extended Warranty Period: **[Eight]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for materials only, free on board **[origin][destination]**, freight prepaid.

PART 2 - PRODUCTS

2.1 EXISTING PRODUCTS TO BE MODIFIED

- A. Basis for Pricing: **<Insert name of manufacturer; model number or series for existing product>**.
- B. Description: **<Insert description of existing product, including special features, options, and finishes that may impact Work>**.
- C. Accessories: **<Insert accessories included with existing product>**.

2.2 EXISTING PRODUCTS TO BE REMOVED AND REINSTALLED

- A. Basis for Pricing: **<Insert name of manufacturer; model number or series for existing product>**.
- B. Description: **<Insert description of existing product, including special features, options, and finishes that may impact the Work>**.
- C. Accessories: **<Insert accessories included with existing product>**.

2.3 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2.4 FABRICATED POWER OUTLET CORD MANAGEMENT ASSEMBLIES

- A. Description: Power outlet cord management assemblies that are custom fabricated by manufacturer or Installer.
- B. Source Limitations: Obtain all components for each power outlet cord management assembly from single manufacturer.

- C. Power Outlet Cord Management Assembly :

- 1. General Characteristics: Provide the following specified products with fabricated power outlet cord management assembly:

- a. Cord Management System:

- 1) Spring-driven commercial/industrial-use cord reel, <Insert wire size> conductors .
- 2) Motor-driven, indoor, general-use cord reel; <Insert wire size> conductors .
- 3) DC motor-driven cable management system .
- 4) Cord reel for use in Class I Group C hazardous location .
- 5) Cord reel for use in Class I Group D hazardous location .
- 6) Cord reel for use in Class II Group E hazardous location .
- 7) Cord reel for use in Class II Group F hazardous location .
- 8) Cord reel for use in Class II Group G hazardous location .
- 9) Cord reel for use in Class III hazardous location .

- b. Termination Fitting:

- 1) Owner-furnished fitting.
- 2) Commercial pendant push-button station .
- 3) Pendant relocatable power tap .
- 4) Fabricated pendant push-button station fitting .
- 5) Indoor-use, dry-location cord connector; <Insert NEMA configuration><Insert drawing designation> specified in Section 262726.51 "Connectors, Cords, and Plugs."
- 6) Indoor-use, sealed cord connector; <Insert NEMA configuration><Insert drawing designation> specified in Section 262726.51 "Connectors, Cords, and Plugs."
- 7) Hospital-grade, indoor-use, sealed cord connector; <Insert NEMA configuration><Insert drawing designation> specified in Section 262726.51 "Connectors, Cords, and Plugs."
- 8) Indoor-use, compression-grip, sealed cord connector; <Insert NEMA configuration><Insert drawing designation> specified in Section 262726.51 "Connectors, Cords, and Plugs."
- 9) Outdoor-use, watertight, sealed cord connector; <Insert NEMA configuration><Insert drawing designation> specified in Section 262726.51 "Connectors, Cords, and Plugs."
- 10) Antimicrobial, watertight, sealed cord connector; <Insert NEMA configuration><Insert drawing designation> specified in Section 262726.51 "Connectors, Cords, and Plugs."

- 11) <Insert title of product><Insert drawing designation> specified in <Insert Section number and title>.

c. Cord or Cable:

- 1) Oil-resistant, extra-hard-usage, jacketed, flexible cord for indoor damp locations; <Indicate wire size>, <Indicate wire quantity>, and <Indicate length> specified in Section 262726.51 "Connectors, Cords, and Plugs."
- 2) Oil-resistant, extra-hard-usage, jacketed, flexible cord for outdoor or indoor wet locations; <Indicate wire size>, <Indicate wire quantity>, and <Indicate length> specified in Section 262726.51 "Connectors, Cords, and Plugs."
- 3) Antimicrobial, oil-resistant, extra-hard-usage, jacketed, flexible cord for outdoor or indoor wet locations; <Indicate wire size>, <Indicate wire quantity>, and <Indicate length> specified in Section 262726.51 "Connectors, Cords, and Plugs."
- 4) Oil-resistant, hard-usage, jacketed, flexible cord for indoor damp locations; <Indicate wire size>, <Indicate wire quantity>, and <Indicate length> specified in Section 262726.51 "Connectors, Cords, and Plugs."
- 5) Oil-resistant, hard-usage, jacketed, flexible cord for outdoor or indoor wet locations; <Indicate wire size>, <Indicate wire quantity>, and <Indicate length> specified in Section 262726.51 "Connectors, Cords, and Plugs."

- d. Strain-relief cord grips specified in Section 262726.51 "Connectors, Cords, and Plugs."

2. Accessories:

- a. Mounting: [Ceiling][Wall][Floor] mounted.
- b. <Insert required accessory>.

3. Seismic and Wind Performance: Installed product must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:

- a. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events[and unit must be fully operational after seismic events].
- b. Component Importance Factor (Ip): [1.0][1.5].
- c. Component Amplification Factor (ap): [1.0][2.5]<Insert value>.
- d. Component Response Modification Factor (Rp): [1.5][2.0][2.5][6.0]<Insert value>.
- e. Component Overstrength Factor (Qo): [1.5][2.5]<Insert value>.

2.5 FABRICATED PENDANT PUSH-BUTTON STATION FITTINGS

- A. Description: Pendant push-button station fittings that are custom fabricated by manufacturer or Installer.
- B. Source Limitations: Obtain all components for each pendant push-button station fitting from single manufacturer.
- C. Pendant Push-Button Station Fitting :

1. General Characteristics: Provide the following specified components with fabricated pendant push-button station fitting:
 - a. Pendant push-button station enclosure .
 - b. <Insert quantity> blank cover plates.
 - c. Horn for 19 mm accessory hole.
 - d. Red pilot light for [12 mm accessory hole][19 mm accessory hole][22 mm button

- space].
 - e. Push-button switch .
 - f. Selector switch .
 - g. <Insert title of product><Insert drawing designation> specified in <Insert Section number and title>.
- 2. Accessories:
 - a. <Insert required accessory>.
- 3. Seismic and Wind Performance: Installed product must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:
 - a. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events[**and unit must be fully operational after seismic events**].
 - b. Component Importance Factor (Ip): [1.0][1.5].
 - c. Component Amplification Factor (ap): [1.0][2.5]<Insert value>.
 - d. Component Response Modification Factor (Rp): [1.5][2.0][2.5][6.0]<Insert value>.
 - e. Component Overstrength Factor (Ωo): [1.5][2.5]<Insert value>.

2.6 SPRING-DRIVEN COMMERCIAL/INDUSTRIAL-USE CORD REELS

- A. Description: Reel equipped with, or intended for use with, length of flexible cord, providing means for cord to be unwound by user as desired, providing spring take-up mechanism to rewind cord on reel, and providing latch to restrain action of spring take-up mechanism while cord reel is in use.
- B. Spring-Driven Commercial/Industrial-Use Cord Reel, No. 14 AWG Conductors :
 - 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Eaton]
 - b. [Ericson Manufacturing Company]
 - c. [Gleason Reel; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - d. <Insert manufacturer's name>
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Eaton]
 - b. [Ericson Manufacturing Company]
 - c. [Gleason Reel; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - d. <Insert manufacturer's name>
 - 3. Listing Criteria:
 - a. Reference Standards: UL CCN SBCV and UL 355.
 - 4. Standard Features:

- a. Spring take-up retraction mechanism.
- b. Electrical Rating with Cable: 600 V, [18 A][15 A][12 A][10.5 A][7.5 A].
- c. Color: [Yellow][Black][White]<Insert color>.
- d. Enclosure Degree of Protection: [Type 4][Type 4X].
- e. Ball stop.
- f. Pivot base.
- g. Spool Capacity:
 - 1) No. 14 AWG, two wires and equipment ground, [20 ft (6 m)][30 ft (9.1 m)][40 ft (12.2 m)][50 ft (15.2 m)][60 ft (18.3 m)][70 ft (21.3 m)].
 - 2) No. 14 AWG, three wires and equipment ground, [20 ft (6 m)][30 ft (9.1 m)][35 ft (10.7 m)][40 ft (12.2 m)][50 ft (15.2 m)][60 ft (18.3 m)][70 ft (21.3 m)].
 - 3) No. 14 AWG, five wires and equipment ground, [20 ft (6 m)][30 ft (9.1 m)][40 ft (12.2 m)][50 ft (15.2 m)][60 ft (18.3 m)].
 - 4) No. 14 AWG, seven wires and equipment ground, [20 ft (6 m)][30 ft (9.1 m)][40 ft (12.2 m)][50 ft (15.2 m)].
 - 5) No. 14 AWG, nine wires and equipment ground, [20 ft (6 m)][30 ft (9.1 m)].
 - 6) No. 14 AWG, eleven wires and equipment ground, [20 ft (6 m)][60 ft (18.3 m)].
 - 7) No. 14 AWG, two wires and equipment ground, [25 ft (7.6 m)][35 ft (10.7 m)][45 ft (13.7 m)][90 ft (27.4 m)][100 ft (30.5 m)][125 ft (38.1 m)][150 ft (45.7 m)].
 - 8) No. 14 AWG, three wires and equipment ground, [25 ft (7.6 m)][45 ft (13.7 m)][65 ft (19.8 m)][80 ft (24.4 m)][90 ft (27.4 m)][100 ft (30.5 m)][125 ft (38.1 m)][150 ft (45.7 m)].
 - 9) No. 14 AWG, five wires and equipment ground, [25 ft (7.6 m)][35 ft (10.7 m)][45 ft (13.7 m)].
 - 10) No. 14 AWG, seven wires and equipment ground, [25 ft (7.6 m)][35 ft (10.7 m)][45 ft (13.7 m)].
 - 11) No. 14 AWG, nine wires and equipment ground, [25 ft (7.6 m)][50 ft (15.2 m)].
 - 12) No. 14 AWG, eleven wires and equipment ground, [25 ft (7.6 m)][30 ft (9.1 m)].
5. Seismic and Wind Performance: Installed product must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:
 - a. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events[**and unit must be fully operational after seismic events**].
 - b. Component Importance Factor (Ip): [1.0][1.5].
 - c. Component Amplification Factor (ap): [1.0][2.5]<Insert value>.
 - d. Component Response Modification Factor (Rp): [1.5][2.0][2.5][6.0]<Insert value>.
 - e. Component Overstrength Factor (Ωo): [1.5][2.5]<Insert value>.
- C. Spring-Driven Commercial/Industrial-Use Cord Reel, No. 12 AWG Conductors :
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Appleton; Emerson Electric Co., Automation Solutions]
 - b. [Ericson Manufacturing Company]
 - c. [Gleason Reel; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - d. [Reelcraft Industries Inc]
 - e. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the

following:

- a. [Appleton; Emerson Electric Co., Automation Solutions]
- b. [Ericson Manufacturing Company]
- c. [Gleason Reel; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
- d. [Reelcraft Industries Inc]
- e. <Insert manufacturer's name>

3. Listing Criteria:

- a. Reference Standards: UL CCN SBCV and UL 355.

4. Standard Features:

- a. Spring take-up retraction mechanism.
- b. Electrical Rating with Cable: 600 V, [25 A][20 A][16 A][14 A].
- c. Color: [Yellow][Black][White]<Insert color>.
- d. Enclosure Degree of Protection: [Type 4][Type 4X].
- e. Ball stop.
- f. Pivot base.
- g. Spool Capacity:
 - 1) No. 12 AWG, two wires and equipment ground, [20 ft (6 m)][25 ft (7.6 m)][30 ft (9.1 m)][40 ft (12.2 m)][50 ft (15.2 m)][60 ft (18.3 m)].
 - 2) No. 12 AWG, three wires and equipment ground, [20 ft (6 m)][25 ft (7.6 m)][30 ft (9.1 m)][40 ft (12.2 m)][45 ft (13.7 m)][50 ft (15.2 m)][60 ft (18.3 m)][100 ft (30.5 m)].
 - 3) No. 12 AWG, five wires and equipment ground, [20 ft (6 m)][30 ft (9.1 m)][40 ft (12.2 m)].
 - 4) No. 12 AWG, seven wires and equipment ground, [20 ft (6 m)][30 ft (9.1 m)].
 - 5) No. 12 AWG, two wires and equipment ground, [35 ft (10.7 m)][45 ft (13.7 m)][70 ft (21.3 m)][80 ft (24.4 m)][90 ft (27.4 m)][100 ft (30.5 m)][125 ft (38.1 m)][150 ft (45.7 m)].
 - 6) No. 12 AWG, three wires and equipment ground, [35 ft (10.7 m)][70 ft (21.3 m)][80 ft (24.4 m)][90 ft (27.4 m)][125 ft (38.1 m)].
 - 7) No. 12 AWG, four wires and equipment ground, [20 ft (6 m)][30 ft (9.1 m)][40 ft (12.2 m)].
 - 8) No. 12 AWG, five wires and equipment ground, [25 ft (7.6 m)][35 ft (10.7 m)][45 ft (13.7 m)].
 - 9) No. 12 AWG, seven wires and equipment ground, [25 ft (7.6 m)][40 ft (12.2 m)].

5. Seismic and Wind Performance: Installed product must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:

- a. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events[**and unit must be fully operational after seismic events**].
- b. Component Importance Factor (Ip): [1.0][1.5].
- c. Component Amplification Factor (ap): [1.0][2.5]<Insert value>.
- d. Component Response Modification Factor (Rp): [1.5][2.0][2.5][6.0]<Insert value>.
- e. Component Overstrength Factor (Oo): [1.5][2.5]<Insert value>.

D. Spring-Driven Commercial/Industrial-Use Cord Reel, No. 10 AWG Conductors :

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

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

- a. [Eaton]
 - b. [Ericson Manufacturing Company]
 - c. [Gleason Reel; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - d. [Reelcraft Industries Inc]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Eaton]
 - b. [Ericson Manufacturing Company]
 - c. [Gleason Reel; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - d. [Reelcraft Industries Inc]
 - e. <Insert manufacturer's name>
3. Listing Criteria:
- a. Reference Standards: UL CCN SBCV and UL 355.
4. Standard Features:
- a. Spring take-up retraction mechanism.
 - b. Electrical Rating with Cable: 600 V, [30 A][25 A][20 A][17.5 A].
 - c. Color: [Yellow][Black][White]<Insert color>.
 - d. Enclosure Degree of Protection: [Type 4][Type 4X].
 - e. Ball stop.
 - f. Pivot base.
 - g. Spool Capacity:
 - 1) No. 10 AWG, two wires and equipment ground, [20 ft (6 m)][30 ft (9.1 m)][40 ft (12.2 m)][50 ft (15.2 m)][60 ft (18.3 m)].
 - 2) No. 10 AWG, three wires and equipment ground, [20 ft (6 m)][30 ft (9.1 m)][40 ft (12.2 m)][50 ft (15.2 m)].
 - 3) No. 10 AWG, five wires and equipment ground, [20 ft (6 m)][30 ft (9.1 m)].
 - 4) No. 10 AWG, two wires and equipment ground, [25 ft (7.6 m)][35 ft (10.7 m)][45 ft (13.7 m)][70 ft (21.3 m)][80 ft (24.4 m)][90 ft (27.4 m)][100 ft (30.5 m)][125 ft (38.1 m)].
 - 5) No. 10 AWG, three wires and equipment ground, [25 ft (7.6 m)][35 ft (10.7 m)][45 ft (13.7 m)][70 ft (21.3 m)][80 ft (24.4 m)][90 ft (27.4 m)][100 ft (30.5 m)][125 ft (38.1 m)].
 - 6) No. 10 AWG, four wires and equipment ground, [30 ft (9.1 m)][60 ft (18.3 m)][70 ft (21.3 m)].
 - 7) No. 10 AWG, five wires and equipment ground, 25 ft (7.6 m).
 - 8) No. 10 AWG, seven wires and equipment ground, 20 ft (6 m).
5. Seismic and Wind Performance: Installed product must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:
- a. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events[and unit must be fully operational after seismic events].

- b. Component Importance Factor (Ip): **[1.0][1.5]**.
- c. Component Amplification Factor (ap): **[1.0][2.5]<Insert value>**.
- d. Component Response Modification Factor (Rp): **[1.5][2.0][2.5][6.0]<Insert value>**.
- e. Component Overstrength Factor (Ωo): **[1.5][2.5]<Insert value>**.

E. Spring-Driven Commercial/Industrial-Use Cord Reel, No. 8 AWG Conductors :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Eaton]**
 - b. **[Ericson Manufacturing Company]**
 - c. **[Gleason Reel; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Eaton]**
 - b. **[Ericson Manufacturing Company]**
 - c. **[Gleason Reel; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - d. **<Insert manufacturer's name>**
3. Listing Criteria:
 - a. Reference Standards: UL CCN SBCV and UL 355.
4. Standard Features:
 - a. Spring take-up retraction mechanism.
 - b. Electrical Rating with Cable: 600 V, **[40 A][35 A]**.
 - c. Color: **[Yellow][Black][White]<Insert color>**.
 - d. Enclosure Degree of Protection: **[Type 4][Type 4X]**.
 - e. Ball stop.
 - f. Pivot base.
 - g. Spool Capacity:
 - 1) No. 8 AWG, two wires and equipment ground, **[20 ft (6 m)][30 ft (9.1 m)]**.
 - 2) No. 8 AWG, three wires and equipment ground, **[20 ft (6 m)][30 ft (9.1 m)]**.
 - 3) No. 8 AWG, two wires and equipment ground, **[25 ft (7.6 m)][50 ft (15.2 m)]**.
 - 4) No. 8 AWG, three wires and equipment ground, **[25 ft (7.6 m)][40 ft (12.2 m)][50 ft (15.2 m)][60 ft (18.3 m)][70 ft (21.3 m)]**.
5. Seismic and Wind Performance: Installed product must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:
 - a. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events **[and unit must be fully operational after seismic events]**.
 - b. Component Importance Factor (Ip): **[1.0][1.5]**.
 - c. Component Amplification Factor (ap): **[1.0][2.5]<Insert value>**.
 - d. Component Response Modification Factor (Rp): **[1.5][2.0][2.5][6.0]<Insert value>**.

- e. Component Overstrength Factor (Ω_o): **[1.5][2.5]<Insert value>**.
- F. Spring-Driven Commercial/Industrial-Use Cord Reel, No. 6 AWG Conductors :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Ericson Manufacturing Company]**
 - b. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Ericson Manufacturing Company]**
 - b. **<Insert manufacturer's name>**
 3. Listing Criteria:
 - a. Reference Standards: UL CCN SBCV and UL 355.
 4. Standard Features:
 - a. Spring take-up retraction mechanism.
 - b. Electrical Rating with Cable: 600 V, **[55 A][45 A][36 A]**.
 - c. Color: **[Yellow][Black][White]<Insert color>**.
 - d. Enclosure Degree of Protection: **[Type 4][Type 4X]**.
 - e. Ball stop.
 - f. Pivot base.
 - g. Spool Capacity:
 - 1) No. 6 AWG, two wires and equipment ground, **70 ft (21.3 m)**.
 - 2) No. 6 AWG, three wires and equipment ground, **[30 ft (9.1 m)][50 ft (15.2 m)]**.
 - 3) No. 6 AWG, four wires and equipment ground, **40 ft (12.2 m)**.
 5. Seismic and Wind Performance: Installed product must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:
 - a. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events **[and unit must be fully operational after seismic events]**.
 - b. Component Importance Factor (I_p): **[1.0][1.5]**.
 - c. Component Amplification Factor (a_p): **[1.0][2.5]<Insert value>**.
 - d. Component Response Modification Factor (R_p): **[1.5][2.0][2.5][6.0]<Insert value>**.
 - e. Component Overstrength Factor (Ω_o): **[1.5][2.5]<Insert value>**.
- G. Spring-Driven Commercial/Industrial-Use Cord Reel, No. 4 AWG Conductors :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Ericson Manufacturing Company]**



- b. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Ericson Manufacturing Company]
 - b. <Insert manufacturer's name>
- 3. Listing Criteria:
 - a. Reference Standards: UL CCN SBCV and UL 355.
- 4. Standard Features:
 - a. Spring take-up retraction mechanism.
 - b. Electrical Rating with Cable: 600 V, 70 A.
 - c. Color: [Yellow][Black][White]<Insert color>.
 - d. Enclosure Degree of Protection: [Type 4][Type 4X].
 - e. Ball stop.
 - f. Pivot base.
 - g. Spool Capacity:
 - 1) No. 4 AWG, two wires and equipment ground, 30 ft (9.1 m).
- 5. Seismic and Wind Performance: Installed product must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:
 - a. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events[and unit must be fully operational after seismic events].
 - b. Component Importance Factor (Ip): [1.0][1.5].
 - c. Component Amplification Factor (ap): [1.0][2.5]<Insert value>.
 - d. Component Response Modification Factor (Rp): [1.5][2.0][2.5][6.0]<Insert value>.
 - e. Component Overstrength Factor (Ωo): [1.5][2.5]<Insert value>.

2.7 MOTOR-DRIVEN CORD REELS

- A. Description: Reel equipped with, or intended for use with, length of flexible cord, providing motor to dispense cord from and rewind cord on reel.
- B. Motor-Driven, Indoor, General-Use Cord Reel :
 - 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Conductix-Wampfler USA; Delachaux Group]
 - b. <Insert manufacturer's name>
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the

following:

- a. **[Conductix-Wampfler USA; Delachaux Group]**
- b. **<Insert manufacturer's name>**
3. Listing Criteria:
 - a. Reference Standards: UL CCN SBCV and UL 355.
4. Standard Features:
 - a. Electrical Rating with Cable: 125 V, 20 A.
 - b. DC motor dispensing and rewinding mechanism.
 - c. Color: **[Yellow][Black][White]<Insert color>**.
 - d. Enclosure Degree of Protection: **[Type 4][Type 4X]**.
 - e. Ball stop.
 - f. Pivot base.
 - g. Spool Capacity:
 - 1) No. 12 AWG, two wires and equipment ground, **[25 ft (7.6 m)][50 ft (15.2 m)]**.
5. Seismic and Wind Performance: Installed product must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:
 - a. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events **[and unit must be fully operational after seismic events]**.
 - b. Component Importance Factor (Ip): **[1.0][1.5]**.
 - c. Component Amplification Factor (ap): **[1.0][2.5]<Insert value>**.
 - d. Component Response Modification Factor (Rp): **[1.5][2.0][2.5][6.0]<Insert value>**.
 - e. Component Overstrength Factor (Qo): **[1.5][2.5]<Insert value>**.

2.8 MOTOR-DRIVEN CABLE MANAGEMENT SYSTEMS

- A. Description: Motor and guiding mechanism for automated dispensing and retrieving of multiconductor cable stored in a basket or container. Unlike reels, motor-driven cable management systems do not require a slip ring to transfer facility power to the cable.
- B. DC Motor-Driven Cable Management System :
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Glendinning Products LLC]**
 - b. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Glendinning Products LLC]**
 - b. **<Insert manufacturer's name>**



3. Listing Criteria:
 - a. Reference Standards: UL CCN SBCV and UL 355.
4. Standard Features:
 - a. Motor: **[12 V(dc)][24 V(dc)]**.
 - b. Environmental Rating: **[Indoor, damp][Outdoor, wet]** location.
 - c. Hawse Pipe: **[None][Stainless steel]**.
 - d. Control Operator: **[Toggle switch][Wireless remote control]**.
 - e. Cable Size:
 - 1) Handles cables between **0.47 inch (12 mm)** OD and **0.83 inch (21 mm)** OD.
 - 2) Handles cables between **0.83 inch (21 mm)** OD and **1.14 inch (29 mm)** OD.
 - 3) Handles cables between **1.14 inch (29 mm)** OD and **1.63 inch (42 mm)** OD.
5. Accessories:
 - a. Mounting Hardware: **<Insert description of hardware needed to mount system to ceiling, wall, or cable storage container>**.
 - b. Cable Storage: **<Insert description of basket or container needed to accommodate size and length of cable>**.
6. Seismic and Wind Performance: Installed product must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:
 - a. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events[**and unit must be fully operational after seismic events**].
 - b. Component Importance Factor (Ip): **[1.0][1.5]**.
 - c. Component Amplification Factor (ap): **[1.0][2.5]<Insert value>**.
 - d. Component Response Modification Factor (Rp): **[1.5][2.0][2.5][6.0]<Insert value>**.
 - e. Component Overstrength Factor (Ωo): **[1.5][2.5]<Insert value>**.

2.9 CORD REELS FOR USE IN HAZARDOUS LOCATIONS

- A. Description: Reel equipped with, or intended for use with, length of flexible cord, intended for installation in hazardous classified locations.
- B. Spring-Driven Cord Reel for Use in Class I Group C Hazardous Locations :
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Conductix-Wampfler USA; Delachaux Group]**
 - b. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[Conductix-Wampfler USA; Delachaux Group]**
 - b. **<Insert manufacturer's name>**
 3. Listing Criteria:
 - a. Reference Standards: UL CCN SAOX and UL 355.
 4. Standard Features:
 - a. Spring take-up retraction mechanism.
 - b. Electrical Rating with Cable: 600 V, **[35 A][25 A][20 A][18 A][15 A]**.
 - c. Color: **[Yellow][Black][White]<Insert color>**.
 - d. Enclosure Degree of Protection: **[Type 4][Type 4X]**.
 - e. Ball stop.
 - f. Pivot base.
 - g. Spool Capacity:
 - 1) No. 14 AWG, two wires and equipment ground, **[20 ft (6 m)][30 ft (9.1 m)][40 ft (12.2 m)][50 ft (15.2 m)][60 ft (18.3 m)][70 ft (21.3 m)]**.
 - 2) No. 14 AWG, three wires and equipment ground, **[20 ft (6 m)][30 ft (9.1 m)][40 ft (12.2 m)][50 ft (15.2 m)][60 ft (18.3 m)]**.
 - 3) No. 12 AWG, two wires and equipment ground, **[20 ft (6 m)][30 ft (9.1 m)][40 ft (12.2 m)][50 ft (15.2 m)][60 ft (18.3 m)]**.
 - 4) No. 12 AWG, three wires and equipment ground, **[20 ft (6 m)][30 ft (9.1 m)][40 ft (12.2 m)][50 ft (15.2 m)]**.
 - 5) No. 10 AWG, two wires and equipment ground, **[20 ft (6 m)][30 ft (9.1 m)][40 ft (12.2 m)]**.
 - 6) No. 10 AWG, three wires and equipment ground, **[20 ft (6 m)][30 ft (9.1 m)][40 ft (12.2 m)]**.
 5. Seismic and Wind Performance: Installed product must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:
 - a. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events **[and unit must be fully operational after seismic events]**.
 - b. Component Importance Factor (Ip): **[1.0][1.5]**.
 - c. Component Amplification Factor (ap): **[1.0][2.5]<Insert value>**.
 - d. Component Response Modification Factor (Rp): **[1.5][2.0][2.5][6.0]<Insert value>**.
 - e. Component Overstrength Factor (Qo): **[1.5][2.5]<Insert value>**.
- C. Spring-Driven Cord Reel for Use in Class I Group D Hazardous Locations :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Appleton; Emerson Electric Co., Automation Solutions]**
 - b. **[Conductix-Wampfler USA; Delachaux Group]**
 - c. **[KH Industries, Inc.]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. [Appleton; Emerson Electric Co., Automation Solutions]
- b. [Conductix-Wampfler USA; Delachaux Group]
- c. [KH Industries, Inc.]
- d. <Insert manufacturer's name>

3. Listing Criteria:

- a. Reference Standards: UL CCN SAOX and UL 355.

4. Standard Features:

- a. Spring take-up retraction mechanism.
- b. Electrical Rating with Cable: 600 V, [35 A][25 A][20 A][18 A][15 A].
- c. Color: [Yellow][Black][White]<Insert color>.
- d. Enclosure Degree of Protection: [Type 4][Type 4X].
- e. Ball stop.
- f. Pivot base.
- g. Spool Capacity:
 - 1) No. 14 AWG, two wires and equipment ground, [20 ft (6 m)][30 ft (9.1 m)][50 ft (15.2 m)].
 - 2) No. 14 AWG, three wires and equipment ground, [20 ft (6 m)][30 ft (9.1 m)][50 ft (15.2 m)].
 - 3) No. 12 AWG, two wires and equipment ground, [30 ft (9.1 m)][50 ft (15.2 m)].
 - 4) No. 14 AWG, two wires and equipment ground, [40 ft (12.2 m)][60 ft (18.3 m)][70 ft (21.3 m)].
 - 5) No. 14 AWG, three wires and equipment ground, [40 ft (12.2 m)][60 ft (18.3 m)].
 - 6) No. 12 AWG, two wires and equipment ground, [20 ft (6 m)][40 ft (12.2 m)][60 ft (18.3 m)].
 - 7) No. 12 AWG, three wires and equipment ground, [20 ft (6 m)][30 ft (9.1 m)][40 ft (12.2 m)][50 ft (15.2 m)].
 - 8) No. 10 AWG, two wires and equipment ground, [20 ft (6 m)][30 ft (9.1 m)][40 ft (12.2 m)].
 - 9) No. 10 AWG, three wires and equipment ground, [20 ft (6 m)][30 ft (9.1 m)][40 ft (12.2 m)].

5. Seismic and Wind Performance: Installed product must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:

- a. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events[**and unit must be fully operational after seismic events**].
- b. Component Importance Factor (Ip): [1.0][1.5].
- c. Component Amplification Factor (ap): [1.0][2.5]<Insert value>.
- d. Component Response Modification Factor (Rp): [1.5][2.0][2.5][6.0]<Insert value>.
- e. Component Overstrength Factor (Oo): [1.5][2.5]<Insert value>.

D. Spring-Driven Cord Reel for Use in Class II Group E Hazardous Locations :

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

- b. **[Conductix-Wampfler USA; Delachaux Group]**
 - c. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Appleton; Emerson Electric Co., Automation Solutions]**
 - b. **[Conductix-Wampfler USA; Delachaux Group]**
 - c. **<Insert manufacturer's name>**
 3. Listing Criteria:
 - a. Reference Standards: UL CCN SAOX and UL 355.
 4. Standard Features:
 - a. Spring take-up retraction mechanism.
 - b. Electrical Rating with Cable: 600 V, **[35 A][25 A][20 A][18 A][15 A]**.
 - c. Color: **[Yellow][Black][White]<Insert color>**.
 - d. Enclosure Degree of Protection: **[Type 4][Type 4X]**.
 - e. Ball stop.
 - f. Pivot base.
 - g. Spool Capacity:
 - 1) No. 14 AWG, two wires and equipment ground, **30 ft (9.1 m)**.
 - 2) No. 14 AWG, three wires and equipment ground, **30 ft (9.1 m)**.
 - 3) No. 14 AWG, two wires and equipment ground, **[20 ft (6 m)][40 ft (12.2 m)][50 ft (15.2 m)][60 ft (18.3 m)][70 ft (21.3 m)]**.
 - 4) No. 14 AWG, three wires and equipment ground, **[20 ft (6 m)][40 ft (12.2 m)][50 ft (15.2 m)][60 ft (18.3 m)]**.
 - 5) No. 12 AWG, two wires and equipment ground, **[20 ft (6 m)][30 ft (9.1 m)][40 ft (12.2 m)][50 ft (15.2 m)][60 ft (18.3 m)]**.
 - 6) No. 12 AWG, three wires and equipment ground, **[20 ft (6 m)][30 ft (9.1 m)][40 ft (12.2 m)][50 ft (15.2 m)]**.
 - 7) No. 10 AWG, two wires and equipment ground, **[20 ft (6 m)][30 ft (9.1 m)][40 ft (12.2 m)]**.
 - 8) No. 10 AWG, three wires and equipment ground, **[20 ft (6 m)][30 ft (9.1 m)][40 ft (12.2 m)]**.
 5. Seismic and Wind Performance: Installed product must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:
 - a. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events **[and unit must be fully operational after seismic events]**.
 - b. Component Importance Factor (Ip): **[1.0][1.5]**.
 - c. Component Amplification Factor (ap): **[1.0][2.5]<Insert value>**.
 - d. Component Response Modification Factor (Rp): **[1.5][2.0][2.5][6.0]<Insert value>**.
 - e. Component Overstrength Factor (Oo): **[1.5][2.5]<Insert value>**.
- E. Spring-Driven Cord Reel for Use in Class II Group F Hazardous Locations :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the**

following]:

- a. [Appleton; Emerson Electric Co., Automation Solutions]
 - b. [Conductix-Wampfler USA; Delachaux Group]
 - c. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Appleton; Emerson Electric Co., Automation Solutions]
 - b. [Conductix-Wampfler USA; Delachaux Group]
 - c. <Insert manufacturer's name>
3. Listing Criteria:
 - a. Reference Standards: UL CCN SAOX and UL 355.
4. Standard Features:
 - a. Spring take-up retraction mechanism.
 - b. Electrical Rating with Cable: 600 V, [35 A][25 A][20 A][18 A][15 A].
 - c. Color: [Yellow][Black][White]<Insert color>.
 - d. Enclosure Degree of Protection: [Type 4][Type 4X].
 - e. Ball stop.
 - f. Pivot base.
 - g. Spool Capacity:
 - 1) No. 14 AWG, two wires and equipment ground, 30 ft (9.1 m).
 - 2) No. 14 AWG, three wires and equipment ground, 30 ft (9.1 m).
 - 3) No. 14 AWG, two wires and equipment ground, [20 ft (6 m)][40 ft (12.2 m)][50 ft (15.2 m)][60 ft (18.3 m)][70 ft (21.3 m)].
 - 4) No. 14 AWG, three wires and equipment ground, [20 ft (6 m)][40 ft (12.2 m)][50 ft (15.2 m)][60 ft (18.3 m)].
 - 5) No. 12 AWG, two wires and equipment ground, [20 ft (6 m)][30 ft (9.1 m)][40 ft (12.2 m)][50 ft (15.2 m)][60 ft (18.3 m)].
 - 6) No. 12 AWG, three wires and equipment ground, [20 ft (6 m)][30 ft (9.1 m)][40 ft (12.2 m)][50 ft (15.2 m)].
 - 7) No. 10 AWG, two wires and equipment ground, [20 ft (6 m)][30 ft (9.1 m)][40 ft (12.2 m)].
 - 8) No. 10 AWG, three wires and equipment ground, [20 ft (6 m)][30 ft (9.1 m)][40 ft (12.2 m)].
5. Seismic and Wind Performance: Installed product must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:
 - a. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events[and unit must be fully operational after seismic events].
 - b. Component Importance Factor (Ip): [1.0][1.5].
 - c. Component Amplification Factor (ap): [1.0][2.5]<Insert value>.
 - d. Component Response Modification Factor (Rp): [1.5][2.0][2.5][6.0]<Insert value>.
 - e. Component Overstrength Factor (Oo): [1.5][2.5]<Insert value>.

F. Spring-Driven Cord Reel for Use in Class II Group G Hazardous Locations :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Appleton; Emerson Electric Co., Automation Solutions]**
 - b. **[Conductix-Wampfler USA; Delachaux Group]**
 - c. **[KH Industries, Inc.]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Appleton; Emerson Electric Co., Automation Solutions]**
 - b. **[Conductix-Wampfler USA; Delachaux Group]**
 - c. **[KH Industries, Inc.]**
 - d. **<Insert manufacturer's name>**
3. Listing Criteria:
 - a. Reference Standards: UL CCN SAOX and UL 355.
4. Standard Features:
 - a. Spring take-up retraction mechanism.
 - b. Electrical Rating with Cable: 600 V, **[35 A][25 A][20 A][18 A][15 A]**.
 - c. Color: **[Yellow][Black][White]<Insert color>**.
 - d. Enclosure Degree of Protection: **[Type 4][Type 4X]**.
 - e. Ball stop.
 - f. Pivot base.
 - g. Spool Capacity:
 - 1) No. 14 AWG, two wires and equipment ground, **[20 ft (6 m)][30 ft (9.1 m)][50 ft (15.2 m)]**.
 - 2) No. 14 AWG, three wires and equipment ground, **[20 ft (6 m)][30 ft (9.1 m)][50 ft (15.2 m)]**.
 - 3) No. 12 AWG, two wires and equipment ground, **[30 ft (9.1 m)][50 ft (15.2 m)]**.
 - 4) No. 14 AWG, two wires and equipment ground, **[40 ft (12.2 m)][60 ft (18.3 m)][70 ft (21.3 m)]**.
 - 5) No. 14 AWG, three wires and equipment ground, **[40 ft (12.2 m)][60 ft (18.3 m)]**.
 - 6) No. 12 AWG, two wires and equipment ground, **[20 ft (6 m)][40 ft (12.2 m)][60 ft (18.3 m)]**.
 - 7) No. 12 AWG, three wires and equipment ground, **[20 ft (6 m)][30 ft (9.1 m)][40 ft (12.2 m)][50 ft (15.2 m)]**.
 - 8) No. 10 AWG, two wires and equipment ground, **[20 ft (6 m)][30 ft (9.1 m)][40 ft (12.2 m)]**.
 - 9) No. 10 AWG, three wires and equipment ground, **[20 ft (6 m)][30 ft (9.1 m)][40 ft (12.2 m)]**.
5. Seismic and Wind Performance: Installed product must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:
 - a. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events **[and unit must be fully operational after seismic events]**.

- b. Component Importance Factor (Ip): [1.0][1.5].
- c. Component Amplification Factor (ap): [1.0][2.5]<Insert value>.
- d. Component Response Modification Factor (Rp): [1.5][2.0][2.5][6.0]<Insert value>.
- e. Component Overstrength Factor (Ωo): [1.5][2.5]<Insert value>.

G. Spring-Driven Cord Reel for Use in Class III Hazardous Locations :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Appleton; Emerson Electric Co., Automation Solutions]**
 - b. **[Conductix-Wampfler USA; Delachaux Group]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Appleton; Emerson Electric Co., Automation Solutions]**
 - b. **[Conductix-Wampfler USA; Delachaux Group]**
 - c. **<Insert manufacturer's name>**
3. Listing Criteria:
 - a. Reference Standards: UL CCN SAOX and UL 355.
4. Standard Features:
 - a. Spring take-up retraction mechanism.
 - b. Electrical Rating with Cable: 600 V, **[35 A][25 A][20 A][18 A][15 A]**.
 - c. Color: **[Yellow][Black][White]<Insert color>**.
 - d. Enclosure Degree of Protection: **[Type 4][Type 4X]**.
 - e. Ball stop.
 - f. Pivot base.
 - g. Spool Capacity:
 - 1) No. 14 AWG, two wires and equipment ground, **30 ft (9.1 m)**.
 - 2) No. 14 AWG, three wires and equipment ground, **30 ft (9.1 m)**.
 - 3) No. 14 AWG, two wires and equipment ground, **[20 ft (6 m)][40 ft (12.2 m)][50 ft (15.2 m)][60 ft (18.3 m)][70 ft (21.3 m)]**.
 - 4) No. 14 AWG, three wires and equipment ground, **[20 ft (6 m)][40 ft (12.2 m)][50 ft (15.2 m)][60 ft (18.3 m)]**.
 - 5) No. 12 AWG, two wires and equipment ground, **[20 ft (6 m)][30 ft (9.1 m)][40 ft (12.2 m)][50 ft (15.2 m)][60 ft (18.3 m)]**.
 - 6) No. 12 AWG, three wires and equipment ground, **[20 ft (6 m)][30 ft (9.1 m)][40 ft (12.2 m)][50 ft (15.2 m)]**.
 - 7) No. 10 AWG, two wires and equipment ground, **[20 ft (6 m)][30 ft (9.1 m)][40 ft (12.2 m)]**.
 - 8) No. 10 AWG, three wires and equipment ground, **[20 ft (6 m)][30 ft (9.1 m)][40 ft (12.2 m)]**.
5. Seismic and Wind Performance: Installed product must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:

- a. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events[**and unit must be fully operational after seismic events**].
- b. Component Importance Factor (Ip): **[1.0][1.5]**.
- c. Component Amplification Factor (ap): **[1.0][2.5]<Insert value>**.
- d. Component Response Modification Factor (Rp): **[1.5][2.0][2.5][6.0]<Insert value>**.
- e. Component Overstrength Factor (Qo): **[1.5][2.5]<Insert value>**.

2.10 PENDANT PUSH-BUTTON STATIONS AND COMPONENTS

- A. Description: Control assembly for electrical equipment, suspended on a flexible cord, that contains push-buttons alone or in combination with other pilot devices, such as selector switches and indicating lights.
- B. Commercial Pendant Push-Button Station :
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Ericson Manufacturing Company]**
 - b. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Ericson Manufacturing Company]**
 - b. **<Insert manufacturer's name>**
 3. Listing Criteria:
 - a. Reference Standards: UL CCN NKCR and **[UL 508][UL 1053][UL 60947-1][UL 60947-4-1][UL 60947-5-1]**.
 4. Standard Features:
 - a. Two buttons; momentary 1 NO/1 NO.
 - b. Two buttons; momentary 2 NO/2 NO.
 - c. Four buttons; two momentary 1 NO/1 NO.
 - d. Four buttons; two momentary 2 NO/2 NO.
 - e. Four buttons; momentary 1 NO/1 NO; momentary 1 NC+NO/1 NC+NO.
 - f. Four buttons; emergency stop; momentary 1 NC+NO/1 NC+NO.
 - g. Six buttons; maintained 1 NO; two momentary 1 NO/1 NO.
 - h. Six buttons; maintained 1 NO; two momentary 2 NO/2 NO.
 - i. Six buttons; maintained 1 NO/1 NC; two momentary 1 NC+NO/1 NC+NO.
 - j. Six buttons; emergency stop; two momentary 1 NC+NO/1 NC+NO.
 - k. Eight buttons; maintained 1 NO; three momentary 1 NO/1 NO.
 - l. Eight buttons; maintained 1 NO; three momentary 2 NO/2 NO.
 - m. Eight buttons; maintained 1 NO; three momentary 1 NC+NO/1 NC+NO.
 - n. Eight buttons; emergency stop; three momentary 1 NC+NO/1 NC+NO.
 - o. Ten buttons; maintained 1 NO; four momentary 1 NO/1 NO.
 - p. Ten buttons; maintained 1 NO; four momentary 1 NC+NO/1 NC+NO.
 - q. Ten buttons; emergency stop; four momentary 1 NC+NO/1 NC+NO.

- r. Twelve buttons; maintained 1 NO; five momentary 1 NO/1 NO.
- s. Twelve buttons; maintained 1 NO; five momentary 1 NC+NO/1 NC+NO.
- t. Twelve buttons; emergency stop; five momentary 1 NC+NO/1 NC+NO.

5. Seismic and Wind Performance: Installed product must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:

- a. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events[**and unit must be fully operational after seismic events**].
- b. Component Importance Factor (Ip): **[1.0][1.5]**.
- c. Component Amplification Factor (ap): **[1.0][2.5]<Insert value>**.
- d. Component Response Modification Factor (Rp): **[1.5][2.0][2.5][6.0]<Insert value>**.
- e. Component Overstrength Factor (Qo): **[1.5][2.5]<Insert value>**.

C. Pendant Push-Button Station Enclosure :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Ericson Manufacturing Company]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Ericson Manufacturing Company]**
 - b. **<Insert manufacturer's name>**
3. Listing Criteria:
 - a. Reference Standards: UL CCN NKCR and **[UL 508][UL 1053][UL 60947-1][UL 60947-4-1][UL 60947-5-1]**.
4. Standard Features:
 - a. Two-button enclosure.
 - b. Four-button enclosure.
 - c. Six-button enclosure.
 - d. Eight-button enclosure.
 - e. Ten-button enclosure.
 - f. Twelve-button enclosure.
5. Accessories:
 - a. Blank cover plates for unused button holes.
 - b. Horn for 19 mm accessory hole, one wire, 125 V(ac), 6 A/250 V(ac), 3 A.
 - c. Red pilot light for 12 mm accessory hole, one wire, 12 V(ac).
 - d. Red pilot light for 19 mm accessory hole, one wire, **[110 V(ac)][12 V(dc)][24 V(ac/dc)]**.
 - e. Red pilot light for 22 mm button space, one wire, **[110 V(ac)][12 V(dc)][24 V(ac/dc)]**.
6. Seismic and Wind Performance: Installed product must perform in accordance with Section

018123 "Facility Seismic and Wind Criteria" and the following:

- a. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events[**and unit must be fully operational after seismic events**].
- b. Component Importance Factor (Ip): **[1.0][1.5]**.
- c. Component Amplification Factor (ap): **[1.0][2.5]<Insert value>**.
- d. Component Response Modification Factor (Rp): **[1.5][2.0][2.5][6.0]<Insert value>**.
- e. Component Overstrength Factor (Qo): **[1.5][2.5]<Insert value>**.

D. Push-Button Switch :

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Ericson Manufacturing Company]**
 - b. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Ericson Manufacturing Company]**
 - b. **<Insert manufacturer's name>**
- 3. Listing Criteria:
 - a. Reference Standards: UL CCN NKCR and **[UL 508][UL 1053][UL 60947-1][UL 60947-4-1][UL 60947-5-1]**.
- 4. Standard Features:
 - a. Button Boot: **<Insert quantity>** clear label cover; **<Insert quantity>** black; **<Insert quantity>** red; **<Insert quantity>** green.
 - b. Emergency stop button, one wire, 1 NC.
 - c. Emergency stop button, one wire, 1 NO.
 - d. Emergency stop button, two wires, 1 NO+NC.
 - e. Emergency stop button, two wires, 2 NC.
 - f. Emergency stop button, two wires, 2 NO.
 - g. One button, one wire, momentary 1 NC.
 - h. One button, one wire, momentary 1 NO.
 - i. One button, two wires, momentary 1 NC+NO.
 - j. One button, two wires, momentary 2 NC.
 - k. One button, two wires, momentary 2 NO.
 - l. Two buttons, one wire, maintained interlocked 1 NO.
 - m. Two buttons, one wire, maintained interlocked 1 NC+NO.
 - n. Two buttons, two wires, momentary non-interlocked 1 NO/1 NC.
 - o. Two buttons, two wires, momentary non-interlocked 1 NO/1 NO.
 - p. Two buttons, two wires, momentary non-interlocked 1 NC+NO/1 NC+NO.
 - q. Two buttons, four wires, dual pole, momentary, with mechanical interlock 2 NO/2 NO.
 - r. Two buttons, four wires, dual pole, momentary, with mechanical interlock 2 NC+NO/2 NC+NO.
 - s. Two buttons, two wires, momentary, with mechanical interlock 1 NO/1 NO.
 - t. Two buttons, two wires, momentary, with mechanical interlock 1 NC+NO/1 NC+NO.



- u. Two buttons, three wires, momentary, with mechanical interlock, 2 Speed 2 NO/2 NO.
 - v. Two buttons, three wires, momentary, with mechanical interlock, 2 Speed 2 NO+NC/2 NO+NC.
 - w. Two buttons, four wires, momentary, with mechanical interlock, 3 Speed 1 NC+3 NO/1 NC+3 NO.
5. Seismic and Wind Performance: Installed product must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:
- a. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events[**and unit must be fully operational after seismic events**].
 - b. Component Importance Factor (Ip): [1.0][1.5].
 - c. Component Amplification Factor (ap): [1.0][2.5]<Insert value>.
 - d. Component Response Modification Factor (Rp): [1.5][2.0][2.5][6.0]<Insert value>.
 - e. Component Overstrength Factor (Qo): [1.5][2.5]<Insert value>.

E. Selector Switch :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Ericson Manufacturing Company]
 - b. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Ericson Manufacturing Company]
 - b. <Insert manufacturer's name>
3. Listing Criteria:
 - a. Reference Standards: UL CCN NKCR and [UL 508][UL 1053][UL 60947-1][UL 60947-4-1][UL 60947-5-1].
4. Standard Features:
 - a. One button, one wire, maintained 1 NC 2 Position.
 - b. One button, one wire, maintained 1 NO 2 Position.
 - c. One button, two wires, maintained 1 NO+NC 2 Position.
 - d. One button, two wires, maintained 2 NO 2 Position.
 - e. One button, two wires, maintained 2 NC 3 Position Center Off.
 - f. One button, two wires, maintained 2 NO 3 Position Center Off.
 - g. One button, two wires, maintained 2 NC 2 Position.
 - h. One button, two wires, maintained 1 NO+NC 3 Position Center Off.
5. Seismic and Wind Performance: Installed product must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:
 - a. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events[**and unit must be fully operational**

after seismic events].

- b. Component Importance Factor (Ip): [1.0][1.5].
- c. Component Amplification Factor (ap): [1.0][2.5]<Insert value>.
- d. Component Response Modification Factor (Rp): [1.5][2.0][2.5][6.0]<Insert value>.
- e. Component Overstrength Factor (Ωo): [1.5][2.5]<Insert value>.

2.11 PENDANT RELOCATABLE POWER TAPS

- A. Description: Electrical enclosure providing one or more receptacle outlets that must be attached to a cord reel in accordance with UL 355 to provide the power supply cord and attachment plug required by UL 1363. Portable power strips do not satisfy these requirements.
- B. Pendant Relocatable Power Tap :
 - 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Ericson Manufacturing Company]
 - b. <Insert manufacturer's name>
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Ericson Manufacturing Company]
 - b. <Insert manufacturer's name>
 - 3. Listing Criteria:
 - a. Reference Standards: UL CCN XBYS and UL 1363.
 - 4. Standard Features:
 - a. Nonmetallic outlet box with two duplex cover plates and two NEMA 5-15R duplex receptacles.
 - b. Weather-resistant, nonmetallic outlet box; two duplex cover plates with flip covers and two NEMA 5-15R duplex receptacles.
 - c. Nonmetallic outlet box with two duplex cover plates and two NEMA 5-20R duplex receptacles.
 - d. Weather-resistant, nonmetallic outlet box; two duplex cover plates with flip covers and two NEMA 5-20R duplex receptacles.
 - e. Weather-resistant, nonmetallic outlet box; two duplex cover plates with flip covers and two NEMA 5-20R duplex GFCI receptacles.
 - f. Nonmetallic outlet box with two cover plates and two NEMA L5-15R receptacles.
 - g. Weather-resistant, nonmetallic outlet box; two cover plates with flip covers and two NEMA L5-15R receptacles.
 - h. Nonmetallic outlet box with two duplex cover plates and two NEMA L5-15R duplex receptacles.
 - i. Weather-resistant, nonmetallic outlet box; two duplex cover plates with flip covers and two NEMA L5-15R duplex receptacles.
 - j. Nonmetallic enclosure with three NEMA L5-15R receptacles.
 - k. Nonmetallic outlet box with two cover plates and two NEMA L5-20R receptacles.
 - l. Weather-resistant, nonmetallic outlet box; two cover plates with flip covers and two NEMA

- L5-20R receptacles.
 - m. Nonmetallic outlet box with two cover plates and two NEMA L6-20R receptacles.
 - n. Weather-resistant, nonmetallic outlet box; two cover plates with flip covers and two NEMA L6-20R receptacles.
 - o. Nonmetallic enclosure with three NEMA 5-15R receptacles.
 - p. Nonmetallic enclosure with three NEMA 5-20R receptacles.
 - q. Nonmetallic enclosure with three NEMA 6-15R receptacles.
 - r. Nonmetallic enclosure with three NEMA 6-20R receptacles.
 - s. Nonmetallic enclosure with three NEMA L5-20R receptacles.
 - t. Nonmetallic enclosure with three NEMA L6-15R receptacles.
 - u. Nonmetallic enclosure with three NEMA L6-20R receptacles.
 - v. Nonmetallic enclosure with three NEMA L7-20R receptacles.
- 5. Seismic and Wind Performance: Installed product must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:
 - a. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events[**and unit must be fully operational after seismic events**].
 - b. Component Importance Factor (Ip): **[1.0][1.5]**.
 - c. Component Amplification Factor (ap): **[1.0][2.5]<Insert value>**.
 - d. Component Response Modification Factor (Rp): **[1.5][2.0][2.5][6.0]<Insert value>**.
 - e. Component Overstrength Factor (Qo): **[1.5][2.5]<Insert value>**.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for cord reel mounting and power connections to verify actual locations of mounts and power connections before cord reel installation.
- B. Examine walls, floors, and ceilings for suitable conditions where cord reel will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:
 - 1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
 - 2. Electrical Maintenance: NFPA 70B.
 - 3. Electrical Safety: NFPA 70E.
 - 4. Hot Work: NFPA 51B.
 - 5. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
 - 6. Work in Confined Spaces: NFPA 350.
 - 7. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
- C. Special Techniques:

1. **<Insert more stringent installation requirements that supplement or supersede manufacturers' instructions>.**

D. Interfaces with Other Work:

1. Coordinate installation of new products for **<Insert system or product group>** with existing conditions.
 - a. **<Insert requirements for transition between new and existing>.**
2. Coordinate with **<Insert Section number and title>** for **<Insert description of interfacing related Work>.**
 - a. **<Insert requirements for transition between this Section and related Work>.**

3.3 FIELD QUALITY CONTROL

A. Administrant for Electrical Power Tests and Inspections:

1. **[Owner][Tenant]** will engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
2. Engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].

B. Acceptance Testing Preparation:

1. **<Insert requirements>.**

C. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>.**

D. Tests and Inspections:

1. Perform manufacturer's recommended tests and inspections.
2. **<Insert Project-specific test or inspection>.**

E. Nonconforming Work:

1. Components and assemblies will be considered defective if they do not pass tests and inspections.
2. Remove and replace defective units and retest.

F. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

G. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.

1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.



3.4 ADJUSTING

- A. Adjust spring mechanisms and moving parts of cord reels and fittings to function smoothly, and lubricate as recommended in writing by manufacturer.

3.5 PROTECTION

- A. After installation, protect cord reels and fittings from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 26 27 26 00H

SECTION 26 27 26 00i - CONNECTORS, CORDS, AND PLUGS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fuseless attachment cord connectors.
2. Extra-hard-usage, jacketed, flexible cord.
3. Antimicrobial, extra-hard-usage, jacketed, flexible cord.
4. Hard-usage, jacketed, flexible cord.
5. Strain-relief cord grips.

B. Products Installed, but Not Furnished, under This Section:

1. **<Insert products identified in "Existing Products to be Modified" Article or "Existing Products to be Removed and Reinstalled" Article>.**

C. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs referenced by this Section.
5. Section 262726.43 "Special-Purpose Power Outlet Assemblies" specifies fabricated power-outlet cord management assemblies containing connectors and cords specified by this Section.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Samples: One for each kind of cord connector specified, in each finish and color specified.
- C. Field quality-control reports.

1.3 INFORMATIONAL SUBMITTALS

- A. Manufacturer's published instructions.
- B. Field Reports:
1. Manufacturer's field reports for field quality-control support.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2.2 FUSELESS ATTACHMENT CORD CONNECTORS

- A. Description: Connectors for attachment to cord that do not incorporate switches or overcurrent protection.
- B. Indoor-Use, Dry Location Cord Connector:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Ericson Manufacturing Company]**
 - b. **<Insert manufacturer's name>**
 - 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Reference Standards: UL CCN AXUT and UL 498.
 - 3. Standard Features:
 - a. Configuration: NEMA 5-15[**with lighted blade**].
- C. Indoor-Use, Sealed Cord Connector:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Ericson Manufacturing Company]**
 - b. **<Insert manufacturer's name>**
 - 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Reference Standards: UL CCN AXUT and UL 498.
 - 3. Standard Features:
 - a. Configuration:

- 1) NEMA 5-15[with diagnostic LED indicator].
- 2) NEMA 5-20[with diagnostic LED indicator].
- 3) NEMA 6-15.
- 4) NEMA 6-20.
- 5) NEMA L5-15.
- 6) NEMA L5-20[with diagnostic LED indicator].
- 7) NEMA L5-30.
- 8) NEMA L6-15.
- 9) NEMA L6-20.
- 10) NEMA L6-30.
- 11) NEMA L7-15.
- 12) NEMA L7-20.
- 13) NEMA L7-30.
- 14) NEMA L14-20.
- 15) NEMA L14-30.
- 16) NEMA L15-20.
- 17) NEMA L15-30.
- 18) NEMA L16-20.
- 19) NEMA L16-30.
- 20) NEMA L17-30.
- 21) NEMA L18-30.

D. Hospital-Grade, Indoor-Use, Sealed Cord Connector:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Ericson Manufacturing Company]
 - b. <Insert manufacturer's name>
2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Reference Standards: UL CCN AXUT and UL 498.
3. Standard Features:
 - a. Configuration: [NEMA 5-15][NEMA 5-20].

E. Indoor-Use, Compression-Grip, Sealed Cord Connector:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Ericson Manufacturing Company]
 - b. <Insert manufacturer's name>
2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

a. Reference Standards: UL CCN AXUT and UL 498.

3. Standard Features:

a. Configuration:

- 1) NEMA 5-15[**with diagnostic LED indicator**].
- 2) NEMA 5-20[**with diagnostic LED indicator**].
- 3) NEMA 6-15.
- 4) NEMA 6-20.
- 5) NEMA L5-15.
- 6) NEMA L5-20[**with diagnostic LED indicator**].
- 7) NEMA L5-30.
- 8) NEMA L6-15.
- 9) NEMA L6-20.
- 10) NEMA L6-30.
- 11) NEMA L7-15.

F. Outdoor-Use, Watertight, Sealed Cord Connector:

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

- a. **[Ericson Manufacturing Company]**
- b. **<Insert manufacturer's name>**

2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

a. Reference Standards: UL CCN AXUT and UL 498.

3. Standard Features:

a. Configuration:

- 1) NEMA 5-15[**with diagnostic LED indicator**].
- 2) NEMA 5-20[**with diagnostic LED indicator**].
- 3) NEMA 6-15.
- 4) NEMA 6-20.
- 5) NEMA L5-15.
- 6) NEMA L5-20[**with diagnostic LED indicator**].
- 7) NEMA L5-30.
- 8) NEMA L6-15.
- 9) NEMA L6-20.
- 10) NEMA L6-30.
- 11) NEMA L7-15.
- 12) NEMA L7-20.
- 13) NEMA L7-30.
- 14) NEMA L14-20.
- 15) NEMA L14-30.
- 16) NEMA L15-20.
- 17) NEMA L15-30.

- 18) NEMA L16-20.
- 19) NEMA L16-30.
- 20) NEMA L17-30.
- 21) NEMA L18-30.

G. Antimicrobial, Watertight, Sealed Cord Connector:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Ericson Manufacturing Company]**
 - b. **<Insert manufacturer's name>**
2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Reference Standards: UL CCN AXUT and UL 498.
3. Options:
 - a. Antimicrobial additive embedded in connector grip polymer.
 - b. Configuration:
 - 1) NEMA 5-15.
 - 2) NEMA 5-20.
 - 3) NEMA 6-15.
 - 4) NEMA 6-20.
 - 5) NEMA L5-15.
 - 6) NEMA L5-20.
 - 7) NEMA L5-30.
 - 8) NEMA L6-15.
 - 9) NEMA L6-20.
 - 10) NEMA L6-30.
 - 11) NEMA L7-15.
 - 12) NEMA L7-20.
 - 13) NEMA L7-30.
 - 14) NEMA L14-20.
 - 15) NEMA L14-30.
 - 16) NEMA L15-20.
 - 17) NEMA L15-30.
 - 18) NEMA L16-20.
 - 19) NEMA L16-30.
 - 20) NEMA L17-30.
 - 21) NEMA L18-30.

2.3 EXTRA-HARD-USAGE, JACKETED, FLEXIBLE CORD

A. Oil-Resistant, Extra-Hard-Usage, Jacketed, Flexible Cord for Indoor Damp Locations:

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

following]:

- a. **[Belden Inc.]**
- b. **[Ericson Manufacturing Company]**
- c. **[Southwire Company, LLC]**
- d. **[U.S. Wire & Cable Corp.]**
- e. **<Insert manufacturer's name>**

- 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

- a. Reference Standards: UL CCN ZJCZ and UL 62.

- 3. Standard Features:

- a. 600 V, 90 deg C, hard service cord with oil-resistant jacket[**and oil-resistant insulation**] for pendant or portable extra-hard usage in damp locations.
- b. Flexible Cord Type: **[STO][STOO][SEO][SEOO][SO][SOO]**.

B. Oil-Resistant, Extra-Hard-Usage, Jacketed, Flexible Cord for Outdoor or Indoor Wet Locations:

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

- a. **[Belden Inc.]**
- b. **[Ericson Manufacturing Company]**
- c. **[Southwire Company, LLC]**
- d. **[U.S. Wire & Cable Corp.]**
- e. **<Insert manufacturer's name>**

- 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

- a. Reference Standards: UL CCN ZJCZ and UL 62.

- 3. Standard Features:

- a. 600 V, 90 deg C, hard service cord with oil-resistant jacket[**and oil-resistant insulation**] for pendant or portable extra-hard usage in damp locations.
- b. Flexible Cord Type: **[STOW][STOOW][SEOW][SEOOW][SOW][SOOW]**.

2.4 ANTIMICROBIAL, EXTRA-HARD-USAGE, JACKETED, FLEXIBLE CORD

A. Antimicrobial, Oil-Resistant, Extra-Hard-Usage, Jacketed, Flexible Cord for Outdoor or Indoor Wet Locations:

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

following]:

- a. [Ericson Manufacturing Company]
 - b. <Insert manufacturer's name>
2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
- a. Reference Standards: UL CCN ZJCZ and UL 62.
3. Standard Features:
- a. 600 V, 90 deg C, hard service cord with oil-resistant jacket for pendant or portable extra-hard usage in damp or wet locations.
 - b. Antimicrobial additive embedded in jacket polymer.
 - c. Flexible Cord Type: [STOW][SEOW].
 - d. Configuration:
 - 1) No. 14 AWG, two wires and equipment ground.
 - 2) No. 12 AWG, two wires and equipment ground.
 - 3) No. 12 AWG, three wires and equipment ground.
 - 4) No. 10 AWG, two wires and equipment ground.
 - 5) No. 10 AWG, three wires and equipment ground.

2.5 HARD-USAGE, JACKETED, FLEXIBLE CORD

A. Oil-Resistant, Hard-Usage, Jacketed, Flexible Cord for Indoor Damp Locations:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Belden Inc.]
 - b. [Ericson Manufacturing Company]
 - c. [Southwire Company, LLC]
 - d. [U.S. Wire & Cable Corp.]
 - e. <Insert manufacturer's name>
2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Reference Standards: UL CCN ZJCZ and UL 62.
3. Standard Features:
 - a. 300 V, 90 deg C, hard service cord with oil-resistant jacket[and oil-resistant insulation] for pendant or portable extra-hard usage in damp locations.
 - b. Flexible Cord Type: [SJTO][SJTOO][SJEO][SJEOO][SJO][SJOO].

B. Oil-Resistant, Hard-Usage, Jacketed, Flexible Cord for Outdoor or Indoor Wet Locations:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Belden Inc.]**
 - b. **[Ericson Manufacturing Company]**
 - c. **[Southwire Company, LLC]**
 - d. **[U.S. Wire & Cable Corp.]**
 - e. **<Insert manufacturer's name>**
2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Reference Standards: UL CCN ZJCZ and UL 62.
3. Standard Features:
 - a. 300 V, 90 deg C, hard service cord with oil-resistant jacket **[and oil-resistant insulation]** for pendant or portable extra-hard usage in damp locations.
 - b. Flexible Cord Type: **[SJTOW][SJTOOW][SJEOW][SJEOW][SJOW][SJOOW]**.

2.6 STRAIN-RELIEF CORD GRIPS

A. Strain-Relief Cord Grip:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Ericson Manufacturing Company]**
 - b. **[Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Pass & Seymour; Legrand North America, LLC]**
 - d. **<Insert manufacturer's name>**
2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Reference Standards: UL CCN QCRV and UL 514B.
3. Standard Features:
 - a. Strain-relief grip for bus drop cable.
 - b. Noninsulated strain-relief grip for flexible cord.
 - c. Insulated strain-relief grip for flexible cord.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with manufacturer's instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:
 - 1. Electrical Construction: ICC IBC, ICC IFB, NFPA 1, NFPA 70, and NECA NEIS 1.
 - 2. Electrical Maintenance: NFPA 70B.
 - 3. Electrical Safety: NFPA 70E.
 - 4. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
 - 5. Work in ITE Rooms: NFPA 75.
 - 6. Work in Health Care Facilities: NFPA 99 and Article 517 of NFPA 70.
 - 7. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
 - 8. Consult Architect for resolution of conflicting requirements.
- C. Special Techniques:
 - 1. **<Insert more stringent installation requirements that supplement or supersede listed standards and manufacturers' instructions>.**
- D. Interfaces with Other Work:
 - 1. Coordinate with Section 262726.43 "Special-Purpose Power Outlet Assemblies" for installation of connectors and cords on fabricated power-outlet cord management assemblies.
 - 2. Coordinate installation of new products for **<Insert system or product group>** with existing conditions.
 - a. **<Insert requirements for transition between new and existing>.**
 - 3. Coordinate with **<Insert Section number and title>** for **<Insert description of interfacing related Work>.**
 - a. **<Insert requirements for transition between this Section and related Work>.**

3.2 FIELD QUALITY CONTROL

- A. Adminstrant for Electrical Power Tests and Inspections:
 - 1. **[Owner][Tenant]** will engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
 - 2. Engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
 - 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
 - 4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].
- B. Acceptance Testing Preparation:
 - 1. **<Insert requirements>.**



- C. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.
- D. Tests and Inspections:
 - 1. Perform tests and inspections indicated in manufacturer's instructions.
 - 2. **<Insert Project-specific test or inspection>**.
- E. Nonconforming Work:
 - 1. Unit will be considered defective if it does not pass tests and inspections.
 - 2. Remove and replace defective units and retest.
- F. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.
- G. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.
 - 1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.

END OF SECTION 26 27 26 00I



Task	Specification	Specification Description
26 27 26 00	26 09 13 00	Electrical Power Monitoring



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SECTION 26 27 33 00 - POWER DISTRIBUTION UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Manufactured power distribution units.

B. Products Installed, but Not Furnished, under This Section:

1. **<Insert products identified in "Existing Products to be Modified" Article or "Existing Products to be Removed and Reinstalled" Article>.**

C. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. Section 260526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding referenced by this Section.
5. Section 260529 "Hangers and Supports for Electrical Systems" specifies hangers, supports, and concrete bases referenced by this Section.
6. Section 260548 "Vibration and Seismic Controls for Electrical Systems" specifies vibration isolation and seismic control devices referenced by this Section.
7. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs referenced by this Section.
8. Section 260573 "Power System Studies" specifies arc-flash hazard analysis, warning labels, and circuit-breaker trip ranges referenced by this Section.

1.2 DEFINITIONS

- A. EPO: Emergency power-off.
- B. SPD: Surge protective device.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Coordination Meeting(s): For power distribution units. Conduct meeting(s) **[as videoconference][or][at Project site]<Insert location> before <Insert construction activity>.**
1. Attendees: Installers, fabricators, representatives of manufacturers, representatives of Owner, and administrators for field tests and inspections. Notify Architect[, **Construction Manager**][, and **Owner's Commissioning Authority**] of scheduled meeting dates.
 2. Coordinate layout and installation of power distribution units with Owner's equipment.



3. Record agreements reached in meetings and distribute record to other participants.
4. Adjust arrangements and locations of power distribution units to accommodate and optimize arrangement and space requirements of equipment.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing agency, certifying product's compliance with specified listing criteria.
 - a. If listed manufacturer differs from selling manufacturer, indicate relationship between entities on submittal. Clearly indicate which entity warrants product performance and fitness for purpose.
 - b. Listing criteria identified in approval letter must match specified listing criteria. UL label indicating approval of equipment's enclosure is not considered approval of equipment for intended application.
 - c. Product identification in approval letter must match product branding and model numbers in submittal. Approval letters for discontinued or superseded products are unacceptable for submitted product.

B. Shop Drawings: Prepare and submit the following:

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

C. Factory test reports.

D. Field quality-control reports.

1.5 INFORMATIONAL SUBMITTALS

- A. Manufacturer's published instructions.
- B. Manufacturer's field reports for field quality-control support.
- C. Manufacturer's field reports for system startup support.
- D. Field reports for infrared scanning.

1.6 QUALIFICATIONS

- A. Electrical Power Testing (EPT) Technician III: Possessing active NICET EPT Level III certification. Able to manage switching procedures, conduct tests of complex equipment, analyze test and equipment data, plan a job, and lead a team. Has experience performing NFPA 70B, IEEE, and NETA electrical tests.
- B. Electrical Power Testing (EPT) Technician IV: Possessing active NICET EPT Level IV certification. Able

to conduct tests of complex metering and relay systems; evaluate tests, test equipment, test results, and power system performance; recommend actions to maintain or improve system performance; and lead multi-team projects.

- C. Electrical Power Testing and Inspecting Agency: Entities possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
 - 1. On-site electrical testing supervisors must possess active NICET EPT Technician [III][IV] certification.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver equipment in fully enclosed vehicles after specified environmental conditions have been permanently established in spaces where equipment is to be placed.
- B. Store equipment in spaces with environments controlled within manufacturer's ambient temperature and humidity tolerances for non-operating equipment.

1.8 SERVICE CONDITIONS FOR ELECTRICAL EQUIPMENT

- A. Modeling, analysis, product selection, installation, and quality control for all electrical Work on the Project must comply with service condition requirements specified in Section 018116 "Facility Environmental Requirements" and Section 018123 "Facility Seismic and Wind Criteria."
- B. Usual Service Conditions: Unless unusual service conditions have been specified in "General Environmental Conditions," "Outdoor Conditions," and "Indoor Conditions" articles of Section 018116 "Facility Environmental Requirements," electrical service and distribution equipment must be suitable for operation under usual service conditions specified in applicable NEMA PB series, IEEE C37 series, and IEEE C57 series standards.

PART 2 - PRODUCTS

2.1 EXISTING PRODUCTS TO BE MODIFIED

- A. Basis for Pricing: **<Insert name of manufacturer; model number or series for existing product>.**
- B. Description: **<Insert description of existing product, including special features, options, and finishes that may impact the Work>.**
- C. Accessories: **<Insert accessories included with existing product>.**

2.2 EXISTING PRODUCTS TO BE REMOVED AND REINSTALLED

- A. Basis for Pricing: **<Insert name of manufacturer; model number or series for existing product>.**
- B. Description: **<Insert description of existing product, including special features, options, and finishes that may impact the Work>.**
- C. Accessories: **<Insert accessories included with existing product>.**



2.3 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2.4 MANUFACTURED POWER DISTRIBUTION UNITS

- A. Source Quality Control:

1. Factory Tests:

- a. Owner will witness required factory tests. Notify Architect at least 14 days before date of tests and indicate their approximate duration.
- b. Testing Administrant: **[Owner will engage][Engage]** qualified electrical testing agency to evaluate power distribution units.
- c. Factory Tests and Inspections: Test and inspect power distribution units, by, or under supervision of, qualified electrical testing laboratory recognized by authorities having jurisdiction, in accordance with referenced standards before delivering to site. Affix label with name and date of **[manufacturer's][qualified electrical testing laboratory's]** certification of system compliance.

- 1) Conduct factory sound-level tests.

- d. Nonconforming Work:

- 1) Equipment that does not pass tests and inspections will be considered defective.

- e. Factory Test Reports: Compile and submit factory test and inspection reports.

- B. Power Distribution Units :

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

- a. **[ABB, Electrification Business]**
- b. **[Eaton]**
- c. **[Liebert; Vertiv Holdings Co.]**
- d. **[Myers Power Products, Inc]**
- e. **[Power Distribution, Inc.; Eaton, Electrical Sector]**
- f. **[Powersmiths International Corp.; Socomec Group]**
- g. **[Square D; Schneider Electric USA]**
- h. **<Insert manufacturer's name>**

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

- a. **[ABB, Electrification Business]**
- b. **[Eaton]**
- c. **[Liebert; Vertiv Holdings Co.]**
- d. **[Myers Power Products, Inc]**

- e. **[Power Distribution, Inc.; Eaton, Electrical Sector]**
 - f. **[Powersmiths International Corp.; Socomec Group]**
 - g. **[Square D; Schneider Electric USA]**
 - h. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
 4. Standard Features:
 - a. Integrated and coordinated assembly of power-line-conditioning and distribution components packaged in single cabinet or modular assembly of cabinets[**each with full-swivel casters mounted to bottom frame**]. Include the following components:
 - 1) Input-power, circuit-breaker section.
 - 2) Isolation transformer.
 - 3) SPD system.
 - 4) Output panelboard(s).
 - 5) Alarm, monitoring, and control system.
 - b. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - c. Wiring Access: **[Top][and][bottom]** wiring access.
 - d. Unit Capacity Rating: Carry indicated RMS kilovolt-ampere load continuously without affecting normal operation of circuit breakers, monitoring system, or unit controls and without exceeding rated insulation temperature for the following input voltage and load current:
 - 1) Input Voltage: Within rated input-voltage tolerance band of unit.
 - 2) Load Current: Minimum of 3.0 crest factor and 85 percent total harmonic distortion.
 - e. Input-Power, Circuit-Breaker Section: Three-pole, **[shunt-tripped,]**thermal-magnetic-type circuit breaker, rated for indicated interrupting capacity and 125 percent of input current of unit at 100 percent rated load at unit capacity rating.
 - 1) Dual-Input Units:
 - a) Two input circuit breakers arranged to provide transfer between two input-power sources.
 - b) Controls and interfaces to allow selecting either open- or closed-transition transfer between two input-power sources.
 - c) Use 120 V permissive signal from both upstream voltage sources to indicate acceptable conditions for closed-transition transfer.
 - d) Open second circuit breaker automatically after closed-transition transfer is completed.
 - 2) Static Transfer Switch: Three-pole, double-throw; solid-state, automatic transfer switch.
 - f. Isolation Transformer Section: Dry-type, electrostatically shielded, three-phase, common-core, convection-air-cooled isolation transformer.
 - 1) Comply with UL 1561[**including requirements for nonsinusoidal load-current-handling capability defined by designated K-factor**].
 - 2) Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses, one leg per phase.
 - 3) Coil Material and Insulation: **[Aluminum][Copper]** windings, 220 deg C insulation

- class.
- 4) Temperature Rise: Designed for **[80][115][150]** deg C rise above 40 deg C ambient.
 - 5) Output Impedance: 3.5 plus or minus 0.5 percent.
 - 6) Regulation: 2 to 4 percent maximum, at full-resistive load; 5 percent maximum, at rated nonlinear load.
 - 7) Taps: Six full-capacity compensation taps at 2.5 percent increments; two above and four below nominal voltage.
 - 8) Full-Load Efficiency: Minimum 96 percent at rated **[nonlinear]** load.
 - 9) Magnetic-Field Strength External to Transformer Enclosure: Less than 0.1 G at **18 inch (450 mm)**.
 - 10) K-Factor Rating: Transformers indicated to be K-factor rated must comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.
 - a) Unit may not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor.
 - b) Indicate value of K-factor on transformer nameplate.
 - 11) Electrostatic Shielding: Independently shield each winding with full-width, **[single][double]**, copper, electrostatic shield arranged to minimize interwinding capacitance.
 - a) Coil leads and terminal trips must be arranged to minimize capacitive coupling between input and output connections.
 - b) Shield Terminal: Separate, and marked "Shield" for grounding connection. Shield must be connected to reference ground point for distribution panels.
 - c) Capacitance: Limit capacitance between primary and secondary windings to maximum of 33 pF over frequency range of 20 Hz to 1 MHz.
 - d) Common-Mode Noise Attenuation: 120 dB minimum, 0.5 to 1.5 kHz; minus 65 dB minimum, 1.5 to 100 kHz.
 - e) Normal-Mode Noise Attenuation: 52 dB minimum, 1.5 to 10 kHz.
 - 12) Neutral Rating: **[1.732 times][200 percent of]** system full-load ampere rating.
 - 13) Shipping Restraints: Paint or otherwise color code bolts, wedges, blocks, and other restraints that are to be removed after installation and before energizing. Use fluorescent colors that are easily identifiable inside transformer enclosure.
- g. SPD System: Integrated SPD system, complying with Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits," to protect unit panelboard, and having the following features:
- 1) Disconnect Device: Manual, three-pole, fused disconnect switch to de-energize SPD system while permitting power distribution units to continue operation. Fuses must be rated for 200 kA interrupting capacity.
 - 2) Nonlinear Loading: System must accommodate rated-load current with minimum 3.0 crest factor and 85 percent total harmonic distortion.
- h. Output Panelboards: Panelboards complying with Section 262416 "Panelboards" except for mounting provisions. Mount **[single][double]** panelboards on power distribution unit behind flush doors. Include the following features:
- 1) Construction: **[30][42]** pole, **[208 V][240 V]**, three phase; capable of accepting branch circuit breakers rated up to 100 A.
 - 2) Panelboard Rating: **[225 A]<Insert value>**, with main circuit breaker.
 - 3) Panelboard Phase, Neutral, and Ground Buses: Copper, with neutral bus at least

- 4) [1.732][two] times nominal phase bus rating.
 - 5) Isolated Ground Bus: Copper, adequate for branch-circuit equipment ground conductors; insulated from supports.
 - 6) Branch Circuit Breakers: **[Bolt][Plug]** on.
 - 7) Cable Racks: Removable and arranged for supporting and routing cables for panelboard entrance.
 - 8) Access Panels: Arranged so additional branch-circuit wiring can be installed and connected in future.
- i. Power Distribution Unit Controls: Include the following control features:
- 1) EPO switch integral with power distribution unit.
 - 2) Power-off input terminals for connection to remote EPO switch.
 - 3) Shutdown with automatic unit disconnection for the following alarm conditions:
 - a) High temperature in transformer coil.
 - b) High or low input or output voltage.
 - c) Phase loss.
 - d) Ground fault.
 - e) Reverse-phase rotation.
 - 4) Alarm Contacts: Electrically isolated, Form C (one normally open and one normally closed), summary alarm; contact set must change state if monitored function goes into alarm mode.
 - 5) Auxiliary Control Outputs: **<Insert control function outputs>**.
- j. Monitoring, Status, and Alarm Annunciation: Microprocessor-based monitoring, status, and alarm annunciation panel mounted flush in front of power distribution unit to provide status display and failure-indicating interface for the following:
- 1) Power Monitoring:
 - a) Input Voltage: Line-to-line, RMS.
 - b) Output Voltage: Line-to-line and line-to-neutral, RMS.
 - c) Output current.
 - 2) Status Indication: Unit on.
 - 3) Alarm Annunciation:
 - a) High temperature in transformer coil.
 - b) High and low input voltage.
 - c) High and low output voltage.
 - d) Phase loss.
 - e) Ground fault.
 - f) Frequency.
 - g) Phase rotation.
 - h) SPD module failure.
 - 4) Audible Alarm and Silencing Switch: Alarm sounds when alarm indication occurs. Silencing switch must silence audible alarm but leave visual indication active until alarm condition is corrected.
- k. Sound Level:
- 1) Fully assembled products must have average audible sound levels[**more than 3 dB**] below the following maximum sound levels, without fans running, when factory

tested in accordance with IEEE C57.12.91:

- a) 9 kVA and Smaller: [40]<Insert number> dB(A-weighted).
 - b) 9.01 to 30 kVA: [45]<Insert number> dB(A-weighted).
 - c) 30.01 to 50 kVA: [45][48]<Insert number> dB(A-weighted).
 - d) 50.01 to 150 kVA: [50][53]<Insert number> dB(A-weighted).
 - e) 150.01 to 300 kVA: [55][58]<Insert number> dB(A-weighted).
 - f) 300.01 to 500 kVA: [60][63]<Insert number> dB(A-weighted).
 - g) 500.01 to 700 kVA: [62][65]<Insert number> dB(A-weighted).
 - h) 700.01 to 1000 kVA: [64][67]<Insert number> dB(A-weighted).
- 2) Mount transformer on rubber isolation pads.
- l. Enclosure:
- 1) Single, freestanding, galvanized steel, UL 50E Type 1 enclosure. Opening of exterior door may not provide access to live parts. Panels and covers that expose hazardous voltages must require tools to remove.
 - 2) Access from front, top, and side only for installation, operations, and normal maintenance, including infrared scanning of bus and breakers. Normal operating controls and instrumentation must be located on front of enclosure.
 - 3) Arrange enclosure to allow lifting and moving via forklift.
- m. Finish: Manufacturer's standard finish over corrosion-resistant pretreatment and primer.
5. Seismic and Wind Performance: Installed product must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:
- a. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events[**and unit must be fully operational after seismic events**]."
 - b. Component Importance Factor (Ip): [1.0][1.5].
 - c. Component Amplification Factor (ap): [2.5]<Insert value>.
 - d. Component Response Modification Factor (Rp): [6.0]<Insert value>.
 - e. Component Overstrength Factor (Ωo): [2.5]<Insert value>.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:
- 1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
 - 2. Electrical Maintenance: NFPA 70B.
 - 3. Electrical Safety: NFPA 70E.
 - 4. Commissioning of Electrical Systems: NECA NEIS 90.
 - 5. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
 - 6. Work in ITE Rooms: NFPA 75.
 - 7. Work in Health Care Facilities: NFPA 99 and Article 517 of NFPA 70.
 - 8. Emergency and Standby Power Work: NFPA 110, NFPA 111, and NECA NEIS 416.

9. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
10. Connections to Connectors and Terminals: Comply with torque-tightening values in UL 486A-486B.
11. Consult Architect for resolution of conflicting requirements.

C. Special Techniques:

1. Arrange power distribution units to provide adequate access to equipment and circulation of cooling air. Locate transformers away from corners and not parallel to adjacent wall surface.

D. Interfaces with Other Work:

1. Identification: Provide labels for power distribution units and associated electrical equipment.
 - a. Identify field-installed conductors, interconnecting wiring, and components.
 - b. Label each enclosure with engraved metal or laminated-plastic nameplate.
 - c. Provide warning signs and arc-flash hazard warning labels for electrical equipment.
2. Coordinate size and location of **[concrete bases][access flooring support]** with actual power distribution unit provided.
3. Equipment Mounting:
 - a. Provide cast-in-place concrete equipment base(s) for equipment.
 - b. Provide vibration isolation and seismic control devices for equipment.
 - c. Supports must penetrate and be independent of access flooring.
4. Ground and bond power distribution unit.
5. Install flexible connections at conduit and conductor terminations and supports to eliminate sound and vibration transmission to building structure.

3.2 FIELD QUALITY CONTROL

A. Administrant for Electrical Power Tests and Inspections:

1. **[Owner][Tenant]** will engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
2. Engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections **[with assistance of factory-authorized service representative]**.

B. Acceptance Testing Preparation:

1. **<Insert requirements>**.

C. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.

D. Tests and Inspections:

1. Perform manufacturer's recommended tests and inspections.
2. Perform each visual and mechanical inspection and electrical test stated in NETA ATS for circuit

breakers, molded case; and for transformers, dry type, air cooled, low voltage. Certify compliance with test parameters.

3. Perform functional tests of power distribution units throughout their operating ranges. Test each monitoring, status, and alarm function.
4. Test Labeling: On completion of satisfactory testing of each unit, attach dated and signed "Satisfactory Test" label to tested component.

E. Nonconforming Work:

1. Power distribution unit will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

F. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

G. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.

1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.

3.3 SYSTEM STARTUP

A. Perform startup service.

1. Complete installation and startup checks in accordance with manufacturer's published instructions.
2. Verify that power distribution units are installed and connected in accordance with the Contract Documents.
3. Verify that electrical wiring installation complies with manufacturer's submittal and with published installation requirements in other electrical Sections.

B. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** system startup.

1. Manufacturer's Field Reports for System Startup Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.

3.4 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

B. Adjust power distribution units to provide optimal voltage to equipment served throughout normal operating cycle of loads served. Record input and output voltages and adjustment settings, and incorporate into test results.

3.5 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

3.6 CLOSEOUT ACTIVITIES

A. Training:

1. **[With assistance from factory-authorized service representatives, train][Train]** Owner's maintenance personnel on the following topics:
 - a. How to adjust, operate, and maintain power distribution units.
2. **[Provide video recordings of training sessions to Owner.][Allow Owner to record training sessions.]**

3.7 PROTECTION

- #### A.
- After installation, protect power distribution units from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

3.8 MAINTENANCE

- #### A.
- Infrared Scanning of Power Distribution Units: Two months after Substantial Completion, perform infrared scan of conductor and bus joints and connections. Remove covers so joints and connections are accessible to portable scanner. Take visible light photographs at same locations and orientations as infrared scans for documentation to ensure follow-on scans match same conditions for valid comparison.
1. Use infrared-scanning device designed to measure temperature or to detect significant deviations from normal values. Provide documentation of device calibration.
 2. Follow-up Infrared Scanning: Perform two follow-up infrared scans of power distribution units, one at four months and another at 11 months after Substantial Completion.
 3. Instrument: Use infrared-scanning device designed to measure temperature or to detect significant deviations from normal values. Provide documentation of device calibration.
 4. Field Reports for Infrared Scanning: Prepare certified report that identifies joints and connections checked and that describes scanning results. Include notation of deficiencies detected, remedial actions taken, and scanning observations after remedial action.

END OF SECTION 26 27 33 00



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Task	Specification	Specification Description
26 27 73 00	26 27 26 00	Wiring Devices



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SECTION 26 28 13 00 - FUSES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Nonrenewable cartridge fuses.
2. Spare-fuse cabinets.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs referenced by this Section.
5. Section 260573 "Power System Studies" specifies coordination studies, arc-flash hazard analysis, warning labels, and circuit-breaker trip ranges referenced by this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product. Include the following for each fuse type indicated:

1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.
 - a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
 - b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.
2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
3. Current-limitation curves for fuses with current-limiting characteristics.
4. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse. Submit **[in electronic format suitable for use in coordination software][and][in PDF format]**.
5. Coordination charts and tables and related data.
6. Fuse sizes for elevator feeders and elevator disconnect switches.

1.3 MAINTENANCE MATERIAL SUBMITTALS

A. Extra stock material.



1.4 FIELD CONDITIONS

- A. Where ambient temperature to which fuses are directly exposed is less than [40 deg F (5 deg C)]<Insert temperature> or more than [100 deg F (38 deg C)]<Insert temperature>, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2.2 NONRENEWABLE CARTRIDGE FUSES

- A. Class CC Nonrenewable Cartridge Fuse :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Bussmann, an Eaton business]
 - b. [Edison; a brand of Bussmann by Eaton]
 - c. [Littelfuse, Inc.]
 - d. [Mersen USA]
 - e. [Optifuse; Vortex Technologies; division of Triad Partners, LLC]
 - f. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Bussmann, an Eaton business]
 - b. [Edison; a brand of Bussmann by Eaton]
 - c. [Littelfuse, Inc.]
 - d. [Mersen USA]
 - e. [Optifuse; Vortex Technologies; division of Triad Partners, LLC]
 - f. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by a qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Cartridge Fuses, Nonrenewable: UL CCN JDDZ, including UL 248-1 and UL 248-4 (Class CC).
5. Standard Features:

- a. NEMA FU 1, Class CC, 200 kA(sym) interrupt rating, current limiting, sizes up to 30 A, 600 V(ac), **[12 s minimum time-delay at 200 percent][non-time-delay]**, with rejection feature.
- B. Class CD Nonrenewable Cartridge Fuse :
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Littelfuse, Inc.]**
 - b. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Littelfuse, Inc.]**
 - b. **<Insert manufacturer's name>**
 - 3. Source Limitations: Obtain products from single manufacturer.
 - 4. Listing Criteria: Investigated, labeled, and marked by a qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Cartridge Fuses, Nonrenewable: UL CCN JDDZ, including UL 248-1 and UL 248-18 (Class CD).
 - 5. Standard Features:
 - a. UL 248-18, Class CD, 200 kA(sym) interrupt rating, current limiting, sizes 31 to 60 A, 600 V(ac), **[12 s minimum time-delay at 200 percent][non-time-delay]**, with rejection feature.
- C. Class J Nonrenewable Cartridge Fuse :
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Bussmann, an Eaton business]**
 - b. **[Edison; a brand of Bussmann by Eaton]**
 - c. **[Littelfuse, Inc.]**
 - d. **[Mersen USA]**
 - e. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Bussmann, an Eaton business]**
 - b. **[Edison; a brand of Bussmann by Eaton]**
 - c. **[Littelfuse, Inc.]**
 - d. **[Mersen USA]**
 - e. **<Insert manufacturer's name>**

3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by a qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Cartridge Fuses, Nonrenewable: UL CCN JDDZ, including UL 248-1 and UL 248-8 (Class J).
5. Standard Features:
 - a. NEMA FU 1, Class J, **[200 kA(sym)][300 kA(sym)]** interrupt rating, current limiting, sizes up to 600 A, 600 V(ac), **[8 to 10 s minimum time-delay at 500 percent][non-time-delay]**, with rejection feature.

D. Class L Nonrenewable Cartridge Fuse :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Bussmann, an Eaton business]**
 - b. **[Edison; a brand of Bussmann by Eaton]**
 - c. **[Littelfuse, Inc.]**
 - d. **[Mersen USA]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Bussmann, an Eaton business]**
 - b. **[Edison; a brand of Bussmann by Eaton]**
 - c. **[Littelfuse, Inc.]**
 - d. **[Mersen USA]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by a qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Cartridge Fuses, Nonrenewable: UL CCN JDDZ, including UL 248-1 and UL 248-10 (Class L).
5. Standard Features:
 - a. NEMA FU 1, Class L, 300 kA(sym) interrupt rating, current limiting, sizes 100 to 6000 A, 600 V(ac), **[4 s minimum time-delay (nonstandard) at 500 percent][10 s minimum time-delay at 500 percent][non-time-delay]**, with rejection feature, with bolt-on terminals.

E. Class RK1 Nonrenewable Cartridge Fuse :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering**

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

- a. [Bussmann, an Eaton business]
 - b. [Edison; a brand of Bussmann by Eaton]
 - c. [Littelfuse, Inc.]
 - d. [Mersen USA]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Bussmann, an Eaton business]
 - b. [Edison; a brand of Bussmann by Eaton]
 - c. [Littelfuse, Inc.]
 - d. [Mersen USA]
 - e. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by a qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
- a. Cartridge Fuses, Nonrenewable: UL CCN JDDZ, including UL 248-1 and UL 248-12 (Class R).
5. Standard Features:
- a. NEMA FU 1, Class RK1, 200 kA(sym) interrupt rating, current limiting, sizes up to 600 A, [250 V(ac)][600 V(ac)], [8 to 10 s minimum time-delay at 500 percent][non-time-delay], with rejection feature.
 - 1) Select ferrule terminals or knife blade terminals to match equipment where fuse is installed.

F. Class RK5 Nonrenewable Cartridge Fuse :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Bussmann, an Eaton business]
 - b. [Edison; a brand of Bussmann by Eaton]
 - c. [Littelfuse, Inc.]
 - d. [Mersen USA]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Bussmann, an Eaton business]
 - b. [Edison; a brand of Bussmann by Eaton]
 - c. [Littelfuse, Inc.]

- d. **[Mersen USA]**
- e. **<Insert manufacturer's name>**
- 3. Source Limitations: Obtain products from single manufacturer.
- 4. Listing Criteria: Investigated, labeled, and marked by a qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Cartridge Fuses, Nonrenewable: UL CCN JDDZ, including UL 248-1 and UL 248-12 (Class R).
- 5. Standard Features:
 - a. NEMA FU 1, Class RK5, 200 kA(sym) interrupt rating, current limiting, sizes up to 600 A, **[250 V(ac)][600 V(ac)]**, **[8 to 10 s minimum time-delay at 500 percent][non-time-delay]**, with rejection feature.
 - 1) Select ferrule terminals or knife blade terminals to match equipment where fuse is installed.

G. Class T Nonrenewable Cartridge Fuse :

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Bussmann, an Eaton business]**
 - b. **[Edison; a brand of Bussmann by Eaton]**
 - c. **[Littelfuse, Inc.]**
 - d. **[Mersen USA]**
 - e. **[Optifuse; Vortex Technologies; division of Triad Partners, LLC]**
 - f. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Bussmann, an Eaton business]**
 - b. **[Edison; a brand of Bussmann by Eaton]**
 - c. **[Littelfuse, Inc.]**
 - d. **[Mersen USA]**
 - e. **[Optifuse; Vortex Technologies; division of Triad Partners, LLC]**
 - f. **<Insert manufacturer's name>**
- 3. Source Limitations: Obtain products from single manufacturer.
- 4. Listing Criteria: Investigated, labeled, and marked by a qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Cartridge Fuses, Nonrenewable: UL CCN JDDZ, including UL 248-1 and UL 248-15 (Class T).
- 5. Standard Features:

- a. NEMA FU 1, Class T, 200 kA(sym) interrupt rating, current limiting, sizes up to 1200 A, **[300 V(ac)][600 V(ac)], [8 to 10 s minimum time-delay at 500 percent][non-time-delay]**, with rejection feature.
 - 1) Select ferrule terminals or knife blade terminals to match equipment where fuse is installed.

2.3 SPARE-FUSE CABINET

- A. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.
 1. Size: Adequate for storage of spare fuses specified with **[15]<Insert number>** percent spare capacity minimum.
 2. Finish: Gray, baked enamel.
 3. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.

2.4 MAINTENANCE MATERIAL ITEMS

- A. Extra Stock Material: Furnish to Owner extra materials[, **from same production run,**] that match products installed and that are packaged with protective covering for storage and identified with labels describing contents. **[Include the following:]**
 1. Fuses: Equal to **[10]<Insert number>** percent of quantity installed for each size and type, but no fewer than **[three]<Insert number>** of each size and type.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.
- B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.
- C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.
- D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF FUSES

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:



1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
 2. Electrical Maintenance: NFPA 70B.
 3. Electrical Safety: NFPA 70E.
 4. Work in Confined Spaces: NFPA 350.
 5. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
 6. Fuse Applications: NECA NEIS 420.
 7. Work with Fuses in Motor Control Centers: NECA NEIS 402.
- C. Provide open-fuse indicator fuses or fuse covers with open fuse indication.
- D. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.
- E. Install spare-fuse cabinet(s) in location indicated on the Drawings or as indicated in the field by **[Architect][Construction Manager][Owner]**.
- F. Interfaces with Other Work:
1. Identification: Provide labels for spare fuse cabinet.
 - a. Legend: "SPARE FUSES" in **1-1/2 inch (38 mm)** high letters on exterior of door.
 2. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with results of coordination study and arc-flash hazard analysis.

END OF SECTION 26 28 13 00



Task	Specification	Specification Description
26 28 13 00	26 11 16 11	Secondary Unit Substations with Switchgear Secondary



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SECTION 26 28 16 00 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Enclosed Switches:
 - a. UL WIAX or NITW - Single- or double-throw enclosed switch.
 - b. UL WIAX or NITW - Fused electrically-tripped enclosed switch.
 - c. UL WIAX or NITW - Electrically-tripped ground-fault protection enclosed switch.
2. Dead-Front Switches:
 - a. UL WHXS - Switch for mounting in separate dead-front enclosure.
3. Enclosed Switches for Use in Hazardous (Classified) Locations:
 - a. UL WRPR - Enclosed switch for use in hazardous location.
4. Fused Power-Circuit Devices:
 - a. UL IYSR - Enclosed fused bolted-pressure contact switch.
 - b. UL IYSR - Enclosed fused high-pressure butt-type contact switch.
5. Molded-Case Circuit Breakers and Enclosures:
 - a. UL DIVQ - Enclosed molded-case circuit breaker.
6. Molded-Case Switches and Enclosures:
 - a. UL WJAZ - Enclosed molded-case switch.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. Section 260526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding electrical equipment including raceways, electrical power cabling, and communications cabling referenced by this Section.
5. Section 260529 "Hangers and Supports for Electrical Systems" specifies hangers, supports, and concrete bases referenced by this Section.
6. Section 260548 "Vibration and Seismic Controls for Electrical Systems" specifies vibration isolation and seismic- [**and wind**-] control devices referenced by this Section.
7. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and



8. warning signs referenced by this Section.
8. Section 260573 "Power System Studies" specifies short-circuit current analysis, coordination study, arc-flash hazard analysis, warning labels, and circuit-breaker trip ranges referenced by this Section.

1.2 DEFINITIONS

- A. AFCI: Arc-fault circuit interrupter.
- B. GFCI: Ground-fault circuit interrupter.
- C. MCCB: Molded-case circuit breaker.
- D. N.C.: Normally closed.
- E. NICET: National Institute for Certification in Engineering Technologies; a division of the National Society of Professional Engineers (NSPE).
- F. N.O.: Normally open.
- G. SPDT: Single pole, double throw.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of specified product.
 1. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing laboratory, certifying that model number corresponding to specified product complies with specified listing criteria.
 2. Include manufacturer's sample extended warranty language.
 3. Include nameplate ratings, dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
 4. Enclosure types and details for types other than UL 50E, Type 1.
 5. Current and voltage ratings.
 6. Short-circuit current ratings (interrupting and withstand, as appropriate).
 7. Include evidence of qualified electrical testing laboratory listing for series rating of installed devices.
 8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
 9. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Provide in **[PDF][and]<Insert calculation program format>** electronic format.
- B. Shop Drawings: Prepare and submit the following:
 1. Drawings, Diagrams, and Supporting Documents for Enclosed Switches and Circuit Breakers:
 - a. Include plans, elevations, sections, details, and attachments to other work.
 - b. Include wiring diagrams for power, signal, and control wiring.
- C. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

- A. Manufacturer's published instructions.
- B. Field Reports:
 - 1. Manufacturer's field reports for field quality-control support.
 - 2. Field reports for infrared scanning.

1.5 CLOSEOUT SUBMITTALS

- A. Warranty documentation.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Spare parts.

1.7 QUALIFICATIONS

- A. Electrical Power Testing (EPT) Technician I: Possessing active NICET EPT Level I certification. Able to work safely around electrical power equipment and cabling under supervision.
- B. Electrical Power Testing (EPT) Technician II: Possessing active NICET EPT Level II certification. Able to isolate and ground electrical power equipment, to connect test equipment, and to conduct and document standard tests of basic equipment.
- C. Electrical Power Testing (EPT) Technician III: Possessing active NICET EPT Level III certification. Able to manage switching procedures, to conduct tests of complex equipment, to analyze test and equipment data, to plan a job, and to lead a team. Has experience performing NFPA 70B, IEEE, and NETA electrical tests.
- D. Electrical Power Testing (EPT) Technician IV: Possessing active NICET EPT Level IV certification. Able to conduct tests of complex metering and relay systems; to evaluate tests, test equipment, test results, and power system performance; to recommend actions to maintain or improve system performance; and to lead multi-team projects.
- E. Electrical Power Testing and Inspecting Agency: Entities possessing active credentials from qualified electrical testing laboratory recognized by authorities having jurisdiction.
 - 1. On-site electrical testing supervisors must possess active NICET EPT Technician [III][IV] certification.

1.8 SERVICE CONDITIONS FOR ELECTRICAL EQUIPMENT

- A. Modeling, analysis, product selection, installation, and quality control for electrical Work specified in this Section must comply with service condition requirements specified in Section 018116 "Facility Environmental Requirements" and Section 018123 "Facility Seismic and Wind Criteria" unless otherwise specified in this Section or on the Drawings.

1.9 WARRANTY

- A. Special Installer Extended Warranty: Installer warrants that fabricated and installed enclosed switches and circuit breakers perform in accordance with specified requirements and agrees to repair or replace components or products that fail to perform as specified within extended-warranty period.
 - 1. Extended-Warranty Period: **[Two]<Insert number>** years from date of Substantial Completion; full coverage for labor, materials, and equipment.
- B. Special Manufacturer Extended Warranty: Manufacturer warrants that enclosed switches and circuit breakers perform in accordance with specified requirements and agrees to provide repair or replacement of components or products that fail to perform as specified within extended-warranty period.
 - 1. Extended-Warranty Period: **[Three]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for labor, materials, and equipment.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- B. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- C. Enclosures:
 - 1. Enclosed Switches and Circuit Breakers: UL 489, NEMA BS 31047, UL 50E, and UL 50, to comply with environmental conditions at installed location.
 - 2. Enclosure Finish: Enclosure must be **[finished with][gray baked enamel paint, electrodeposited on cleaned, phosphatized steel (UL 50E Type 1)][gray baked enamel paint, electrodeposited on cleaned, phosphatized galvanized steel (UL 50E Types 3R, 12)][a brush finish on Type 304 stainless steel (UL 50E Type 4-4X stainless steel)][copper-free cast aluminum alloy (UL 50E Types 7, 9)]**.
 - 3. Conduit Entry: UL 50E Types 4, 4X, and 12 enclosures may not contain knockouts. UL 50E Types 7 and 9 enclosures must be provided with threaded conduit openings in both endwalls.
 - 4. Operating Mechanism: Circuit-breaker operating handle must be **[externally operable with operating mechanism being integral part of box, not cover][directly operable through front cover of enclosure (UL 50E Type 1)][directly operable through dead front trim of enclosure (UL 50E Type 3R)][externally operable with operating mechanism being integral part of cover (UL 50E Types 7, 9)]**. Cover interlock mechanism must have externally operated override. Override may not permanently disable interlock mechanism, which must return to locked position once override is released. Tool used to override cover interlock mechanism must not be required to enter enclosure in order to override interlock.
 - 5. Enclosures designated as UL 50E Type 4, 4X stainless steel, 12, or 12K must have dual cover interlock mechanism to prevent unintentional opening of enclosure cover when circuit breaker is ON and to prevent turning circuit breaker ON when enclosure cover is open.
 - 6. UL 50E Type 7/9 enclosures must be furnished with breather and drain kit to allow their use in outdoor and wet location applications.

- D. Seismic and Wind Performance: Installed assembly must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:
1. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events [, **and unit must be fully operational after seismic events**] .
 2. Component Importance Factor (Ip): [1.0][1.5] .
 3. Component Amplification Factor (ap): [1.0][2.5]<Insert value> .
 4. Component Response Modification Factor (Rp): [1.5][2.0][2.5][6.0]<Insert value> .
 5. Component Overstrength Factor (Qo): [1.5][2.5]<Insert value> .

2.2 ENCLOSED SWITCHES

- A. UL WIAx or NITW - Single- or Double-Throw Enclosed Switch :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following] :
 - a. [ABB Industrial Connections & Solutions LLC]
 - b. [ABB Industrial Connections and Solutions LLC (Tradename Midwest)]
 - c. [Appleton; Emerson Electric Co., Automation Solutions]
 - d. [Bussmann; Eaton, Electrical Sector]
 - e. [Crouse-Hinds; brand of Eaton, Electrical Sector]
 - f. [Eaton]
 - g. [Hubbell Inc Wiring Device Div]
 - h. [Leviton Manufacturing Co., Inc.]
 - i. [Siemens]
 - j. [Square D; Schneider Electric USA]
 - k. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [ABB Industrial Connections & Solutions LLC]
 - b. [ABB Industrial Connections and Solutions LLC (Tradename Midwest)]
 - c. [Appleton; Emerson Electric Co., Automation Solutions]
 - d. [Bussmann; Eaton, Electrical Sector]
 - e. [Crouse-Hinds; brand of Eaton, Electrical Sector]
 - f. [Eaton]
 - g. [Hubbell Inc Wiring Device Div]
 - h. [Leviton Manufacturing Co., Inc.]
 - i. [Siemens]
 - j. [Square D; Schneider Electric USA]
 - k. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by [UL Solutions][or][FM Approvals][, CSA Group (with "US" marking)][, Intertek ETL][, TÜV Rheinland][, or other qualified electrical testing laboratory recognized by authorities having jurisdiction] in accordance with one or more of the following guide information and corresponding standards:
 - a. Listed Enclosed Switches: UL CCN WIAx, including UL 98.



- b. Listed Industrial Control Panels: UL CCN NITW, including UL 508A for entire assembly and UL 98 component certification for switches.

5. Standard Features:

- a. Product Reference Standard: "Heavy Duty" switches meeting requirements of NEMA BS 31047.
- b. Enclosure Rating: Marked for intended use and location in accordance with UL 50E.
- c. Motor Rating: Motor-circuit switches must be marked with horsepower ratings for starting characteristics of motor.
- d. Short-Circuit Current Rating: As determined by results of Power System Studies [**and selection of fuses**] .
- e. Fuseholders: Provide clips or bolt pads to accommodate selected fuses.
- f. Lockable Handle: Capability to accept three padlocks, and interlocked with cover in closed position.
- g. Voltage Rating: [120 V(ac)][120/240 V(ac)][125 V(dc)][125/250 V(dc)][240 V(ac)][240/480 V(ac)][250 V(dc)][480 V(ac)][600 V(ac)][600 V(dc)] .
- h. Poles: [Two][Three][Four] .
- i. Wires: [Two][Three][Four][Five] (including solid neutral) .
- j. Current Rating: [30 A][60 A][100 A][200 A][400 A][600 A][800 A][1200 A][1600 A][2000 A][2500 A][3000 A][4000 A] .
- k. Horsepower Rating: [1/2 hp][1-1/2 hp][2 hp][3 hp][5 hp][7-1/2 hp][10 hp][15 hp][25 hp][30 hp][50 hp][60 hp][75 hp][100 hp][200 hp][250 hp] .
- l. Fusing: [Fused][Nonfused] .
- m. Load Class: [General][Isolating] Use.
- n. Throw: [Single][Double] .

6. Accessories:

- a. Receptacle: Polarized, three-phase, four-wire receptacle (fourth wire connected to enclosure ground lug).
 - 1) Interlocking Linkage: Provide interlock between receptacle and switch mechanism to prevent inserting or removing plug while switch is in on position, while inserting plug other than specified, and while turning switch on if incorrect plug is inserted or correct plug has not been fully inserted into receptacle.
- b. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
- c. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
- d. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
- e. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
- f. Service-Rated Switches: Labeled for use as service equipment.
- g. Hookstick Handle: Allows use of hookstick to operate handle.
- h. Auxiliary Contact Kit: [One][Two] N.O./N.C. (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - [24 V(ac)][120 V(ac)][208 V(ac)][240 V(ac)][6 V(dc)][12 V(dc)][24 V(dc)] .
- i. Lugs: [Mechanical][Compression] type, suitable for number, size, and conductor material.

B. UL WIAx or NITW - Fused Electrically-Tripped Enclosed Switch :

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

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

- a. [Eaton]
 - b. [Mersen USA]
 - c. [Siemens]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Eaton]
 - b. [Mersen USA]
 - c. [Siemens]
 - d. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by [UL Solutions][or][FM Approvals][, CSA Group (with "US" marking)][, Intertek ETL][, TÜV Rheinland][, or other qualified electrical testing laboratory recognized by authorities having jurisdiction] in accordance with one or more of the following guide information and corresponding standards:
- a. Listed Enclosed Switches: UL CCN WIA, including UL 98.
 - b. Listed Industrial Control Panels: UL CCN NITW, including UL 508A for entire assembly and UL 98 component certification for switches.
5. Standard Features:
- a. Product Reference Standard: "Heavy Duty" switches meeting requirements of NEMA BS 31047.
 - b. Enclosure Rating: Marked for intended use and location in accordance with UL 50E.
 - c. Motor Rating: Motor-circuit switches must be marked with horsepower ratings for starting characteristics of motor.
 - d. Short-Circuit Current Rating: As determined by results of Power System Studies [and selection of fuses] .
 - e. Fuseholders: Provide clips or bolt pads to accommodate selected fuses.
 - f. Lockable Handle: Capability to accept three padlocks, and interlocked with cover in closed position.
 - g. Shunt Trip: Comply with [ASME A17.1,] UL 50E, and UL 98, with Class J fuse block and 200 kA interrupting and short-circuit current rating.
 - h. Shunt Trip Control Circuit: 120 V(ac); obtained from [integral control power transformer, with primary and secondary fuses,]<Insert source of control power> with control power [transformer][source] of enough capacity to operate shunt trip, pilot, indicating and control devices.
 - i. Voltage Rating: [120 V(ac)][120/240 V(ac)][125 V(dc)][125/250 V(dc)][240 V(ac)][240/480 V(ac)][250 V(dc)][480 V(ac)][600 V(ac)][600 V(dc)] .
 - j. Poles: [Two][Three][Four] .
 - k. Wires: [Two][Three][Four][Five] (including solid neutral) .
 - l. Current Rating: [30 A][60 A][100 A][200 A][400 A][600 A][800 A][1200 A][1600 A][2000 A][2500 A][3000 A][4000 A] .
 - m. Horsepower Rating: [1/2 hp][1-1/2 hp][2 hp][3 hp][5 hp][7-1/2 hp][10 hp][15 hp][25 hp][30 hp][50 hp][60 hp][75 hp][100 hp][200 hp][250 hp] .
 - n. Fusing: [Fused][Nonfused] .
 - o. Load Class: [General][Isolating] Use.
 - p. Throw: [Single][Double] .

6. Accessories:

a. Elevator Disconnect Accessories:

- 1) Oiltight key switch for key-to-test function.
- 2) Oiltight Pilot Light: **[Red][Green][White][Yellow]** ON.
- 3) Isolated Neutral Lug: **[100][200]** percent rating.
- 4) Mechanically interlocked auxiliary contacts that change state when switch is opened and closed.
- 5) Three-pole, double-throw, fire-safety and alarm relay: **[120 V(ac)][24 V(dc)]** coil voltage.
- 6) Three-pole, double-throw, fire-alarm voltage monitoring relay complying with NFPA 72.

- b. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
- c. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
- d. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
- e. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
- f. Service-Rated Switches: Labeled for use as service equipment.
- g. Hookstick Handle: Allows use of hookstick to operate handle.
- h. Auxiliary Contact Kit: **[One][Two]** N.O./N.C. (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - **[24 V(ac)][120 V(ac)][208 V(ac)][240 V(ac)][6 V(dc)][12 V(dc)][24 V(dc)]**.
- i. Lugs: **[Mechanical][Compression]** type, suitable for number, size, and conductor material.

C. UL WIAx or NITW - Electrically-Tripped Ground-Fault Protection Enclosed Switch :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Eaton]**
 - b. **[Mersen USA]**
 - c. **[Siemens]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Eaton]**
 - b. **[Mersen USA]**
 - c. **[Siemens]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by **[UL Solutions][or][FM Approvals][, CSA Group (with "US" marking)][, Intertek ETL][, TÜV Rheinland][, or other qualified electrical testing laboratory recognized by authorities having jurisdiction]** in accordance with one or more of the following guide information and corresponding standards:

- a. Listed Enclosed Switches: UL CCN WIAAX, including UL 98.
 - b. Listed Industrial Control Panels: UL CCN NITW, including UL 508A for entire assembly and UL 98 component certification for switches.
5. Standard Features:
- a. Product Reference Standard: "Heavy Duty" switches meeting requirements of NEMA BS 31047.
 - b. Enclosure Rating: Marked for intended use and location in accordance with UL 50E.
 - c. Motor Rating: Motor-circuit switches must be marked with horsepower ratings for starting characteristics of motor.
 - d. Short-Circuit Current Rating: As determined by results of Power System Studies [**and selection of fuses**] .
 - e. Fuseholders: Provide clips or bolt pads to accommodate selected fuses.
 - f. Lockable Handle: Capability to accept three padlocks, and interlocked with cover in closed position.
 - g. Shunt Trip: Comply with UL 50E, and UL 98, with Class J fuse block and 200 kA interrupting and short-circuit current rating.
 - h. Shunt Trip Control Circuit: 120 V(ac); obtained from [**integral control power transformer, with primary and secondary fuses,**] <Insert source of control power> with control power [**transformer**] [**source**] of enough capacity to operate shunt trip, pilot, indicating and control devices.
 - i. Voltage Rating: [**120 V(ac)**] [**120/240 V(ac)**] [**125 V(dc)**] [**125/250 V(dc)**] [**240 V(ac)**] [**240/480 V(ac)**] [**250 V(dc)**] [**480 V(ac)**] [**600 V(ac)**] [**600 V(dc)**] .
 - j. Poles: [**Two**] [**Three**] [**Four**] .
 - k. Wires: [**Two**] [**Three**] [**Four**] [**Five**] [(including solid neutral)] .
 - l. Current Rating: [**30 A**] [**60 A**] [**100 A**] [**200 A**] [**400 A**] [**600 A**] [**800 A**] [**1200 A**] [**1600 A**] [**2000 A**] [**2500 A**] [**3000 A**] [**4000 A**] .
 - m. Horsepower Rating: [**1/2 hp**] [**1-1/2 hp**] [**2 hp**] [**3 hp**] [**5 hp**] [**7-1/2 hp**] [**10 hp**] [**15 hp**] [**25 hp**] [**30 hp**] [**50 hp**] [**60 hp**] [**75 hp**] [**100 hp**] [**200 hp**] [**250 hp**] .
 - n. Fusing: [**Fused**] [**Nonfused**] .
 - o. Load Class: [**General**] [**Isolating**] Use.
 - p. Throw: [**Single**] [**Double**] .
6. Accessories:
- a. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
 - b. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 - c. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
 - d. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
 - e. Service-Rated Switches: Labeled for use as service equipment.
 - f. Hookstick Handle: Allows use of hookstick to operate handle.
 - g. Auxiliary Contact Kit: [**One**] [**Two**] N.O./N.C. (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - [**24 V(ac)**] [**120 V(ac)**] [**208 V(ac)**] [**240 V(ac)**] [**6 V(dc)**] [**12 V(dc)**] [**24 V(dc)**] .
 - h. Lugs: [**Mechanical**] [**Compression**] type, suitable for number, size, and conductor material.

2.3 DEAD-FRONT SWITCHES

A. UL WHXS - Switch for Mounting in Separate Dead-Front Enclosure :

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

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

- a. **[Eaton]**
 - b. **[Erickson Electrical Equipment Company]**
 - c. **[Siemens]**
 - d. **[Square D; Schneider Electric USA]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Eaton]**
 - b. **[Erickson Electrical Equipment Company]**
 - c. **[Siemens]**
 - d. **[Square D; Schneider Electric USA]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by **[UL Solutions][or][FM Approvals][, CSA Group (with "US" marking)][, Intertek ETL][, TÜV Rheinland][, or other qualified electrical testing laboratory recognized by authorities having jurisdiction]** in accordance with the following guide information and corresponding standards:
 - a. Listed Dead-Front Switches: UL CCN WHXS, including UL 98.
5. Standard Features:
 - a. Product Reference Standard: "Heavy Duty" switches meeting requirements of NEMA BS 31047.
 - b. Enclosure Rating: Marked for intended use and location in accordance with UL 50E.
 - c. Motor Rating: Motor-circuit switches marked with horsepower ratings for starting characteristics of motor.
 - d. Short-Circuit Current Rating: As determined by results of Power System Studies [**and selection of fuses**] .
 - e. Fuseholders: Provide clips or bolt pads to accommodate selected fuses.
 - f. Lockable Handle: Capability to accept three padlocks, and interlocked with cover in closed position.
 - g. Voltage Rating: **[120 V(ac)][120/240 V(ac)][125 V(dc)][125/250 V(dc)][240 V(ac)][240/480 V(ac)][250 V(dc)][480 V(ac)][600 V(ac)][600 V(dc)]** .
 - h. Poles: **[Two][Three][Four]** .
 - i. Wires: **[Two][Three][Four][Five][(including solid neutral)]** .
 - j. Current Rating: **[30 A][60 A][100 A][200 A][400 A][600 A][800 A][1200 A][1600 A][2000 A][2500 A][3000 A][4000 A]** .
 - k. Horsepower Rating: **[1/2 hp][1-1/2 hp][2 hp][3 hp][5 hp][7-1/2 hp][10 hp][15 hp][25 hp][30 hp][50 hp][60 hp][75 hp][100 hp][200 hp][250 hp]** .
 - l. Fusing: **[Fused][Nonfused]** .
 - m. Load Class: **[General][Isolating]** Use.
 - n. Throw: **[Single][Double]** .
6. Accessories:
 - a. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground

- conductors.
- b. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
- c. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
- d. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
- e. Service-Rated Switches: Labeled for use as service equipment.
- f. Hookstick Handle: Allows use of hookstick to operate handle.
- g. Auxiliary Contact Kit: **[One][Two]** N.O./N.C. (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - **[24 V(ac)][120 V(ac)][208 V(ac)][240 V(ac)][6 V(dc)][12 V(dc)][24 V(dc)]** .
- h. Lugs: **[Mechanical][Compression]** type, suitable for number, size, and conductor material.

2.4 ENCLOSED SWITCHES FOR USE IN HAZARDOUS (CLASSIFIED) LOCATIONS

A. UL WRPR - Enclosed Switch for Use in Hazardous Location :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[Appleton Group (tradename NEER)]**
 - b. **[Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Rockwell Automation, Inc.]**
 - d. **[Square D; Schneider Electric USA]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Appleton Group (tradename NEER)]**
 - b. **[Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Rockwell Automation, Inc.]**
 - d. **[Square D; Schneider Electric USA]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by **[UL Solutions][or][FM Approvals][, CSA Group (with "US" marking)][, Intertek ETL][, TÜV Rheinland][, or other qualified electrical testing laboratory recognized by authorities having jurisdiction]** in accordance with the following guide information and corresponding standards:
 - a. Listed Enclosed Switches: UL CCN WRPR, including UL 98.
 - b. Listed Equipment for Use in and Relating to Classes I, II, and III, Divisions 1 and 2 Hazardous Locations: UL CCN AAIZ, including one or more of the following combinations of applicable standards:
 - 1) Class I, Division 1: UL 1203, UL 913, NFPA 496, UL 60079-28, and UL 60079-33.
 - 2) Class I, Division 2: UL 121201, NFPA 496, UL 60079-28, and UL 60079-33.
 - 3) Class II, Division 1: UL 1203, UL 913, NFPA 496, UL 60079-28, and UL 60079-33.
 - 4) Class II, Division 2: UL 121201, NFPA 496, UL 60079-28, and UL 60079-33.
 - 5) Class III, Divisions 1 and 2: UL 913, UL 121201, and UL 60079-33.

5. Standard Features:

- a. Product Reference Standard: "Heavy Duty" switches meeting requirements of NEMA BS 31047.
- b. Enclosure Rating: Marked for intended use and location in accordance with UL 50E.
- c. Motor Rating: Motor-circuit switches marked with horsepower ratings for starting characteristics of motor.
- d. Short-Circuit Current Rating: As determined by results of Power System Studies [**and selection of fuses**] .
- e. Fuseholders: Provide clips or bolt pads to accommodate selected fuses.
- f. Lockable Handle: Capability to accept three padlocks, and interlocked with cover in closed position.
- g. Voltage Rating: [**120 V(ac)**][**120/240 V(ac)**][**125 V(dc)**][**125/250 V(dc)**][**240 V(ac)**][**240/480 V(ac)**][**250 V(dc)**][**480 V(ac)**][**600 V(ac)**][**600 V(dc)**] .
- h. Poles: [**Two**][**Three**][**Four**] .
- i. Wires: [**Two**][**Three**][**Four**][**Five**][(including solid neutral)] .
- j. Current Rating: [**30 A**][**60 A**][**100 A**][**200 A**][**400 A**][**600 A**][**800 A**][**1200 A**][**1600 A**][**2000 A**][**2500 A**][**3000 A**][**4000 A**] .
- k. Horsepower Rating: [**1/2 hp**][**1-1/2 hp**][**2 hp**][**3 hp**][**5 hp**][**7-1/2 hp**][**10 hp**][**15 hp**][**25 hp**][**30 hp**][**50 hp**][**60 hp**][**75 hp**][**100 hp**][**200 hp**][**250 hp**] .
- l. Fusing: [**Fused**][**Nonfused**] .
- m. Load Class: [**General**][**Isolating**] Use.
- n. Throw: [**Single**][**Double**] .

6. Accessories:

- a. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
- b. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
- c. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
- d. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
- e. Service-Rated Switches: Labeled for use as service equipment.
- f. Hookstick Handle: Allows use of hookstick to operate handle.
- g. Auxiliary Contact Kit: [**One**][**Two**] N.O./N.C. (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - [**24 V(ac)**][**120 V(ac)**][**208 V(ac)**][**240 V(ac)**][**6 V(dc)**][**12 V(dc)**][**24 V(dc)**] .
- h. Lugs: [**Mechanical**][**Compression**] type, suitable for number, size, and conductor material.

2.5 FUSED POWER-CIRCUIT DEVICES

A. UL IYSR - Enclosed Fused Bolted-Pressure Contact Switch :

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

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

- a. **[Eaton]**
 - b. **[Schneider Electric USA, Inc.]**
 - c. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: Investigated, labeled, and marked by **[UL Solutions][or][FM Approvals][, CSA Group (with "US" marking)][, Intertek ETL][, TÜV Rheinland][, or other qualified electrical testing laboratory recognized by authorities having jurisdiction]** in accordance with the following guide information and corresponding standards:
 - a. Listed Fused Power-Circuit Devices: UL CCN IYSR, including UL 977.
 5. Standard Features:
 - a. Product Reference Standard: "Heavy Duty" switches meeting requirements of NEMA BS 31047 providing additional pressure or clamping action at both ends of the switch blades when the blades are in a fully closed position.
 - b. Enclosure Rating: Marked for intended use and location in accordance with UL 50E.
 - c. Motor Rating: Motor-circuit switches marked with horsepower ratings for starting characteristics of motor.
 - d. Short-Circuit Current Rating: As determined by results of Power System Studies [**and selection of fuses**] .
 - e. Fuseholders: Provide clips or bolt pads to accommodate selected fuses.
 - f. Lockable Handle: Capability to accept three padlocks, and interlocked with cover in closed position.
 - g. Voltage Rating: **[120 V(ac)][120/240 V(ac)][125 V(dc)][125/250 V(dc)][240 V(ac)][240/480 V(ac)][250 V(dc)][480 V(ac)][600 V(ac)][600 V(dc)]** .
 - h. Poles: **[Two][Three][Four]** .
 - i. Wires: **[Two][Three][Four][Five][(including solid neutral)]** .
 - j. Current Rating: **[30 A][60 A][100 A][200 A][400 A][600 A][800 A][1200 A][1600 A][2000 A][2500 A][3000 A][4000 A]** .
 - k. Horsepower Rating: **[1/2 hp][1-1/2 hp][2 hp][3 hp][5 hp][7-1/2 hp][10 hp][15 hp][25 hp][30 hp][50 hp][60 hp][75 hp][100 hp][200 hp][250 hp]** .
 - l. Fusing: **[Fused][Nonfused]** .
 - m. Load Class: **[General][Isolating]** Use.
 - n. Throw: **[Single][Double]** .
 6. Accessories:
 - a. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
 - b. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 - c. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
 - d. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
 - e. Service-Rated Switches: Labeled for use as service equipment.
 - f. Hookstick Handle: Allows use of hookstick to operate handle.
 - g. Auxiliary Contact Kit: **[One][Two]** N.O./N.C. (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - **[24 V(ac)][120 V(ac)][208 V(ac)][240 V(ac)][6 V(dc)][12 V(dc)][24 V(dc)]** .
 - h. Lugs: **[Mechanical][Compression]** type, suitable for number, size, and conductor material.

B. UL IYSR - Enclosed Fused High-Pressure Butt-Type Contact Switch :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[ABB]**
 - b. **[Eaton]**
 - c. **[Siemens]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB]**
 - b. **[Eaton]**
 - c. **[Siemens]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by **[UL Solutions][or][FM Approvals][, CSA Group (with "US" marking)][, Intertek ETL][, TÜV Rheinland][, or other qualified electrical testing laboratory recognized by authorities having jurisdiction]** in accordance with the following guide information and corresponding standards:
 - a. Listed Fused Power-Circuit Devices: UL CCN IYSR, including UL 977.
5. Standard Features:
 - a. Product Reference Standard: "Heavy Duty" switches meeting requirements of NEMA BS 31047 and having butt-type contacts and a spring-charged mechanism.
 - b. Enclosure Rating: Marked for intended use and location in accordance with UL 50E.
 - c. Motor Rating: Motor-circuit switches marked with horsepower ratings for starting characteristics of motor.
 - d. Short-Circuit Current Rating: As determined by results of Power System Studies **[and selection of fuses]** .
 - e. Fuseholders: Provide clips or bolt pads to accommodate selected fuses.
 - f. Lockable Handle: Capability to accept three padlocks, and interlocked with cover in closed position.
 - g. Voltage Rating: **[120 V(ac)][120/240 V(ac)][125 V(dc)][125/250 V(dc)][240 V(ac)][240/480 V(ac)][250 V(dc)][480 V(ac)][600 V(ac)][600 V(dc)]** .
 - h. Poles: **[Two][Three][Four]** .
 - i. Wires: **[Two][Three][Four][Five][(including solid neutral)]** .
 - j. Current Rating: **[30 A][60 A][100 A][200 A][400 A][600 A][800 A][1200 A][1600 A][2000 A][2500 A][3000 A][4000 A]** .
 - k. Horsepower Rating: **[1/2 hp][1-1/2 hp][2 hp][3 hp][5 hp][7-1/2 hp][10 hp][15 hp][25 hp][30 hp][50 hp][60 hp][75 hp][100 hp][200 hp][250 hp]** .
 - l. Fusing: **[Fused][Nonfused]** .
 - m. Load Class: **[General][Isolating]** Use.
 - n. Throw: **[Single][Double]** .
6. Accessories:

- a. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
- b. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
- c. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
- d. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
- e. Service-Rated Switches: Labeled for use as service equipment.
- f. Hookstick Handle: Allows use of hookstick to operate handle.
- g. Auxiliary Contact Kit: **[One][Two]** N.O./N.C. (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - **[24 V(ac)][120 V(ac)][208 V(ac)][240 V(ac)][6 V(dc)][12 V(dc)][24 V(dc)]** .
- h. Lugs: **[Mechanical][Compression]** type, suitable for number, size, and conductor material.

2.6 MOLDED-CASE CIRCUIT BREAKERS AND ENCLOSURES

A. UL DIVQ - Enclosed Molded-Case Circuit Breaker :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[ABB]**
 - b. **[ABB Industrial Connections and Solutions LLC (GE ED&C)]**
 - c. **[Eaton]**
 - d. **[Hubbell Inc Wiring Device Div]**
 - e. **[Leviton Manufacturing Co., Inc.]**
 - f. **[Littelfuse, Inc.]**
 - g. **[NOARK Electric North America]**
 - h. **[Siemens Industry, Inc.]**
 - i. **[Square D; Schneider Electric USA]**
 - j. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB]**
 - b. **[ABB Industrial Connections and Solutions LLC (GE ED&C)]**
 - c. **[Eaton]**
 - d. **[Hubbell Inc Wiring Device Div]**
 - e. **[Leviton Manufacturing Co., Inc.]**
 - f. **[Littelfuse, Inc.]**
 - g. **[NOARK Electric North America]**
 - h. **[Siemens Industry, Inc.]**
 - i. **[Square D; Schneider Electric USA]**
 - j. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by **[UL Solutions][or][FM Approvals][, CSA Group (with "US" marking)][, Intertek ETL][, TÜV Rheinland][, or other qualified electrical testing laboratory recognized by authorities having jurisdiction]** in accordance with the following guide information and corresponding standards:

- a. Listed Fused Power-Circuit Devices: UL CCN DIVQ, including UL 489.
5. Standard Features:
- a. Product Reference Standard: NEMA AB 3.
 - b. Enclosure Rating: Marked for intended use and location in accordance with UL 50E.
 - c. Short-Circuit Current Rating: As determined by results of Power System Studies.
 - d. System Frequency: **[50/60 Hz][DC][400 Hz]<Insert frequency>** .
 - e. Voltage Rating: **[120 V(ac)][125 V(ac)][120/240 V(ac)][208 V(ac)][208Y/120 V(ac)][240 V(ac)][277 V(ac)][480Y/277 V(ac)][480 V(ac)][347 V(ac)][600Y/347 V(ac)][600 V(ac)][24 V(dc)][48 V(dc)][60 V(dc)][65 V(dc)][80 V(dc)][125 V(dc)][125/250 V(dc)][160 V(dc)][250 V(dc)][500 V(dc)][600 V(dc)]** .
 - f. Poles: **[One][Two][Three][corner-grounded delta]** .
 - g. Wires: **[Two][Three][Four][Five]** (including solid neutral) .
 - h. Current Rating: **[15 A][20 A][25 A][30 A][34 A][40 A][45 A][50 A][60 A][70 A][80 A][90 A][100 A][110 A][125 A][150 A][175 A][200 A][225 A][250 A][300 A][350 A][400 A][450 A][500 A][600 A][700 A][800 A][1000 A][1200 A][1600 A][2000 A][2500 A][3000 A][4000 A][5000 A][6000 A]** .
 - i. Tripping Means: **[Thermal-Magnetic][Hydraulic-Magnetic][Electronic (Solid-State)]** .
 - j. Intended Use: **[Main][Feeder][Branch circuit]** protection.
 - k. Specific Purpose Categories:
 - 1) Remotely operated.
 - 2) Integrally-fused.
 - 3) Current-limiting.
 - 4) Switching Duty (SWD).
 - 5) Instantaneous trip only (motor circuit protector or circuit interrupter).
 - 6) Heating, air conditioning, and refrigeration (HACR).
 - 7) Marine.
 - 8) Naval.
 - 9) Mining.
 - 10) High intensity discharge lighting (HID).
 - 11) Ground-fault circuit interrupter (GFCI).
 - 12) Arc-fault circuit interrupter (AFCI).
 - 13) Equipment ground-fault protective device.
 - 14) Classified (alternates).
 - 15) Secondary surge arrester.
 - 16) Transient voltage surge suppressor (TVSS).
 - 17) For use with uninterruptible power supplies (UPS).
 - 18) 100 percent rated.
 - 19) Photovoltaic (PV).
 - l. Fusing: **[Fused][Nonfused]** .
 - m. Conductor Connections: **[Front-connected][Rear-connected]** .
 - n. Mounting Arrangement: **[Stationary][Plug-in][Drawout]** .
 - o. Lugs: **[Mechanical][Compression]** type, suitable for number, size, trip ratings, and conductor material. Suitable for **[60 deg C rated wire on 125 A circuit breakers and below][75 deg C rated wire][90 deg C rated wire, sized in accordance with 75 deg C temperature rating in NFPA 70]** .
 - p. Ground-Fault Protection: Comply with UL 1053; **[integrally mounted, self-powered][remote-mounted and powered]** type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
 - q. Communication Capability: **[Circuit-breaker-mounted][Universal-mounted][Integral][Din-rail-mounted]** communication module with functions and features

compatible with power monitoring and control system, specified in Section 260913 "Electrical Power Monitoring."

6. Accessories:

- a. Interchangeable Trip Unit: Field-installable assembly that controls tripping functions.
- b. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
- c. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
- d. Auxiliary Switch: **[Rated for pilot duty][Not rated for pilot duty]** . **[One SPDT switch][Two SPDT switches]** with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
- e. Alarm Switch: **[Rated for pilot duty][Not rated for pilot duty]** . One **[N.O.][N.C.]** contact operates only when circuit breaker has tripped.
- f. Electrical Operator: Provide remote control for on, off, and reset operations.
- g. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key must be removable only when circuit breaker is in off position.
- h. Zone-Selective Interlocking: Integral with **[electronic][ground-fault]** trip unit; for interlocking ground-fault protection function.
- i. Handle Locking Device: Capable of locking circuit breaker in isolated position.
- j. Accessory Control Power: **[Integrally mounted, self-powered][Remote mounted and powered]** ; **[24 V(ac)][120 V(ac)][208 V(ac)][240 V(ac)][12 V(dc)][24 V(dc)][120 V(dc)]** .

2.7 MOLDED-CASE SWITCHES AND ENCLOSURES

A. UL WJAZ - Enclosed Molded-Case Switch :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]** :
 - a. **[ABB Industrial Connections & Solutions LLC]**
 - b. **[Bussmann; Eaton, Electrical Sector]**
 - c. **[Eaton]**
 - d. **[NOARK Electric North America]**
 - e. **[Schneider Electric USA, Inc.]**
 - f. **[Siemens Industry, Inc.]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB Industrial Connections & Solutions LLC]**
 - b. **[Bussmann; Eaton, Electrical Sector]**
 - c. **[Eaton]**
 - d. **[NOARK Electric North America]**
 - e. **[Schneider Electric USA, Inc.]**
 - f. **[Siemens Industry, Inc.]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by **[UL Solutions][or][FM Approvals][, CSA Group (with "US" marking)][, Intertek ETL][, TÜV Rheinland][, or other qualified electrical**

testing laboratory recognized by authorities having jurisdiction] in accordance with the following guide information and corresponding standards:

- a. Listed Fused Power-Circuit Devices: UL CCN WJAZ, including UL 489.
5. Standard Features:
- a. Product Reference Standard: NEMA AB 3 and is designed to open and close a circuit by nonautomatic means.
 - b. Enclosure Rating: Marked for intended use and location in accordance with UL 50E.
 - c. Short-Circuit Current Rating: As determined by results of Power System Studies.
 - d. System Frequency: **[50/60 Hz][DC][400 Hz]<Insert frequency>** .
 - e. Voltage Rating: **[120 V(ac)][125 V(ac)][120/240 V(ac)][208 V(ac)][208Y/120 V(ac)][240 V(ac)][277 V(ac)][480Y/277 V(ac)][480 V(ac)][347 V(ac)][600Y/347 V(ac)][600 V(ac)][24 V(dc)][48 V(dc)][60 V(dc)][65 V(dc)][80 V(dc)][125 V(dc)][125/250 V(dc)][160 V(dc)][250 V(dc)][500 V(dc)][600 V(dc)]** .
 - f. Poles: **[One][Two][Three][<corner-grounded delta>]** .
 - g. Wires: **[Two][Three][Four][Five][<including solid neutral>]** .
 - h. Current Rating: **[15 A][20 A][25 A][30 A][34 A][40 A][45 A][50 A][60 A][70 A][80 A][90 A][100 A][110 A][125 A][150 A][175 A][200 A][225 A][250 A][300 A][350 A][400 A][450 A][500 A][600 A][700 A][800 A][1000 A][1200 A][1600 A][2000 A][2500 A][3000 A][4000 A][5000 A][6000 A]** .
 - i. Tripping Means: **[Thermal-Magnetic][Hydraulic-Magnetic][Electronic (Solid-State)]** .
 - j. Intended Use: **[Main][Feeder][Branch circuit]** protection.
 - k. Specific Purpose Categories:
 - 1) Remotely operated.
 - 2) Integrally-fused.
 - 3) Current-limiting.
 - 4) Switching Duty (SWD).
 - 5) Instantaneous trip only (motor circuit protector or circuit interrupter).
 - 6) Heating, air conditioning, and refrigeration (HACR).
 - 7) Marine.
 - 8) Naval.
 - 9) Mining.
 - 10) High intensity discharge lighting (HID).
 - 11) Ground fault circuit interrupter (GFCI).
 - 12) Arc fault circuit interrupter (AFCI).
 - 13) Equipment ground fault protection.
 - 14) Classified (alternates).
 - 15) Secondary surge arrester.
 - 16) Transient voltage surge suppressor (TVSS).
 - 17) For use with uninterruptible power supplies (UPS).
 - 18) 100 percent rated.
 - 19) Photovoltaic (PV).
 - l. Fusing: **[Fused][Nonfused]** .
 - m. Conductor Connections: **[Front-connected][Rear-connected]** .
 - n. Mounting Arrangement: **[Stationary][Plug-in][Drawout]** .
 - o. Lugs: **[Mechanical][Compression]** type, suitable for number, size, trip ratings, and conductor material. Suitable for **[60 deg C rated wire on 125 A switches and below][75 deg C rated wire][90 deg C rated wire, sized in accordance with 75 deg C temperature rating in NFPA 70]** .
 - p. Ground-Fault Protection: Comply with UL 1053; **[integrally mounted, self-powered][remote-mounted and powered]** type with mechanical ground-fault indicator;

- relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
- q. Communication Capability: **[Circuit-breaker-mounted][Universal-mounted][Integral][DIN-rail-mounted]** communication module with functions and features compatible with power monitoring and control system, specified in Section 260913 "Electrical Power Monitoring."

6. Accessories:

- a. Interchangeable Trip Unit: Field-installable assembly that controls tripping functions.
- b. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
- c. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
- d. Auxiliary Switch: **[Rated for pilot duty][Not rated for pilot duty]** . **[One SPDT switch][Two SPDT switches]** with "a" and "b" contacts; "a" contacts mimic switch contacts, "b" contacts operate in reverse of switch contacts.
- e. Alarm Switch: **[Rated for pilot duty][Not rated for pilot duty]** . One **[N.O.][N.C.]** contact operates only when switch has tripped.
- f. Electrical Operator: Provide remote control for on, off, and reset operations.
- g. Key Interlock Kit: Externally mounted to prohibit switch operation; key must be removable only when switch is in off position.
- h. Zone-Selective Interlocking: Integral with **[electronic][ground-fault]** trip unit; for interlocking ground-fault protection function.
- i. Handle Locking Device: Capable of locking switch in isolated position.
- j. Accessory Control Power: **[Integrally mounted, self-powered][Remote mounted and powered]** ; **[24 V(ac)][120 V(ac)][208 V(ac)][240 V(ac)][12 V(dc)][24 V(dc)][120 V(dc)]** .

2.8 MAINTENANCE MATERIAL ITEMS

- A. Spare Parts: Furnish to Owner spare parts, for repairing enclosed switches and circuit breakers, that are packaged with protective covering for storage on-site and identified with labels describing contents. [**Include the following:**]
1. Fuses: Equal to **[10]<Insert number>** percent of quantity installed for each size and type, but no fewer than **[three]<Insert number>** of each size and type.
 2. Fuse Pullers: **[Two]<Insert number>** for each size and type.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.
 1. Commencement of work will indicate Installer's acceptance of areas and conditions as satisfactory.

3.2 SELECTION OF ENCLOSURES

- A. Indoor, Dry and Clean Locations: UL 50E, **[Type 1]<Insert type>** .



- B. Outdoor Locations: UL 50E, [Type 3R][Type 4X]<Insert type> .
- C. Kitchen and Wash-Down Areas: UL 50E, [Type 4X]<Insert type> , [stainless steel]<Insert material> .
- D. Other Wet or Damp, Indoor Locations: UL 50E, [Type 4]<Insert type> .
- E. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: UL 50E, Type 12.
- F. Hazardous Areas Indicated on the Drawings: UL 50E, [Type 7][Type 9]<Insert type>[with cover attached by Type 316 stainless steel bolts] .

3.3 INSTALLATION, GENERAL

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:
 - 1. Electrical Construction: ICC IBC, ICC IFB, NFPA 1, NFPA 70, and NECA NEIS 1.
 - 2. Electrical Maintenance: NFPA 70B and NECA NEIS 91.
 - 3. Electrical Safety: NFPA 70E.
 - 4. Commissioning of Electrical Systems: NECA NEIS 90.
 - 5. Commissioning of Active and Passive Fire Protection Features: NFPA 3 and NFPA 4.
 - 6. Hot Work: NFPA 51B.
 - 7. Fire-Alarm and Premises Security Work: NFPA 72, NFPA 731, NFPA 1225, and NECA NEIS 305.
 - 8. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
 - 9. Communications Work: BICSI N1.
 - 10. Work in ITE Rooms: NFPA 75.
 - 11. Work in Health Care Facilities: NFPA 99 and Article 517 of NFPA 70.
 - 12. Life Safety and Means of Egress Work: NFPA 101.
 - 13. Emergency and Standby Power Work: NFPA 110, NFPA 111, and NECA NEIS 416.
 - 14. Work in Confined Spaces: NFPA 350.
 - 15. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
 - 16. Evaluation of Unlabeled Electrical Equipment: NFPA 791.
 - 17. Consult Architect for resolution of conflicting requirements.
- C. Interfaces with Other Work:
 - 1. Identification: Provide labels for enclosed switches, circuit breakers, and associated electrical equipment.
 - a. Identify field-installed conductors, interconnecting wiring, and components.
 - b. Label each enclosure with engraved metal or laminated-plastic nameplate.
 - c. Provide warning signs and arc-flash hazard warning labels for electrical equipment.
 - 2. Grounding and Bonding:
 - a. Equipment Grounding Conductors: Provide and route insulated equipment grounding conductors with other feeder or branch circuit conductors. Bond equipment grounding conductor to enclosure using provided hardware in accordance with manufacturer's published instructions.
 - b. Equipment Bonding Conductors: Provide equipment bonding straps or jumpers where additional bonding is indicated on the Drawings between enclosed switches or circuit breakers and adjacent metallic equipment, enclosures, piping, or building structure. Route

bonding conductors along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access panels or placing conductors where they may be subjected to strain, impact, or damage.

3.4 INSTALLATION OF ENCLOSED SWITCHES AND CIRCUIT BREAKERS

A. Special Techniques:

1. Layout Coordination: Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
2. Mounting Heights: Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
3. Seismic Controls: Provide equipment mounts and anchors complying with seismic requirements for the Project.
4. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
5. Fusing: Install fuses in fusible devices.

3.5 FIELD QUALITY CONTROL OF ENCLOSED SWITCHES AND CIRCUIT BREAKERS

A. Administrant for Electrical Power Tests and Inspections:

1. **[Owner][Tenant]** will engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
2. Engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections [**with assistance of factory-authorized service representative**] .

B. Acceptance Testing Preparation: **<Insert requirements>** .

C. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>** .

D. Tests and Inspections for Enclosed Switches, Dead-Front Switches, Enclosed Switches for Use in Hazardous (Classified) Locations, and Fused Power-Circuit Devices:

1. Visual and Mechanical Inspection:

- a. Inspect physical and mechanical condition.
- b. Inspect anchorage, alignment, grounding, and clearances.
- c. Verify that unit is clean.
- d. Verify blade alignment, blade penetration, travel stops, and mechanical operation.
- e. Verify that fuse sizes and types match the Specifications and the Drawings.
- f. Verify that each fuse has adequate mechanical support and contact integrity.
- g. Inspect bolted electrical connections for high resistance using one of the methods as follows:

1) Use low-resistance ohmmeter.

- a) Compare bolted connection resistance values to values of similar

connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of lowest value.

- 2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.
 - a) Bolt-torque levels must be in accordance with manufacturer's published data. In absence of manufacturer's published data, use NETA ATS Table 100.12.
- h. Verify that operation and sequencing of interlocking systems is as described in the Specifications and shown on the Drawings.
- i. Verify correct phase barrier installation.
- j. Verify lubrication of moving current-carrying parts and moving and sliding surfaces.

2. Electrical Tests:

- a. Perform resistance measurements through bolted connections with low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of lowest value.
- b. Measure contact resistance across each switchblade fuseholder. Drop values may not exceed high level of manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of lowest value.
- c. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, use Table 100.1 from NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.
- d. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.
- e. Perform ground fault test in accordance with NETA ATS Section 7.14 "Ground Fault Protection Systems, Low-Voltage."

E. Tests and Inspections for Molded-Case Circuit Breakers and Enclosures and for Molded-Case Switches and Enclosures:

1. Visual and Mechanical Inspection:

- a. Verify that equipment nameplate data are as described in the Specifications and shown on the Drawings.
- b. Inspect physical and mechanical condition.
- c. Inspect anchorage, alignment, grounding, and clearances.
- d. Verify that unit is clean.
- e. Operate circuit breaker to ensure smooth operation.
- f. Inspect bolted electrical connections for high resistance using one of the methods as follows:
 - 1) Use low-resistance ohmmeter.
 - a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of lowest value.

- 2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.
 - a) Bolt-torque levels must be in accordance with manufacturer's published data. In absence of manufacturer's published data, use NETA ATS Table 100.12.
 - g. Inspect operating mechanism, contacts, and chutes in unsealed units.
 - h. Perform adjustments for final protective device settings in accordance with coordination study.
 2. Electrical Tests:
 - a. Perform resistance measurements through bolted connections with low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of lowest value.
 - b. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, use Table 100.1 from NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.
 - c. Perform contact/pole resistance test. Drop values may not exceed high level of manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of lowest value.
 - d. Perform insulation resistance tests on control wiring with respect to ground. Applied potential must be 500 V(dc) for 300 V rated cable and 1000 V(dc) for 600 V rated cable. Test duration must be one minute. For units with solid state components, follow manufacturer's recommendation. Insulation resistance values may be no less than 2 MΩ.
 - e. Determine the primary current injection by the following:
 - 1) Long-time pickup and delay. Pickup values must be as specified. Trip characteristics may not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
 - 2) Short-time pickup and delay. Short-time pickup values must be as specified. Trip characteristics may not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
 - 3) Ground-fault pickup and time delay. Ground-fault pickup values must be as specified. Trip characteristics may not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
 - 4) Instantaneous pickup. Instantaneous pickup values must be as specified and within manufacturer's published tolerances.
 - f. Test functionality of trip unit by means of primary current injection. Pickup values and trip characteristics must be as specified and within manufacturer's published tolerances.
 - g. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data. Minimum pickup voltage of shunt trip and close coils must be as indicated by manufacturer.
 - h. Verify correct operation of auxiliary features such as trip and pickup indicators; zone interlocking; electrical close and trip operation; trip-free, anti-pump function; and trip unit battery condition. Reset trip logs and indicators. Investigate units that do not function as designed.
 - i. Verify operation of charging mechanism. Investigate units that do not function as designed.
 3. Test and adjust controls, remote monitoring, and safeties.

- F. Nonconforming Work:
1. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.
 2. Remove and replace defective units and retest.
- G. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.
1. Test procedures used.
 2. Include identification of each enclosed switch and circuit breaker tested and describe test results.
 3. List deficiencies detected, remedial action taken, and observations after remedial action.
- H. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.
1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.

3.6 ADJUSTING

- A. Adjust moving parts and operable components to function smoothly, and lubricate in accordance with manufacturer's published instructions.
- B. Set field-adjustable circuit-breaker trip ranges [**in accordance with results of power system studies.**][**to values indicated on the Drawings.**][**to values indicated in attached schedule.**]

3.7 PROTECTION

- A. After installation, protect enclosed switches and circuit breakers from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

3.8 MAINTENANCE

- A. Infrared Scanning of Enclosed Switches and Circuit Breakers: Two months after Substantial Completion, perform infrared scan of joints and connections. Remove covers so joints and connections are accessible to portable scanner. Take visible light photographs at same locations and orientations as infrared scans for documentation to ensure follow-on scans match same conditions for valid comparison.
1. Instruments and Equipment: Use infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 2. Follow-up Infrared Scanning: Perform two follow-up infrared scans of enclosed switches and breakers, one at four months and another at 11 months after Substantial Completion.
 3. Instrument: Use infrared-scanning device designed to measure temperature or to detect significant deviations from normal values. Provide documentation of device calibration.
 4. Field Reports for Infrared Scanning: Prepare certified report that identifies units checked and that describes scanning results. Include notation of deficiencies detected, remedial actions taken, and scanning observations after remedial action.



END OF SECTION 26 28 16 00



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Task	Specification	Specification Description
26 28 16 13	26 24 16 00	Panelboards
26 28 16 13	26 28 16 00	Enclosed Switches And Circuit Breakers
26 28 16 16	26 28 16 00	Enclosed Switches And Circuit Breakers



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SECTION 26 29 13 00 - MANUAL AND MAGNETIC MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Manual motor controllers.
2. Magnetic motor controllers.
3. Combination motor controllers.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. Section 260526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding referenced by this Section.
5. Section 260529 "Hangers and Supports for Electrical Systems" specifies hangers, supports, and concrete bases referenced by this Section.
6. Section 260548 "Vibration and Seismic Controls for Electrical Systems" specifies vibration isolation and seismic-[**and wind**]-control devices referenced by this Section.
7. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs referenced by this Section.
8. Section 260573 "Power System Studies" specifies arc-flash hazard analysis, warning labels, and circuit-breaker trip ranges referenced by this Section.

1.2 DEFINITIONS

- A. CPT: Control power transformer.
- B. MCCB: Molded-case circuit breaker.
- C. MCP: Motor circuit protector.
- D. N.C.: Normally closed.
- E. OCPD: Overcurrent protective device.
- F. SCCR: Short-circuit current rating.
- G. SCPD: Short-circuit protective device.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - 2. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing laboratory, certifying that model number corresponding to specified product complies with specified listing criteria.
- B. Shop Drawings: Prepare and submit the following:
 - 1. Include plans, elevations, sections, and mounting details.
 - 2. Indicate dimensions, weights, required clearances, and location and size of each field connection.
 - 3. Wire Termination Diagrams and Schedules: Include diagrams for signal, and control wiring. Identify terminals and wiring designations and color-codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features. Differentiate between manufacturer-installed and field-installed wiring.
 - 4. Include features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
- C. Product Schedule: List the following for each enclosed controller:
 - 1. Each installed magnetic controller type.
 - 2. Laboratory and file number for listing by qualified electrical testing laboratory.
 - 3. Factory-installed accessories.
 - 4. Nameplate legends.
 - 5. SCCR of integrated unit.
 - 6. For each combination magnetic controller include features, characteristics, ratings, and factory setting of the SCPD and OCPD.
 - a. Listing document proving Type 2 coordination.
 - 7. For each series-rated combination state the listed integrated short-circuit current (withstand) rating of SCPD and OCPDs by qualified electrical testing laboratory recognized by authorities having jurisdiction.
- D. Field quality-control reports.
- E. System startup testing reports.

1.4 INFORMATIONAL SUBMITTALS

- A. Manufacturer's published instructions.
- B. Field Reports:
 - 1. Manufacturer's field reports for field quality-control support.
 - 2. Manufacturer's field reports for system startup support.
 - 3. Field reports for infrared scanning.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Spare parts.

1.6 QUALIFICATIONS

- A. Electrical Power Testing (EPT) Technician I: Possessing active NICET EPT Level I certification. Able to work safely around electrical power equipment and cabling under supervision.
- B. Electrical Power Testing (EPT) Technician II: Possessing active NICET EPT Level II certification. Able to isolate and ground electrical power equipment, to connect test equipment, and to conduct and document standard tests of basic equipment.
- C. Electrical Power Testing (EPT) Technician III: Possessing active NICET EPT Level III certification. Able to manage switching procedures, to conduct tests of complex equipment, to analyze test and equipment data, to plan a job, and to lead a team. Has experience performing NFPA 70B, IEEE, and NETA electrical tests.
- D. Electrical Power Testing (EPT) Technician IV: Possessing active NICET EPT Level IV certification. Able to conduct tests of complex metering and relay systems; to evaluate tests, test equipment, test results, and power system performance; to recommend actions to maintain or improve system performance; and to lead multi-team projects.
- E. Electrical Power Testing and Inspecting Agency: Entities possessing active credentials from qualified electrical testing laboratory recognized by authorities having jurisdiction.
 - 1. On-site electrical testing supervisors must possess active NICET EPT Technician [III][IV] certification.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Store controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.
- B. If stored in areas subject to weather, cover controllers to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; **[install temporary electric heating, with at least][50 W]<Insert number>[per controller][connect factory-installed space heaters to temporary electrical service].**

1.8 SERVICE CONDITIONS FOR ELECTRICAL EQUIPMENT

- A. Modeling, analysis, product selection, installation, and quality control for all electrical Work on the Project must comply with service condition requirements specified in Section 018116 "Facility Environmental Requirements" and Section 018123 "Facility Seismic and Wind Criteria."
- B. Ambient Environment Ratings: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - 1. Ambient Temperature: Not less than **23 deg F (minus 5 deg C)** and not exceeding **104 deg F (40 deg C)**.
 - 2. Altitude: Not exceeding **6600 ft (2010 m)** for electromagnetic and manual devices.
 - 3. The effect of solar radiation is insignificant.



4. <Insert unusual service condition>.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- B. Enclosures:
 - 1. Environmental Ratings: Comply with UL 50E, type designations as indicated on the Drawings.
 - 2. Construction: Comply with NEMA IA 10030.
 - 3. Controllers in Hazardous (Classified) Locations: Comply with UL 1203.
- C. Seismic and Wind Performance: Installed assembly must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:
 - 1. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events[, and unit must be fully operational after seismic events].
 - 2. Component Importance Factor (Ip): [1.0][1.5].
 - 3. Component Amplification Factor (ap): [1.0][2.5]<Insert value>.
 - 4. Component Response Modification Factor (Rp): [1.5][2.0][2.5][6.0]<Insert value>.
 - 5. Component Overstrength Factor (Ωo): [1.5][2.5]<Insert value>.

2.2 MANUAL MOTOR CONTROLLERS

- A. Motor-Starting Switches (MSS) :
 - 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [ABB, Motion Business]
 - b. [Eaton]
 - c. [Rockwell Automation, Inc.]
 - d. [Siemens Industry, Inc., Energy Management Division]
 - e. [Square D; Schneider Electric USA]
 - f. <Insert manufacturer's name>
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [ABB, Motion Business]
 - b. [Eaton]
 - c. [Rockwell Automation, Inc.]
 - d. [Siemens Industry, Inc., Energy Management Division]

- e. **[Square D; Schneider Electric USA]**
 - f. **<Insert manufacturer's name>**
- 3. Source Limitations: Obtain products from single manufacturer.
 - 4. Listing Criteria: Investigated, labeled, and marked by **[UL Solutions][or][FM Approvals][, CSA Group (with "US" marking)][, Intertek ETL][, TÜV Rheinland][, or other qualified electrical testing laboratory recognized by authorities having jurisdiction]** in accordance with one or more of the following guide information and corresponding standards:
 - a. Motor Controllers, Manual: UL CCN NLRV, including UL 60947-1 and UL 60947-4-1.
 - 5. Standard Features: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off or on.
 - a. Referenced Standards: Comply with NEMA ICS 2, general purpose, Class A.
 - b. Configuration: **[Nonreversing][Reversing][Two speed]**.
 - c. Mounting: **[Flush][Surface]**.
 - d. Pilot Light Color: **[Red][Green]**.
 - e. Additional Nameplates: **[FORWARD and REVERSE for reversing switches][HIGH and LOW for two-speed switches]<Insert special markings>**.
- B. Fractional Horsepower Manual Controllers (FHPMC) :
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB Electrification Installations Products]**
 - b. **[ABB, Motion Business]**
 - c. **[Eaton]**
 - d. **[Rockwell Automation, Inc.]**
 - e. **[Siemens Industry, Inc., Energy Management Division]**
 - f. **[Square D; Schneider Electric USA]**
 - g. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB Electrification Installations Products]**
 - b. **[ABB, Motion Business]**
 - c. **[Eaton]**
 - d. **[Rockwell Automation, Inc.]**
 - e. **[Siemens Industry, Inc., Energy Management Division]**
 - f. **[Square D; Schneider Electric USA]**
 - g. **<Insert manufacturer's name>**
 - 3. Source Limitations: Obtain products from single manufacturer.
 - 4. Listing Criteria: Investigated, labeled, and marked by **[UL Solutions][or][FM Approvals][, CSA Group (with "US" marking)][, Intertek ETL][, TÜV Rheinland][, or other qualified electrical testing laboratory recognized by authorities having jurisdiction]** in accordance with one or more of the following guide information and corresponding standards:
 - a. Motor Controllers, Manual: UL CCN NLRV, including UL 60947-1 and UL 60947-4-1.

5. Standard Features: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.
 - a. Referenced Standards: Comply with NEMA ICS 2.
 - 1) Overload Relays:
 - a) Inverse-time-current characteristics; **[Class 10]<Insert class>** tripping characteristics; heaters matched to nameplate full-load current of actual protected motor; external reset push button; **bimetallic type**; **melting alloy type**.
 - b) Bimetallic class as scheduled on the Drawings.
 - b. Configuration: **[Nonreversing][Two speed]**.
 - c. Pilot Light: **[Red]<Insert color>**.

C. Integral Horsepower Manual Controllers (IHPMC) :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB Electrification Installations Products]**
 - b. **[ABB, Motion Business]**
 - c. **[Eaton]**
 - d. **[Rockwell Automation, Inc.]**
 - e. **[Siemens Industry, Inc., Energy Management Division]**
 - f. **[Square D; Schneider Electric USA]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB Electrification Installations Products]**
 - b. **[ABB, Motion Business]**
 - c. **[Eaton]**
 - d. **[Rockwell Automation, Inc.]**
 - e. **[Siemens Industry, Inc., Energy Management Division]**
 - f. **[Square D; Schneider Electric USA]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by **[UL Solutions][or][FM Approvals][, CSA Group (with "US" marking)][, Intertek ETL][, TÜV Rheinland][, or other qualified electrical testing laboratory recognized by authorities having jurisdiction]** in accordance with one or more of the following guide information and corresponding standards:
 - a. Motor Controllers, Manual: UL CCN NLRV, including UL 60947-1 and UL 60947-4-1.
5. Standard Features: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.
 - a. Referenced Standards: Comply with NEMA ICS 2.

- 1) Overload Relays:
 - a) Inverse-time-current characteristics; **[Class 10]<Insert class>** tripping characteristics; heaters matched to nameplate full-load current of actual protected motor; external reset push button[; **bimetallic type**]; **melting alloy type**].
 - b) Bimetallic class as scheduled on the Drawings.
- b. Configuration: **[Nonreversing][Two speed]**.

2.3 MAGNETIC MOTOR CONTROLLERS

A. Enclosed Full-Voltage Magnetic Motor Controllers :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB Electrification Installations Products]**
 - b. **[ABB, Motion Business]**
 - c. **[Eaton]**
 - d. **[Rockwell Automation, Inc.]**
 - e. **[Siemens Industry, Inc., Energy Management Division]**
 - f. **[Square D; Schneider Electric USA]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB Electrification Installations Products]**
 - b. **[ABB, Motion Business]**
 - c. **[Eaton]**
 - d. **[Rockwell Automation, Inc.]**
 - e. **[Siemens Industry, Inc., Energy Management Division]**
 - f. **[Square D; Schneider Electric USA]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by **[UL Solutions][or][FM Approvals][, CSA Group (with "US" marking)][, Intertek ETL][, TÜV Rheinland][, or other qualified electrical testing laboratory recognized by authorities having jurisdiction]** in accordance with one or more of the following guide information and corresponding standards:
 - a. Motor Controllers, Magnetic: UL CCN NLDX, including UL 60947-1 and UL 60947-4-1.
5. Standard Features: Across-the-line start, electrically held, for nominal system voltage of 600 V(ac) and less.
 - a. Referenced Standards: Comply with UL 508 and NEMA ICS 2, general purpose, Class A.
 - b. Configuration: **[Nonreversing]<Insert configuration>**.
 - c. Contactor Coils: Pressure-encapsulated type[**with coil transient suppressors when indicated**].



- 1) Operating Voltage: Manufacturer's standard unless otherwise indicated.
- d. Control Power: For on-board control power, obtain from line circuit or from integral CPT with capacity to operate integral devices and remotely located pilot, indicating, and control devices.
 - 1) Spare CPT Capacity as Indicated on the Drawings: **[50][100][200]<Insert number> VA.**
- e. Overload Relays:
 - 1) Thermal Overload Relays:
 - a) Inverse-time-current characteristic.
 - b) **[Class 10][Class 20][Class 30]** tripping characteristic.
 - c) Heaters: In each phase; coordinate with nameplate full-load current of actual protected motor; include appropriate adjustment for duty cycle.
 - d) Ambient compensated.
 - e) Automatic resetting.
 - 2) Solid-State Overload Relay:
 - a) Switch or dial selectable for motor-running overload protection.
 - b) Sensors in each phase.
 - c) **[Class 10][Class 20][Class 30][Class 10/20 selectable]** tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
- f. Class II Ground-Fault Protection: Comply with UL 1053 to interrupt low-level ground faults. The ground-fault detection system includes circuitry that will prevent the motor controller from tripping when the fault current exceeds the interrupting capacity of the controller. Equip with start and run delays to prevent nuisance trip on starting, and a trip indicator.
- g. Digital communication module, using **[TIA-485 Modbus, RTU protocol,][2][4]-wire connection to host devices with a compatible port]<Insert protocol>** to transmit the following to the LAN:
 - 1) Instantaneous rms current each phase, and 3-phase average.
 - 2) Voltage: L-L for each phase, L-L 3-phase average, L-N each phase and L-N 3-phase average - rms.
 - 3) Active Energy (kWh): 3-phase total.
 - 4) Power Factor:**[Each phase and]** 3-phase total.
 - 5) **<Insert value>.**

B. Enclosed Reduced-Voltage Magnetic Motor Controllers :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB Electrification Installations Products]**
 - b. **[ABB, Motion Business]**
 - c. **[Eaton]**
 - d. **[Rockwell Automation, Inc.]**
 - e. **[Siemens Industry, Inc., Energy Management Division]**

- f. **[Square D; Schneider Electric USA]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB Electrification Installations Products]**
 - b. **[ABB, Motion Business]**
 - c. **[Eaton]**
 - d. **[Rockwell Automation, Inc.]**
 - e. **[Siemens Industry, Inc., Energy Management Division]**
 - f. **[Square D; Schneider Electric USA]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by **[UL Solutions][or][FM Approvals][, CSA Group (with "US" marking)][, Intertek ETL][, TÜV Rheinland][, or other qualified electrical testing laboratory recognized by authorities having jurisdiction]** in accordance with one or more of the following guide information and corresponding standards:
 - a. Motor Controllers, Magnetic: UL CCN NLDX, including UL 60947-1 and UL 60947-4-1.
5. Standard Features: Electrically held; closed transition; adjustable time delay on transition, 600 V(ac) or less.
 - a. Referenced Standards: Comply with UL 508 and NEMA ICS 2, general purpose, Class A.
 - b. Configuration:
 - 1) Wye-Delta Controller: Four contactors, with a three-phase starting resistor/reactor bank.
 - 2) Part-Winding Controller: Separate START and RUN contactors, field-selectable for one-half- or two-thirds-winding start mode, with either six- or nine-lead motors; with separate overload relays for starting and running sequences.
 - 3) Autotransformer Reduced-Voltage Controller: Medium-duty service, with integral overtemperature protection; taps for starting at 50, 65, and 80 percent of line voltage; two START and one RUN contactors.
 - c. Contactor Coils: Pressure-encapsulated type **[with coil transient suppressors when indicated]**.
 - 1) Operating Voltage: Manufacturer's standard unless otherwise indicated.
 - d. Control Power: **[24][120]** V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
 - 1) Spare CPT Capacity: **[50][100][200]<Insert number>** VA.
 - e. Overload Relays:
 - 1) Thermal Overload Relays: **[Melting alloy type][Bimetallic type]**.
 - a) Inverse-time-current characteristic.
 - b) **[Class 10][Class 20][Class 30]** tripping characteristic.
 - c) Heaters in each phase matched to nameplate full-load current of actual

- protected motor and with appropriate adjustment for duty cycle.
 - d) Ambient compensated.
 - e) Automatic resetting.
- 2) Solid-State Overload Relay:
 - a) Switch or dial selectable for motor-running overload protection.
 - b) Sensors in each phase.
 - c) **[Class 10][Class 20][Class 30][Class 10/20 selectable]** tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
- f. Class II Ground-Fault Protection: Comply with UL 1053 to interrupt low-level ground faults. The ground-fault detection system includes circuitry that will prevent the motor controller from tripping when the fault current exceeds the interrupting capacity of the controller. Equip with start and run delays to prevent nuisance trip on starting, and a trip indicator.
- g. Digital Communication Module: **[TIA-485 Modbus, RTU protocol,][2][4][-wire connection to host devices with a compatible port]<Insert protocol>** to transmit the following to the LAN:
 - 1) Instantaneous rms current each phase, and 3-phase average.
 - 2) Voltage: L-L for each phase, L-L 3-phase average, L-N each phase and L-N 3-phase average - rms.
 - 3) Active Energy (kWh): 3-phase total.
 - 4) Power Factor: **[Each phase and]** 3-phase total.
 - 5) **<Insert value>**.

C. Multispeed Magnetic Controllers :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB Electrification Installations Products]**
 - b. **[ABB, Motion Business]**
 - c. **[Eaton]**
 - d. **[Rockwell Automation, Inc.]**
 - e. **[Siemens Industry, Inc., Energy Management Division]**
 - f. **[Square D; Schneider Electric USA]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB Electrification Installations Products]**
 - b. **[ABB, Motion Business]**
 - c. **[Eaton]**
 - d. **[Rockwell Automation, Inc.]**
 - e. **[Siemens Industry, Inc., Energy Management Division]**
 - f. **[Square D; Schneider Electric USA]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.

4. Listing Criteria: Investigated, labeled, and marked by **[UL Solutions][or][FM Approvals][, CSA Group (with "US" marking)][, Intertek ETL][, TÜV Rheinland][, or other qualified electrical testing laboratory recognized by authorities having jurisdiction]** in accordance with one or more of the following guide information and corresponding standards:
 - a. Motor Controllers, Magnetic: UL CCN NLDX, including UL 60947-1 and UL 60947-4-1.
5. Standard Features: Two speed, full voltage, across the line, electrically held.
 - a. Referenced Standards: Comply with NEMA ICS 2, general purpose, Class A.
 - b. Configuration: Nonreversing[, **multispeed**].
 - 1) Contactor Coils: Pressure-encapsulated type[**with coil transient suppressors**].
 - a) Operating Voltage: Manufacturer's standard unless otherwise indicated.
 - 2) Power Contacts: Totally enclosed, double break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
 - a) Control Power: **[24][120]** V(ac); obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
 - b) Spare CPT Capacity: **[50][100][200]<Insert number>** VA.
 - 3) Compelling Relays: Ensure that motor will start only at low speed.
 - 4) Accelerating Timer Relays: Ensure properly timed acceleration through speeds lower than that selected.
 - 5) Decelerating Timer Relays: Ensure automatically timed deceleration through each speed.
 - 6) Antiplugging Timer Relays: Ensure a time delay when transferring from FORWARD to REVERSE and back.
 - c. Overload Relays:
 - 1) Thermal Overload Relays: **[Melting alloy type][Bimetallic type]**.
 - a) Inverse-time-current characteristic.
 - b) **[Class 10][Class 20][Class 30]** tripping characteristic.
 - c) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 - d) Ambient compensated.
 - e) Automatic resetting.
 - 2) Solid-State Overload Relay:
 - a) Switch or dial selectable for motor-running overload protection.
 - b) Sensors in each phase.
 - c) **[Class 10][Class 20][Class 30][Class 10/20 selectable]** tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
 - d. Class II Ground-Fault Protection: Comply with UL 1053 to interrupt low-level ground faults. The ground-fault detection system includes circuitry that will prevent the motor controller from tripping when the fault current exceeds the interrupting capacity of the controller. Equip with start and run delays to prevent nuisance trip on starting, and a trip indicator.
 - e. Digital communication module, using **[TIA-485 Modbus, RTU protocol,][2][4]-wire**

connection to host devices with a compatible port]<Insert protocol> to transmit the following to the LAN:

- 1) Instantaneous rms current each phase, and 3-phase average.
- 2) Voltage: L-L for each phase, L-L 3-phase average, L-N each phase and L-N 3-phase average - rms.
- 3) Active Energy (kWh): 3-phase total.
- 4) Power Factor:[**Each phase and**] 3-phase total.
- 5) **<Insert value>**.

2.4 COMBINATION MAGNETIC MOTOR CONTROLLERS

A. Combination Full-Voltage Magnetic Motor Controller :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB Electrification Installations Products]**
 - b. **[ABB, Motion Business]**
 - c. **[Eaton]**
 - d. **[Rockwell Automation, Inc.]**
 - e. **[Siemens Industry, Inc., Energy Management Division]**
 - f. **[Square D; Schneider Electric USA]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB Electrification Installations Products]**
 - b. **[ABB, Motion Business]**
 - c. **[Eaton]**
 - d. **[Rockwell Automation, Inc.]**
 - e. **[Siemens Industry, Inc., Energy Management Division]**
 - f. **[Square D; Schneider Electric USA]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by **[UL Solutions][or][FM Approvals][, CSA Group (with "US" marking)][, Intertek ETL][, TÜV Rheinland][, or other qualified electrical testing laboratory recognized by authorities having jurisdiction]** in accordance with one or more of the following guide information and corresponding standards:
 - a. Combination Motor Controllers: UL CCN NKJH (36 BPMs), including UL 60947-1 and UL 60947-4-1.
5. Standard Features: Factory-assembled, combination full-voltage magnetic motor controller consisting of the controller described in this article, indicated disconnecting means, SCPD and OCPD, in a single enclosure.
 - a. Referenced Standards: Comply with NEMA ICS 2, general purpose, Class A.
 - b. Configuration: **[Nonreversing]<Insert configuration>**.

- c. Contactor Coils: Pressure-encapsulated type[**with coil transient suppressors when indicated**].
 - 1) Operating Voltage: Manufacturer's standard unless otherwise indicated.
- d. Control Power: For on-board control power, obtain from line circuit or from integral CPT with capacity to operate integral devices and remotely located pilot, indicating, and control devices.
 - 1) Spare CPT Capacity as Indicated on the Drawings: **[50][100][200]<Insert number> VA**.
- e. Overload Relays:
 - 1) Thermal Overload Relays:
 - a) Inverse-time-current characteristic.
 - b) **[Class 10][Class 20][Class 30]** tripping characteristic.
 - c) Heaters: In each phase coordinate with nameplate full-load current of actual protected motor; include appropriate adjustment for duty cycle.
 - d) Ambient compensated.
 - e) Automatic resetting.
 - 2) Solid-State Overload Relay:
 - a) Switch or dial selectable for motor-running overload protection.
 - b) Sensors in each phase.
 - c) **[Class 10][Class 20][Class 30][Class 10/20 selectable]** tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
- f. Class II Ground-Fault Protection: Comply with UL 1053 to interrupt low-level ground faults. The ground-fault detection system includes circuitry that will prevent the motor controller from tripping when the fault current exceeds the interrupting capacity of the controller. Equip with start and run delays to prevent nuisance trip on starting, and a trip indicator.
- g. Digital communication module, using **[TIA-485 Modbus, RTU protocol,][2][4][-wire connection to host devices with a compatible port]<Insert protocol>** to transmit the following to the LAN:
 - 1) Instantaneous rms current each phase, and 3-phase average.
 - 2) Voltage: L-L for each phase, L-L 3-phase average, L-N each phase and L-N 3-phase average - rms.
 - 3) Active Energy (kWh): 3-phase total.
 - 4) Power Factor:[**Each phase and**] 3-phase total.
 - 5) **<Insert value>**.
- h. Fusible Disconnecting Means:
 - 1) NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate indicated fuses.
 - 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
- i. Nonfusible Disconnecting Means:
 - 1) NEMA KS 1, heavy-duty, horsepower-rated, nonfusible switch.

- 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
- j. MCP Disconnecting Means:
 - 1) UL 489 and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
 - 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
- k. MCCB Disconnecting Means:
 - 1) UL 489 and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse-time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
 - 2) Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 - 3) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

B. Combination Reduced-Voltage Motor Controllers :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB Electrification Installations Products]**
 - b. **[ABB, Motion Business]**
 - c. **[Eaton]**
 - d. **[Rockwell Automation, Inc.]**
 - e. **[Siemens Industry, Inc., Energy Management Division]**
 - f. **[Square D; Schneider Electric USA]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB Electrification Installations Products]**
 - b. **[ABB, Motion Business]**
 - c. **[Eaton]**
 - d. **[Rockwell Automation, Inc.]**
 - e. **[Siemens Industry, Inc., Energy Management Division]**
 - f. **[Square D; Schneider Electric USA]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by **[UL Solutions][or][FM Approvals][, CSA Group (with "US" marking)][, Intertek ETL][, TÜV Rheinland][, or other qualified electrical testing laboratory recognized by authorities having jurisdiction]** in accordance with one or more of the following guide information and corresponding standards:
 - a. Combination Motor Controllers: UL CCN NKJH (36 BPMs), including UL 60947-1 and UL

60947-4-1.

5. Standard Features: Factory-assembled, combination reduced-voltage magnetic motor controller consisting of the controller described in this article, indicated disconnecting means, and SCPD and OCPD, in a single enclosure.
 - a. Configuration:
 - 1) Wye-Delta Controller: Four contactors, with a three-phase starting resistor/reactor bank.
 - 2) Part-Winding Controller: Separate START and RUN contactors, field-selectable for one-half- or two-thirds-winding start mode, with either six- or nine-lead motors; with separate overload relays for starting and running sequences.
 - 3) Autotransformer Reduced-Voltage Controller: Medium-duty service, with integral overtemperature protection; taps for starting at 50, 65, and 80 percent of line voltage; two START and one RUN contactors.
 - b. Contactor Coils: Pressure-encapsulated type[**with coil transient suppressors when indicated**].
 - 1) Operating Voltage: Manufacturer's standard unless otherwise indicated.
 - c. Control Power: **[24][120]** V(ac); obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
 - 1) Spare CPT Capacity: **[50][100][200]<Insert number> VA**.
 - d. Overload Relays:
 - 1) Thermal Overload Relays: **[Melting alloy type][Bimetallic type]**.
 - a) Inverse-time-current characteristic.
 - b) **[Class 10][Class 20][Class 30]** tripping characteristic.
 - c) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 - d) Ambient compensated.
 - e) Automatic resetting.
 - 2) Solid-State Overload Relay:
 - a) Switch or dial selectable for motor-running overload protection.
 - b) Sensors in each phase.
 - c) **[Class 10][Class 20][Class 30][Class 10/20 selectable]** tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
 - e. Class II Ground-Fault Protection: Comply with UL 1053 to interrupt low-level ground faults. The ground-fault detection system includes circuitry that will prevent the motor controller from tripping when the fault current exceeds the interrupting capacity of the controller. Equip with start and run delays to prevent nuisance trip on starting, and a trip indicator.
 - f. Digital Communication Module: **[TIA-485 Modbus, RTU protocol,][2][4][-wire connection to host devices with a compatible port]<Insert protocol>** to transmit the following to the LAN:
 - 1) Instantaneous rms current each phase, and 3-phase average.



- 2) Voltage: L-L for each phase, L-L 3-phase average, L-N each phase and L-N 3-phase average - rms.
- 3) Active Energy (kWh): 3-phase total.
- 4) Power Factor: **[Each phase and]** 3-phase total.
- 5) **<Insert value>**.

g. Fusible Disconnecting Means:

- 1) NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate indicated fuses.
- 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

h. Nonfusible Disconnecting Means:

- 1) NEMA KS 1, heavy-duty, horsepower-rated, nonfusible switch.
- 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

i. MCP Disconnecting Means:

- 1) UL 489 and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
- 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

j. MCCB Disconnecting Means:

- 1) UL 489 and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse-time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
- 2) Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
- 3) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

C. Combination Multispeed Magnetic Motor Controller :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ABB Electrification Installations Products]**
 - b. **[ABB, Motion Business]**
 - c. **[Eaton]**
 - d. **[Rockwell Automation, Inc.]**
 - e. **[Siemens Industry, Inc., Energy Management Division]**
 - f. **[Square D; Schneider Electric USA]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[ABB Electrification Installations Products]**
 - b. **[ABB, Motion Business]**
 - c. **[Eaton]**
 - d. **[Rockwell Automation, Inc.]**
 - e. **[Siemens Industry, Inc., Energy Management Division]**
 - f. **[Square D; Schneider Electric USA]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: Investigated, labeled, and marked by **[UL Solutions][or][FM Approvals][, CSA Group (with "US" marking)][, Intertek ETL][, TÜV Rheinland][, or other qualified electrical testing laboratory recognized by authorities having jurisdiction]** in accordance with one or more of the following guide information and corresponding standards:
 - a. Combination Motor Controllers: UL CCN NKJH (36 BPMs), including UL 60947-1 and UL 60947-4-1.
 5. Standard Features: Factory-assembled, combination of multispeed magnetic motor controller, consisting of the controller, indicated disconnecting means, and SCPD and OCPD, in a single enclosure.
 - a. Referenced Standards: Comply with NEMA ICS 2, general purpose, Class A.
 - b. Configuration: **[Nonreversing][Reversing]; [consequent pole][two-winding]**.
 - 1) Contactor Coils: Pressure-encapsulated type **[with coil transient suppressors]**.
 - a) Operating Voltage: Manufacturer's standard unless otherwise indicated.
 - 2) Power Contacts: Totally enclosed, double break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
 - 3) Control Power: **[24][120]** V(ac); obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
 - a) Spare CPT Capacity: **[50][100][200]<Insert number> VA**.
 - 4) Compelling Relays: Ensure that motor will start only at low speed.
 - 5) Accelerating Timer Relays: Ensure properly timed acceleration through speeds lower than that selected.
 - 6) Decelerating Timer Relays: Ensure automatically timed deceleration through each speed.
 - 7) Antiplugging Timer Relays: Ensure a time delay when transferring from FORWARD to REVERSE and back.
 - c. Overload Relays:
 - 1) Thermal Overload Relays: **[Melting alloy type][Bimetallic type]**.
 - a) Inverse-time-current characteristic.
 - b) **[Class 10][Class 20][Class 30]** tripping characteristic.
 - c) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 - d) Ambient compensated.
 - e) Automatic resetting.
 - 2) Solid-State Overload Relay:

- a) Switch or dial selectable for motor-running overload protection.
 - b) Sensors in each phase.
 - c) **[Class 10][Class 20][Class 30][Class 10/20 selectable]** tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
- d. Class II Ground-Fault Protection: Comply with UL 1053 to interrupt low-level ground faults. The ground-fault detection system includes circuitry that will prevent the motor controller from tripping when the fault current exceeds the interrupting capacity of the controller. Equip with start and run delays to prevent nuisance trip on starting, and a trip indicator.
- e. Digital communication module, using **[TIA-485 Modbus, RTU protocol,][2][4][-wire connection to host devices with a compatible port]<Insert protocol>** to transmit the following to the LAN:
 - 1) Instantaneous rms current each phase, and 3-phase average.
 - 2) Voltage: L-L for each phase, L-L 3-phase average, L-N each phase and L-N 3-phase average - rms.
 - 3) Active Energy (kWh): 3-phase total.
 - 4) Power Factor:**[Each phase and]** 3-phase total.
 - 5) **<Insert value>**.
- f. Fusible Disconnecting Means:
 - 1) NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate indicated fuses.
 - 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
- g. Nonfusible Disconnecting Means:
 - 1) NEMA KS 1, heavy-duty, horsepower-rated, nonfusible switch.
 - 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
- h. MCP Disconnecting Means:
 - 1) UL 489 and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
 - 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
- i. MCCB Disconnecting Means:
 - 1) UL 489 and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse-time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
 - 2) Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 - 3) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

2.5 ACCESSORIES

- A. General Requirements for Control Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.
1. Push-Buttons, Pilot Lights, and Selector Switches: Standard duty, except as needed to match enclosure type. Heavy duty or oiltight where indicated in the controller schedule.
 - a. Push-Buttons: As indicated in the controller schedule.
 - b. Pilot Lights: As indicated in the controller schedule.
 2. Elapsed Time Meters: Heavy duty with digital readout in hours[; **nonresettable**][; **resettable**].
 3. Meters: Panel type, **2-1/2-inch (64-mm)** minimum size with 90- or 120-degree scale and plus or minus two percent accuracy. Where indicated, provide selector switches with an off position.
- B. Motor Protection Relays: Provide solid-state sensing circuit and isolated output contacts for hardwired connections.
1. Phase-failure.
 2. Phase-reversal, with bicolor LED to indicate normal and fault conditions. Automatic reset when phase reversal is corrected.
 3. Under/overvoltage, operate when the circuit voltage reaches a preset value, and drop out when the operating voltage drops to a level below the preset value. Include adjustable time-delay setting.
 4. **<Insert description>**.
- C. Breather Assemblies: Maintain interior pressure and release condensation in **[Type 4][Type 4X][Type 7][Type 9]<Insert type>** enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.
- D. Space Heaters: Provide N.C. auxiliary contacts, to mitigate condensation in **[Type 3R][Type 4X][Type 12]<Insert type>** enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.
- E. Sun Shields: Install on fronts, sides, and tops of enclosures that are installed outdoors and subject to direct and extended sun exposure.
- F. **<Insert accessories>**.

2.6 MAINTENANCE MATERIAL ITEMS

- A. Spare Parts: Furnish to Owner spare parts, for repairing motor controllers, that are packaged with protective covering for storage on-site and identified with labels describing contents.[**Include the following:**]
1. Fuses for Fused Switches: Equal to **[10]<Insert number>** percent of quantity installed for each size and type, but no fewer than **[three]<Insert number>** of each size and type.
 2. Control Power Fuses: Equal to **[10]<Insert number>** percent of quantity installed for each size and type, but no fewer than **[two]<Insert number>** of each size and type.
 3. Indicating Lights: **[Two]<Insert number>** of each type and color installed.
 4. Auxiliary Contacts: Furnish **[one]<Insert number>** spare(s) for each size and type of magnetic controller installed.
 5. Power Contacts: Furnish **[three]<Insert number>** spares for each size and type of magnetic contactor installed.
 6. **<Insert extra materials>**.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and space conditions for compliance with requirements for motor controllers, their relationship with the motors, and other conditions affecting performance of the Work.

3.2 INSTALLATION OF MANUAL AND MAGNETIC MOTOR CONTROLLERS

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:
 - 1. Electrical Construction: ICC IBC, ICC IFB, NECA NEIS 1, NFPA 1, and NFPA 70.
 - 2. Electrical Maintenance: NECA NEIS 91 and NFPA 70B.
 - 3. Electrical Safety: NFPA 70E.
 - 4. Commissioning of Electrical Systems: NECA NEIS 90.
 - 5. Hot Work: NFPA 51B.
 - 6. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
 - 7. Work in Confined Spaces: NFPA 350.
 - 8. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
 - 9. Evaluation of Unlabeled Electrical Equipment: NFPA 791.
 - 10. Consult Architect for resolution of conflicting requirements.
- C. Special Installation Techniques:
 - 1. Wall-Mounted Controllers: Install magnetic controllers on walls with tops at uniform height indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks for support unless otherwise indicated.
 - 2. Floor-Mounted Controllers: Install controllers on cast-in-place concrete equipment base(s).
 - 3. Provide seismic control devices.
 - 4. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
 - 5. Setting of Overload Relays: Select and set overloads on the basis of full-load current rating as shown on motor nameplate. Adjust setting value for special motors as required by NFPA 70 for motors that are high-torque, high-efficiency, and so on.
- D. Interfaces with Other Work:
 - 1. Identification: Provide labels for motor controllers and associated electrical equipment.
 - a. Identify field-installed conductors, interconnecting wiring, and components.
 - b. Label each enclosure and each compartment with **[baked-enamel signs][metal-backed butyrate signs][laminated acrylic or melamine plastic signs]**, mounted with corrosion-resistant screws.
 - c. Provide warning signs for electrical equipment.
 - 2. Arc-Flash Warning Labels:
 - a. Provide self-adhesive equipment label for each work location **[included in the arc-flash**

hazard analysis].

- b. Labels must be machine printed, with no field-applied markings.
- c. Labels must have orange header with wording, "WARNING, ARC-FLASH HAZARD," and must include the following information taken directly from the arc-flash hazard analysis:
 - 1) Location designation.
 - 2) Nominal voltage.
 - 3) Flash protection boundary.
 - 4) Hazard risk category.
 - 5) Incident energy.
 - 6) Working distance.
 - 7) Engineering report number, revision number, and issue date.

3.3 FIELD QUALITY CONTROL OF MANUAL AND MAGNETIC MOTOR CONTROLLERS

A. Administrant for Electrical Power Tests and Inspections:

- 1. **[Owner][Tenant]** will engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
- 2. Engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
- 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
- 4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].

B. Acceptance Testing Preparation:

- 1. **<Insert requirements>**.

C. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.

D. Tests and Inspections:

- 1. Comply with NFPA 70B.
- 2. Visual and Mechanical Inspection:
 - a. Compare equipment nameplate data with drawings and specifications.
 - b. Inspect physical and mechanical condition.
 - c. Inspect anchorage, alignment, and grounding.
 - d. Verify the unit is clean.
 - e. Inspect contactors:
 - 1) Verify mechanical operation.
 - 2) Verify contact gap, wipe, alignment, and pressure are in accordance with manufacturer's published data.
 - f. Motor-Running Protection:
 - 1) Verify overload element rating is correct for its application.
 - 2) If motor-running protection is provided by fuses, verify correct fuse rating.
 - g. Inspect bolted electrical connections for high resistance using one of the two following methods:

- 1) Use a low-resistance ohmmeter. Compare bolted connection resistance values with values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.
- h. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
3. Electrical Tests:
- a. **[For the contactor and circuit breaker, perform][Perform]** insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole.
 - 1) Insulation Resistance: In accordance with manufacturer's published data or NETA ATS Table 100.1. In the absence of manufacturer's published data, use Table 100.5.
 - 2) Investigate and correct insulation resistance values less than those of this table or manufacturer's published instructions.
 - b. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.
 - c. Test motor protection devices in accordance with manufacturer's published data.
 - d. Test circuit breakers as follows:
 - 1) Operate the circuit breaker to ensure smooth operation.
 - 2) For adjustable circuit breakers, adjust protective device settings in accordance with the coordination study. Comply with coordination study recommendations.
 - e. Perform operational tests by initiating control devices.
- E. Nonconforming Work:
1. Motor controller will be considered defective if it does not pass tests and inspections.
 2. Remove and replace defective units and retest.
- F. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.
- G. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.
1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.
- 3.4 SYSTEM STARTUP
- A. Perform startup service in accordance with manufacturer's published instructions.
 - B. System Startup Testing: Verify the correct interaction of sensing, processing, and action devices. Perform system startup testing after field quality control tests have been completed and all components have passed specified tests.

1. Develop test parameters and perform tests for the purpose of evaluating performance of integral components and their functioning as a complete unit within design requirements and manufacturer's published data.
2. Verify the correct operation of interlock safety devices for fail-safe functions in addition to design function.
3. Verify the correct operation of sensing devices, alarms, and indicating devices.

C. Nonconforming Work:

1. Motor controller will be considered defective if it does not pass system startup testing.

D. System Startup Testing Report: Compile, prepare, and submit system startup testing reports.

E. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** system startup.

1. Manufacturer's Field Reports for System Startup Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.

3.5 CLOSEOUT ACTIVITIES

A. Training:

1. **[With assistance from factory-authorized service representatives, train][Train]** Owner's maintenance personnel on the following topics:
 - a. How to adjust, operate, and maintain equipment specified in Section 262913.03 "Manual and Magnetic Motor Controllers."
2. **[Provide video recordings of training sessions to Owner][Allow Owner to record training sessions].**

3.6 MAINTENANCE

A. Infrared Scanning of Motor Controllers: Perform infrared scanning during periods of maximum possible loading. Comply with NFPA 70B requirements. Remove covers so joints and connections are accessible to portable scanner. Take visible light photographs at same locations and orientations as infrared scans for documentation to ensure follow-on scans match same conditions for valid comparison.

1. Equipment: Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1 deg C at 30 deg C. The equipment must detect emitted radiation and convert detected radiation to a visual signal.
2. Act on inspection results and recommended action, and considering the recommendations of NETA ATS Table 100.18. Correct possible and probable deficiencies as soon as Owner's operations permit. Retest until deficiencies are corrected.
3. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared inspection of the electrical power connections of each motor controller.
4. Follow-On Infrared Scanning: Perform follow-up infrared scans of motor controller at 11 months after Substantial Completion.
5. Field Reports for Infrared Scanning: Prepare a certified report including the following information:
 - a. Identities of personnel performing infrared scanning.



- b. Description of test equipment used and record of their calibration.
- c. Description of motor controllers and associated equipment tested.
- d. Deficiencies found, remedial actions taken, and observations found when scans were repeated after the remedial actions.
- e. Temperature difference between the area of concern and the reference area.
- f. Probable cause of temperature difference.
- g. Areas inspected. Identify inaccessible and unobservable areas and equipment.
- h. Load conditions at time of inspection.
- i. Photographs and thermograms of the deficient area.
- j. Recommended action.

END OF SECTION 26 29 13 00

SECTION 26 29 13 00A - SOFT-START MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Soft-start motor controllers.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. Section 260526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding referenced by this Section.
5. Section 260529 "Hangers and Supports for Electrical Systems" specifies hangers, supports, and concrete bases referenced by this Section.
6. Section 260548 "Vibration and Seismic Controls for Electrical Systems" specifies vibration isolation and seismic-[**and wind**]-control devices referenced by this Section.
7. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs referenced by this Section.
8. Section 260573 "Power System Studies" specifies arc-flash hazard analysis, warning labels, and circuit-breaker trip ranges referenced by this Section.
9. Section 264313 "Surge Protective Devices for Low-Voltage Electrical Power Circuits" specifies field-installed surge protection referenced by this Section.

1.2 DEFINITIONS

- A. CPT: Control power transformer.
- B. FLA: Full-load amperes.
- C. MCCB: Molded-case circuit breaker.
- D. MCP: Motor circuit protector.
- E. N.C.: Normally closed.
- F. N.O.: Normally open.
- G. OCPD: Overcurrent protective device.
- H. SCCR: Short-circuit current rating.
- I. SCPD: Short-circuit protective device.

- J. SCR: Silicon-controlled rectifier.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
2. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing laboratory, certifying that model number corresponding to specified product complies with specified listing criteria.

- B. Shop Drawings: Prepare and submit the following:

1. Include plans, elevations, sections, and mounting details.
2. Indicate dimensions, weights, required clearances, and location and size of each field connection.
3. Wire Termination Diagrams and Schedules: Include diagrams for signal and control wiring. Identify terminals and wiring designations and color-codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features. Differentiate between manufacturer-installed and field-installed wiring.
4. Include features, characteristics, ratings, and factory settings of individual OCPD and auxiliary components.

- C. Product Schedule: For each enclosed controller.

1. Each installed soft-start controller type.
2. Laboratory and file number for listing by qualified electrical testing laboratory..
3. Factory-installed accessories.
4. Nameplate legends.
5. SCCR of integrated unit.
 - a. For each combination soft-start controller, include features, characteristics, ratings, and factory setting of the SCPD and OCPD.
 - 1) Listing document proving Type 2 coordination.
 - b. For each series-rated combination, state the listed integrated SCCR (withstand) of SCPDs and OCPDs by qualified electrical testing laboratory acceptable to authorities having jurisdiction.

- D. Field quality-control reports.

- E. System startup testing reports.

1.4 INFORMATIONAL SUBMITTALS

- A. Manufacturer's published instructions.

- B. Field Reports:

1. Manufacturer's field reports for field quality-control support.

2. Manufacturer's field reports for system startup support.
3. Field reports for infrared scanning.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Spare parts.

1.6 QUALIFICATIONS

- A. Electrical Power Testing (EPT) Technician I: Possessing active NICET EPT Level I certification. Able to work safely around electrical power equipment and cabling under supervision.
- B. Electrical Power Testing (EPT) Technician II: Possessing active NICET EPT Level II certification. Able to isolate and ground electrical power equipment, to connect test equipment, and to conduct and document standard tests of basic equipment.
- C. Electrical Power Testing (EPT) Technician III: Possessing active NICET EPT Level III certification. Able to manage switching procedures, to conduct tests of complex equipment, to analyze test and equipment data, to plan a job, and to lead a team. Has experience performing NFPA 70B, IEEE, and NETA electrical tests.
- D. Electrical Power Testing (EPT) Technician IV: Possessing active NICET EPT Level IV certification. Able to conduct tests of complex metering and relay systems; to evaluate tests, test equipment, test results, and power system performance; to recommend actions to maintain or improve system performance; and to lead multi-team projects.
- E. Electrical Power Testing and Inspecting Agency: Entities possessing active credentials from qualified electrical testing laboratory recognized by authorities having jurisdiction.
 1. On-site electrical testing supervisors must possess active NICET EPT Technician [III][IV] certification.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Store soft-start controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect soft-start controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.
- B. If stored in areas subject to weather, cover soft-start controllers to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; **[install temporary electric heating, with at least][50 W]<Insert number>[per controller][connect factory-installed space heaters to temporary electrical service].**

1.8 SERVICE CONDITIONS FOR ELECTRICAL EQUIPMENT

- A. Modeling, analysis, product selection, installation, and quality control for all electrical Work on the Project must comply with service condition requirements specified in Section 018116 "Facility Environmental Requirements" and Section 018123 "Facility Seismic and Wind Criteria."
- B. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:



1. Ambient Temperature: Not less than **32 deg F (0 deg C)** and not exceeding **104 deg F (40 deg C)**, humidity noncondensing.
2. Altitude: Not exceeding **3300 ft (1000 m)**.
3. The effect of solar radiation is insignificant.
4. **<Insert unusual service condition>**.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- B. Enclosures:
 1. Environmental Ratings: Comply with UL 50E, type designations as indicated on Drawings.
 2. Construction: Comply with NEMA ICS IA 10030.
 3. Controllers in Hazardous (Classified) Locations: Comply with UL 1203.
- C. Seismic and Wind Performance: Installed assembly must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:
 1. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events[, **and unit must be fully operational after seismic events**].
 2. Component Importance Factor (Ip): **[1.0][1.5]**.
 3. Component Amplification Factor (ap): **[1.0][2.5]<Insert value>**.
 4. Component Response Modification Factor (Rp): **[1.5][2.0][2.5][6.0]<Insert value>**.
 5. Component Overstrength Factor (Ωo): **[1.5][2.5]<Insert value>**.

2.2 SOFT-START MOTOR CONTROLLERS

- A. Enclosed Soft-Start Motor Controllers :
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB Electrification Installations Products]**
 - b. **[ABB, Motion Business]**
 - c. **[Eaton]**
 - d. **[Rockwell Automation, Inc.]**
 - e. **[Siemens Industry, Inc., Energy Management Division]**
 - f. **[Square D; Schneider Electric USA]**
 - g. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[ABB Electrification Installations Products]**
 - b. **[ABB, Motion Business]**
 - c. **[Eaton]**
 - d. **[Rockwell Automation, Inc.]**
 - e. **[Siemens Industry, Inc., Energy Management Division]**
 - f. **[Square D; Schneider Electric USA]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: Investigated, labeled, and marked by **[UL Solutions][or][FM Approvals][, CSA Group (with "US" marking)][, Intertek ETL][, TÜV Rheinland][, or other qualified electrical testing laboratory recognized by authorities having jurisdiction]** in accordance with one or more of the following guide information and corresponding standards:
 - a. Motor Controllers, Mechanically Operated and Solid-State: UL CCN NMFT, including UL 508, UL 60947-1, and UL 60947-4-1.
 5. Standard Features: Controllers designed for reduced-voltage start, full-voltage run, and optional soft stop.
 - a. Construction: Integrated unit with power SCRs, heat sink, microprocessor logic board, door-mounted digital display and user interface module, run-bypass contactor, and overload relay(s); suitable for use with NEMA MG 1, Design B, polyphase, medium induction motors.
 - b. Run-Bypass Contactor: Magnetic contactor in parallel with the SCR of the soft-start controller, bypassing the SCR when full voltage is achieved.
 - c. Referenced Standards: NEMA ICS 2, general purpose, Class A.
 - d. Configuration: **[Standard duty]<Insert configurations>**.
 - 1) Motor Starting and Stopping: Provide at least two SCRs per phase.
 - 2) Microprocessor Control: Continuously monitor current and proper operation of the SCRs.
 - e. Bypass Contactor: Operates automatically when full voltage is applied to motor, and bypasses the SCRs. Soft-start controller protective features and deceleration controls must remain active when this contactor is in the bypass mode.
 - 1) Power Electronics Disconnect Contactor. Where indicated, installed ahead of the power electronics equipment, and opens automatically when the motor is stopped, or a controller fault is detected, or when an SCR shorts.
 - 2) Logic Board: Identical for all ampere ratings and voltage classes, with environmental protective coating.
 - 3) Surge Protection: Provide **[NEMA ICS 2 compliant factory-installed][field-installed]** surge suppression.
 - f. Control Power:
 - 1) For on-board control power, obtain from line circuit or from integral CPT with capacity to operate integral devices and remotely located pilot, indicating, and control devices.
 - 2) Spare CPT Capacity: As indicated on Drawings, available in increments of 100 VA, from 100 to 500 VA.
 - g. Controller Diagnostics and Protection:
 - 1) Microprocessor-based thermal-protection system for monitoring SCR and motor

- thermal characteristics, and providing controller overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
 - 2) Protection from line-side reverse phasing; line-side and motor-side phase loss; motor jam, stall, and under-load conditions; and line frequency over or under normal.
 - 3) Input isolation contactor that opens when the controller diagnostics detect a faulted soft-start component or when the motor is stopped.
 - 4) **<Insert items>**.
- h. Cover mounted-controller status panel with LED lights or alphanumeric display to show the following:
- 1) Starter Status: "Ready," "Starting," "Stopping," or "Run."
 - 2) Motor current in amperes.
 - 3) Faults:
 - a) Motor overcurrent trip.
 - b) Motor thermal overload.
 - c) Starter thermal fault.
 - d) Low line voltage.
 - e) Loss of a phase.
 - f) Phases reversed.
 - g) Maximum stator time exceeded.
 - h) Serial communications error.
- i. Interface Panel: **[Mounted on controller door][Mounted remotely within 50 ft (15 m)].[With plug-in connector and removable.]**
- 1) Guarded adjustable set points, not readily accessible.
 - a) Motor FLA, adjustable from **[40 to 110]<Insert numbers>** percent of the controller's rating.
 - b) Current limitation on starting, adjustable from 200 to 500 percent of FLA, typically set at 300 percent.
 - c) NEMA ICS 2 Overload Class: Include the following selections: Class 5, Class 10, Class 15, Class 20, and Class 30.
 - 2) Adjustable set points, readily accessible[, **password protected**].
 - a) Linear acceleration, adjustable from **[1 to 60 s]<Insert range in seconds>**.
 - b) Maximum start time, adjustable from **[1 to 250 s]<Insert range in seconds>**.
 - c) Selector switch; select coast to stop or soft stop.
 - d) Linear deceleration, adjustable from **[1 to 60 s]<Insert range in seconds>**.
- j. Remote Output Features. All outputs prewired to terminal blocks.
- 1) Analog output for field-selectable assignment of motor operating characteristics; **[0-to 10 V(dc)][4- to 20 mA(dc)]**.
 - 2) Form C status contacts that change state when controller is running.
 - 3) Form C alarm contacts that change state when a fault condition occurs.
 - 4) **<Insert items>**.
- k. Digital Communication Module: **[TIA-485 Modbus, RTU protocol, 2-wire connection to host devices with a compatible port][TIA-485 Modbus, RTU protocol, 4-wire connection to host devices with a compatible port]<Insert protocol>** to transmit the following to the LAN:

- 1) Instantaneous root mean square (RMS) current each phase, and three-phase average.
- 2) RMS Voltage: L-L for each phase, L-L three-phase average, L-N each phase, and L-N three-phase average.
- 3) Active Energy (kilowatt-hour): Three-phase total.
- 4) Power Factor: **[Each phase and]** three-phase total.
- 5) **<Insert value>**.

B. Combination Soft-Start Motor Controllers :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB Electrification Installations Products]**
 - b. **[ABB, Motion Business]**
 - c. **[Eaton]**
 - d. **[Rockwell Automation, Inc.]**
 - e. **[Siemens Industry, Inc., Energy Management Division]**
 - f. **[Square D; Schneider Electric USA]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB Electrification Installations Products]**
 - b. **[ABB, Motion Business]**
 - c. **[Eaton]**
 - d. **[Rockwell Automation, Inc.]**
 - e. **[Siemens Industry, Inc., Energy Management Division]**
 - f. **[Square D; Schneider Electric USA]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by **[UL Solutions][or][FM Approvals][, CSA Group (with "US" marking)][, Intertek ETL][, TÜV Rheinland][, or other qualified electrical testing laboratory recognized by authorities having jurisdiction]** in accordance with one or more of the following guide information and corresponding standards:
 - a. Motor Controllers, Mechanically Operated and Solid-State: UL CCN NMFT, including UL 508, UL 60947-1, and UL 60947-4-1.
5. Standard Features: Factory-assembled, combination, reduced-voltage soft-start controller with a disconnecting means, SCPD and OCPD, in a single enclosure.
 - a. Construction: Integrated unit with power SCRs, heat sink, microprocessor logic board, door-mounted digital display and user interface module, run-bypass contactor, and overload relay(s); suitable for use with NEMA MG 1, Design B, polyphase, medium induction motors.
 - b. Run-Bypass Contactor: Magnetic contactor in parallel with the SCR of the soft-start controller, bypassing the SCR when full voltage is achieved.
 - c. Referenced Standards: NEMA ICS 2, general purpose, Class A.
 - d. Configuration: **[Standard duty]<Insert configurations>**.

- 1) At least two SCRs per phase to control the starting and stopping of the motor.
 - 2) Continuously monitor current and proper operation of the SCRs.
 - 3) Bypass Contactor: Operates automatically when full voltage is applied to motor, and bypasses the SCRs. Soft-start controller protective features and deceleration controls remain active when this contactor is in the bypass mode.
 - 4) Power Electronics Disconnect Contactor. Where indicated, installed ahead of the power electronics equipment, and opens automatically when the motor is stopped, or a controller fault is detected, or when an SCR shorts.
 - 5) Logic Board: Identical for all ampere ratings and voltage classes, with environmental protective coating.
 - 6) Surge Protection: Provide **[NEMA ICS 2 compliant factory-installed][field-installed]** surge suppression.
- e. Control Power:
- 1) For on-board control power, obtain from line circuit or from integral CPT with capacity to operate integral devices and remotely located pilot, indicating, and control devices.
 - 2) Spare CPT Capacity: As indicated on Drawings, available in increments of 100 VA, from 100 to 500 VA.
- f. Controller Diagnostics and Protection:
- 1) Microprocessor-based thermal-protection system for monitoring SCR and motor thermal characteristics, and providing controller overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
 - 2) Protection from line-side reverse phasing; line-side and motor-side phase loss; motor jam, stall, and under-load conditions; and line frequency over or under normal.
 - 3) Input isolation contactor that opens when the controller diagnostics detect a faulted soft-start component or when the motor is stopped.
 - 4) **<Insert items>**.
- g. Cover mounted-controller status panel with LED lights or alphanumeric display to show the following:
- 1) Starter Status: "Ready," "Starting," "Stopping," or "Run."
 - 2) Motor current in amperes.
 - 3) Faults:
 - a) Motor overcurrent trip.
 - b) Motor thermal overload.
 - c) Starter thermal fault.
 - d) Low line voltage.
 - e) Loss of a phase.
 - f) Phases reversed.
 - g) Maximum stating time exceeded.
 - h) Serial communications error.
- h. Interface Panel: **[Mounted on controller door][Mounted remotely within 50 ft (15 m)].[With plug-in connector and removable.]**
- 1) Guarded adjustable set points, not readily accessible.
 - a) Motor FLA, adjustable from **[40 to 110]<Insert numbers>** percent of the controller's rating.

- b) Current limitation on starting, adjustable from 200 to 500 percent of FLA, typically set at 300 percent.
 - c) NEMA ICS 2 Overload Class: Include the following selections: Class 5, Class 10, Class 15, Class 20, and Class 30.
- 2) Adjustable set points, readily accessible[, **password protected**].
 - a) Linear acceleration, adjustable from **[1 to 60 s]<Insert range in seconds>**.
 - b) Maximum start time, adjustable from **[1 to 250 s]<Insert range in seconds>**.
 - c) Selector switch; select coast to stop or soft stop.
 - d) Linear deceleration, adjustable from **[1 to 60 s]<Insert range in seconds>**.
- i. Remote Output Features: All outputs prewired to terminal blocks.
 - 1) Analog output for field-selectable assignment of motor operating characteristics; **[0- to 10 V(dc)][4- to 20 mA(dc)]**.
 - 2) Form C status contacts that change state when controller is running.
 - 3) Form C alarm contacts that change state when a fault condition occurs.
 - 4) **<Insert items>**.
- j. Digital Communication Module: **[TIA-485 Modbus, RTU protocol, 2-wire connection to host devices with a compatible port][TIA-485 Modbus, RTU protocol, 4-wire connection to host devices with a compatible port]<Insert protocol>** to transmit the following to the LAN:
 - 1) Instantaneous RMS current each phase, and three-phase average.
 - 2) RMS Voltage: L-L for each phase, L-L three-phase average, L-N each phase, and L-N three-phase average.
 - 3) Active Energy (kilowatt-hour): Three-phase total.
 - 4) Power Factor: **[Each phase and]** three-phase total.
 - 5) **<Insert value>**.
- k. Fusible Disconnecting Means:
 - 1) NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate **[Class J][Class L][indicated]** fuses.
 - 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - 3) Auxiliary Contacts: N.O. or N.C., arranged to activate before switch blades open.
- l. MCP Disconnecting Means:
 - 1) UL 489 and NEMA AB 3 (with interrupting capacity to comply with available fault currents) instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
 - 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - 3) Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
 - 4) **[N.C.][N.O.]** alarm contact that operates only when MCP has tripped.
 - 5) Current-limiting module to increase controller SCCR (withstand) to 100 kA.
- m. MCCB Disconnecting Means:
 - 1) UL 489 and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.

- 2) Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
- 3) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
- 4) Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.
- 5) **[N.C.][N.O.]** alarm contact that operates only when MCCB has tripped.

n. Molded-Case Switch Disconnecting Means:

- 1) UL 489 and NEMA AB 3, with in-line fuse block for Class J or Class L power fuses (depending on ampere rating), providing an interrupting capacity to comply with available fault currents; MCCB with fixed, high-set instantaneous trip only.
- 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
- 3) Auxiliary contacts "a" and "b" arranged to activate with molded-case switch handle.
- 4) **[N.C.][N.O.]** alarm contact that operates only when molded-case switch has tripped.

C. Bypass Motor Controller :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ABB Electrification Installations Products]**
 - b. **[ABB, Motion Business]**
 - c. **[Eaton]**
 - d. **[Rockwell Automation, Inc.]**
 - e. **[Siemens Industry, Inc., Energy Management Division]**
 - f. **[Square D; Schneider Electric USA]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ABB Electrification Installations Products]**
 - b. **[ABB, Motion Business]**
 - c. **[Eaton]**
 - d. **[Rockwell Automation, Inc.]**
 - e. **[Siemens Industry, Inc., Energy Management Division]**
 - f. **[Square D; Schneider Electric USA]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by **[UL Solutions][or][FM Approvals][, CSA Group (with "US" marking)][, Intertek ETL][, TÜV Rheinland][, or other qualified electrical testing laboratory recognized by authorities having jurisdiction]** in accordance with one or more of the following guide information and corresponding standards:
 - a. Motor Controllers, Mechanically Operated and Solid-State: UL CCN NMFT, including UL 508, UL 60947-1, and UL 60947-4-1.
5. Standard Features: Factory-assembled, combination, full-voltage electromagnetic motor controller with a disconnecting means, SCPD and OCPD, in a single enclosure. Connected as a

bypass controller, operating manually, with NORMAL/BYPASS selector switch.

- a. Referenced Standards: NEMA ICS 2, general purpose, Class A.
- b. Configuration: Across-the-line start, electrically held.
- c. Contactor Coils: Pressure-encapsulated type[**with coil transient suppressors when indicated**].
 - 1) Operating Voltage: Manufacturer's standard unless otherwise indicated.
- d. Control Power: **[24][120]** V(ac); obtained from integral CPT, with primary and secondary fuses, and with CPT of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
 - 1) Spare CPT Capacity: As indicated on Drawings, **[50][100][200]<Insert number>** VA.
- e. Overload Relays:
 - 1) Thermal-Overload Relays:
 - a) Inverse-time-current characteristic.
 - b) **[Class 10][Class 20][Class 30]** tripping characteristic.
 - c) Heaters: In each phase; coordinate with nameplate FLA of actual protected motor; include appropriate adjustment for duty cycle.
 - d) Ambient compensated.
 - e) Automatic resetting.
 - 2) Solid-State Overload Relays:
 - a) Switch or dial selectable for motor running overload protection.
 - b) Sensors in each phase.
 - c) **[Class 10][Class 20][Class 30][Class 10/20 selectable]** tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
- f. Class II Ground-Fault Protection: Comply with UL 1053 to interrupt low-level ground faults. The ground-fault detection system includes circuitry that will prevent the motor controller from tripping when the fault current exceeds the interrupting capacity of the controller. Equip with start and run delays to prevent nuisance trip on starting, and a trip indicator.
- g. Digital Communication Module: **[TIA-485 Modbus, RTU protocol, 2-wire connection to host devices with a compatible port][TIA-485 Modbus, RTU protocol, 4-wire connection to host devices with a compatible port]<Insert protocol>** to transmit the following to the LAN:
 - 1) Instantaneous RMS current each phase, and three-phase average.
 - 2) RMS Voltage: L-L for each phase, L-L three-phase average, L-N each phase, and L-N three-phase average.
 - 3) Active Energy (kilowatt-hour): Three-phase total.
 - 4) Power Factor:[**Each phase and**] three-phase total.
 - 5) **<Insert value>**.
- h. Fusible Disconnecting Means:
 - 1) NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate indicated fuses.
 - 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

- i. Nonfusible Disconnecting Means:
 - 1) NEMA KS 1, heavy-duty, horsepower-rated, nonfusible switch.
 - 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
- j. MCP Disconnecting Means:
 - 1) UL 489 and NEMA AB 3 (with interrupting capacity to comply with available fault currents) instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
 - 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
- k. MCCB Disconnecting Means:
 - 1) UL 489 and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
 - 2) Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 - 3) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

2.3 ACCESSORIES

- A. General Requirements for Control Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.
 - 1. Push-Buttons, Pilot Lights, and Selector Switches: Standard duty, except as needed to match enclosure type. Heavy duty or oiltight where indicated in the controller schedule.
 - a. Push-Buttons: As indicated in the controller schedule.
 - b. Pilot Lights: As indicated in the controller schedule.
 - 2. Elapsed Time Meters: Heavy duty with digital readout in hours[; **nonresettable**][; **resettable**].
 - 3. Meters: Panel type, **2-1/2 inch (64 mm)** minimum size with 90- or 120-degree scale and plus or minus 2 percent accuracy. Where indicated, provide selector switches with an off position.
- B. Breather Assemblies: Maintain interior pressure and release condensation in **[Type 4][Type 4X][Type 7][Type 9]<Insert type>** enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.
- C. Space Heaters: Provide N.C. auxiliary contacts, to mitigate condensation in **[Type 3R][Type 4X][Type 12]<Insert type>** enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.
- D. Sun Shields: Install on fronts, sides, and tops of enclosures that are installed outdoors and subject to direct and extended sun exposure.
- E. **<Insert accessories>**.

2.4 MAINTENANCE MATERIAL ITEMS

- A. Spare Parts: Furnish to Owner spare parts, for repairing motor controllers, that are packaged with protective covering for storage on-site and identified with labels describing contents. [**Include the following:**]
1. Fuses for Fused Switches: Equal to [10]<Insert number> percent of quantity installed for each size and type, but no fewer than [three]<Insert number> of each size and type.
 2. Control Power Fuses: Equal to [10]<Insert number> percent of quantity installed for each size and type, but no fewer than [two]<Insert number> of each size and type.
 3. Indicating Lights: [Two]<Insert number> of each type and color installed.
 4. Auxiliary Contacts: Furnish [one]<Insert number> spare(s) for each size and type of magnetic controller installed.
 5. Power Contacts: Furnish [three]<Insert number> spares for each size and type of magnetic contactor installed.
 6. <Insert extra materials>.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and space conditions for compliance with requirements for motor controllers, their relationship with the motors, and other conditions affecting performance of the Work.

3.2 INSTALLATION OF SOFT-START MOTOR CONTROLLERS

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:
1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
 2. Electrical Maintenance: NFPA 70B and NECA NEIS 91.
 3. Electrical Safety: NFPA 70E.
 4. Commissioning of Electrical Systems: NECA NEIS 90.
 5. Hot Work: NFPA 51B.
 6. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
 7. Work in Confined Spaces: NFPA 350.
 8. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
 9. Evaluation of Unlabeled Electrical Equipment: NFPA 791.
 10. Consult Architect for resolution of conflicting requirements.
- C. Special Installation Techniques:
1. Wall-Mounted Controllers: Install controllers on walls with tops at uniform height indicated, and by bolting units to wall or mounting on slotted support systems and bolted to wall.
 2. Freestanding Controllers: Provide slotted support systems.
 3. Floor-Mounted Controllers: Install controllers on cast-in-place concrete equipment base(s).
 4. Provide seismic control devices.
 5. Control Wiring: Separate control wiring from power wiring. Where unavoidable, use twisted pair cabling or shielded cables for control wiring.
 6. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and

distribution spools.

7. Setting of Overload Relays: Select and set overloads on the basis of FLA rating as shown on motor nameplate. Adjust setting value for special motors as required by NFPA 70 for high-torque, high-efficiency, and similar motors.

D. Interfaces with Other Work:

1. Identification: Provide labels for motor controllers and associated electrical equipment.
 - a. Identify field-installed conductors, interconnecting wiring, and components.
 - b. Label each enclosure and each compartment with **[baked enamel signs][metal backed butyrate signs][laminated acrylic or melamine plastic signs]**, mounted with corrosion-resistant screws
 - c. Provide warning signs for electrical equipment.
2. Arc-Flash Warning Labels:
 - a. Provide self-adhesive equipment label for each work location **[included in the arc-flash hazard analysis]**.
 - b. Labels must be machine printed, with no field-applied markings.
 - c. Labels must have orange header with wording, "WARNING, ARC-FLASH HAZARD," and must include the following information taken directly from the arc-flash hazard analysis:
 - 1) Location designation.
 - 2) Nominal voltage.
 - 3) Flash protection boundary.
 - 4) Hazard risk category.
 - 5) Incident energy.
 - 6) Working distance.
 - 7) Engineering report number, revision number, and issue date.

3.3 FIELD QUALITY CONTROL OF SOFT-START MOTOR CONTROLLERS

A. Administrant for Electrical Power Tests and Inspections:

1. **[Owner][Tenant]** will engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
2. Engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections **[with assistance of factory-authorized service representative]**.

B. Acceptance Testing Preparation:

1. **<Insert requirements>**.

C. Tests and Inspections:

1. Comply with NFPA 70B.
2. Visual and Mechanical Inspection:
 - a. Compare equipment nameplate data with Drawings and the Specifications.

- b. Inspect physical and mechanical condition.
 - c. Inspect anchorage, alignment, and grounding.
 - d. Verify that the unit is clean.
 - e. Ensure that vent path openings are free from debris and that heat-transfer surfaces are clean.
 - f. Verify correct connections of circuit boards, wiring, disconnects, and ribbon cables.
 - g. Inspect Contactors:
 - 1) Verify mechanical operation.
 - 2) Verify that contact gap, wipe, alignment, and pressure are in accordance with manufacturer's published data.
 - h. Motor-Running Protection:
 - 1) Verify that motor FLA is at, or under, the controller current rating.
 - 2) Verify that overload element setting is correct for its application.
 - 3) Apply minimum- and maximum-speed set points. Verify that set points are within limitations of the load coupled to the motor.
 - 4) If motor-running protection is provided by fuses, verify correct fuse rating.
 - i. Inspect bolted electrical connections for high resistance using one of the following two methods:
 - 1) Use a low-resistance ohmmeter. Compare bolted-connection-resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS, Table 100.12.
 - j. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
3. Electrical Tests:
- a. **[For the contactor and circuit breaker, perform][Perform]** insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole.
 - 1) Insulation Resistance: In accordance with manufacturer's published instructions or NETA ATS, Table 100.1. In the absence of manufacturer's published instructions, use Table 100.5.
 - 2) Investigate and correct insulation resistance values less than those of this table or manufacturer's published instructions.
 - b. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.
 - c. Test motor protection devices according to manufacturer's published instructions.
 - d. Test circuit breakers as follows:
 - 1) Operate the circuit breaker to ensure smooth operation.
 - 2) For adjustable circuit breakers, adjust protective device settings in accordance with the coordination study. Comply with coordination study recommendations.
 - e. Test the electronic motor overload relay elements by injecting primary current through the overload circuit and monitoring trip time of the overload element.



- f. Test the following parameters in accordance with NETA relay calibration procedures, or as recommended by manufacturer:
 - 1) ANSI No. 49R, Overtemperature Protection:
 - a) Determine time delay at 300 percent of setting.
 - b) Determine a second point on the operating curve.
 - c) Determine pickup.
 - 2) ANSI No. 47, Input Phase Loss and Reversed Phases Protection:
 - a) Determine positive sequence voltage to close the N.O. contact.
 - b) Determine positive sequence voltage to open the N.C. contact (undervoltage trip).
 - c) Verify negative sequence trip.
 - d) Determine time delay to close the N.O. contact with sudden application of 120 percent of pickup.
 - e) Determine time delay to close the N.C. contact on removal of voltage when previously set to rated system voltage.
 - 3) ANSI No. 81, Overfrequency Protection:
 - a) Verify frequency set points.
 - b) Determine time delay.
 - c) Determine undervoltage cutoff.
 - 4) Fault Alarm Outputs: Verify that each relay contact performs its intended function in the control scheme including breaker trip tests, close inhibit tests, lockout tests, and alarm functions.
- g. Perform operational tests by initiating control devices.

D. Nonconforming Work:

1. Motor controllers will be considered defective if they do not pass tests and inspections.
2. Remove and replace defective units and retest.

E. Field Quality Control Reports: Collect, assemble, and submit test and inspection reports.

F. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.

1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.

3.4 SYSTEM STARTUP

A. Perform startup service in accordance with manufacturer's published instructions.

B. System Startup Testing: Verify the correct interaction of sensing, processing, and action devices. Perform system startup testing after field quality-control tests have been completed and all components have passed specified tests.

1. Develop test parameters and perform tests for the purpose of evaluating performance of integral components and their functioning as a complete unit within design requirements and manufacturer's published data.
 2. Verify the correct operation of interlock safety devices for fail-safe functions in addition to design function.
 3. Verify the correct operation of sensing devices, alarms, and indicating devices.
- C. Motor controllers will be considered defective if they do not pass system startup testing.
- D. System Startup Testing Report: Compile, prepare, and submit test and inspection reports.
- E. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** system startup.
1. Manufacturer's Field Reports for System Startup Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.

3.5 CLOSEOUT ACTIVITIES

- A. Training:
1. **[With assistance from factory-authorized service representatives, train][Train]** Owner's maintenance personnel on the following topics:
 - a. How to adjust, operate, and maintain equipment specified in Section 262913.03 "Manual and Magnetic Motor Controllers."
 2. **[Provide video recordings of training sessions to Owner][Allow Owner to record training sessions].**

3.6 MAINTENANCE

- A. Infrared Scanning of Motor Controllers: Perform infrared scanning during periods of maximum possible loading. Comply with NFPA 70B requirements. Remove covers so joints and connections are accessible to portable scanner. Take visible light photographs at same locations and orientations as infrared scans for documentation to ensure follow-on scans match same conditions for valid comparison.
1. Equipment: Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1 deg C at 30 deg C. The equipment detects emitted radiation and convert detected radiation to a visual signal.
 2. Act on inspection results and recommended action, and considering the recommendations of NETA ATS, Table 100.18. Correct possible and probable deficiencies as soon as Owner's operations permit. Retest until deficiencies are corrected.
 3. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared inspection of the electrical power connections of each motor controller.
 4. Follow-On Infrared Scanning: Perform follow-up infrared scans of motor controller at 11 months after Substantial Completion.
 5. Field Reports for Infrared Scanning: Prepare a certified report including the following information:
 - a. Identities of personnel performing infrared scanning.
 - b. Description of test equipment used and record of their calibration.
 - c. Description of motor controllers and associated equipment tested.



- d. Deficiencies found, remedial actions taken, and observations found when scans were repeated after the remedial actions.
- e. Temperature difference between the area of concern and the reference area.
- f. Probable cause of temperature difference.
- g. Areas inspected. Identify inaccessible and unobservable areas and equipment.
- h. Load conditions at time of inspection.
- i. Photographs and thermograms of the deficient area.
- j. Recommended action.

END OF SECTION 26 29 13 00A



Task	Specification	Specification Description
26 29 13 13	26 29 13 00	Manual and Magnetic Motor Controllers
26 29 13 13	26 29 13 00a	Soft-Start Motor Controllers



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SECTION 26 29 23 00 - VARIABLE-FREQUENCY MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes separately enclosed, preassembled, combination VFCs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.
- B. Related Requirements:
 - 1. Section 262419 "Motor-Control Centers" for VFCs installed in motor-control centers.

1.2 DEFINITIONS

- A. CE: Conformance Europeene (European Compliance).
- B. CPT: Control power transformer.
- C. DDC: Direct digital control.
- D. EMI: Electromagnetic interference.
- E. LED: Light-emitting diode.
- F. NC: Normally closed.
- G. NO: Normally open.
- H. OCPD: Overcurrent protective device.
- I. PID: Control action, proportional plus integral plus derivative.
- J. RFI: Radio-frequency interference.
- K. VFC: Variable-frequency motor controller.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type and rating of VFC indicated.
 - 1. Include dimensions and finishes for VFCs.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For each VFC indicated.
 - 1. Include mounting and attachment details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field

- connection.
- 3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Required working clearances and required area above and around VFCs.
 - 2. Show VFC layout and relationships between electrical components and adjacent structural and mechanical elements.
 - 3. Show support locations, type of support, and weight on each support.
 - 4. Indicate field measurements.
- B. Qualification Data: For testing agency.
- C. Seismic Qualification Data: Certificates, for each VFC, accessories, and components, from manufacturer.
 - 1. Certificate of compliance.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based, and their installation requirements.
- D. Product Certificates: For each VFC from manufacturer.
- E. Harmonic Analysis Report: Provide Project-specific calculations and manufacturer's statement of compliance with IEEE 519.
- F. Source quality-control reports.
- G. Field quality-control reports.
- H. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For VFCs to include in emergency, operation, and maintenance manuals.
 - 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Manufacturer's written instructions for testing and adjusting thermal-magnetic circuit breaker and motor-circuit protector trip settings.
 - b. Manufacturer's written instructions for setting field-adjustable overload relays.
 - c. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
 - d. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.
 - e. Load-Current and Overload-Relay Heater List: Compile after motors have been installed,

- and arrange to demonstrate that selection of heaters suits actual motor nameplate, full-load currents.
- f. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Power Fuses: Equal to [10]<Insert number> percent of quantity installed for each size and type, but no fewer than [three]<Insert number> of each size and type.
 2. Control Power Fuses: Equal to [10]<Insert number> percent of quantity installed for each size and type, but no fewer than [two]<Insert number> of each size and type.
 3. Indicating Lights: [Two]<Insert number> of each type and color installed.
 4. Auxiliary Contacts: Furnish [one]<Insert number> spare(s) for each size and type of magnetic controller installed.
 5. Power Contacts: Furnish [three]<Insert number> spares for each size and type of magnetic contactor installed.
 6. <Insert extra materials>.

1.7 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Accredited by NETA.
1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. If stored in space that is not permanently enclosed and air conditioned, remove loose packing and flammable materials from inside controllers and **[install temporary electric heating, with at least 250 W per controller][connect factory-installed space heaters to temporary electrical service]**.
- B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFCs, including clearances between VFCs, and adjacent surfaces and other items.

1.9 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace VFCs that fail in materials or workmanship within specified warranty period.
1. Warranty Period: [Five]<Insert number> years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 VARIABLE-FREQUENCY MOTOR CONTROLLERS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide**

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

1. [ABB, Electrification Business]
2. [ABB, Motion Business]
3. [Cerus Industrial, Inc.]
4. [Danfoss, Inc.]
5. [Eaton]
6. [Nidec Motor Corporation; Nidec Corporation]
7. [Rockwell Automation, Inc.]
8. [Schneider Electric USA, Inc.]
9. [Siemens Industry, Inc., Building Technologies Division]
10. [Yaskawa Electric America, Inc.]
11. <Insert manufacturer's name>

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

1. [ABB, Electrification Business]
2. [ABB, Motion Business]
3. [Cerus Industrial, Inc.]
4. [Danfoss, Inc.]
5. [Eaton]
6. [Nidec Motor Corporation; Nidec Corporation]
7. [Rockwell Automation, Inc.]
8. [Schneider Electric USA, Inc.]
9. [Siemens Industry, Inc., Building Technologies Division]
10. [Yaskawa Electric America, Inc.]
11. <Insert manufacturer's name>

2.2 SYSTEM DESCRIPTION

- A. General Requirements for VFCs:

1. VFCs and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA ICS 7, NEMA ICS 61800-2, and [UL 508A][UL 508C]<Insert standard>.

- B. Application: [Constant torque][and][variable torque]<Insert application>.

- C. VFC Description: Variable-frequency motor controller, consisting of power converter that employs pulse-width-modulated inverter, factory built and tested in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.

1. Units suitable for operation of NEMA MG 1, Design A and Design B motors, as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both."
2. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
3. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.

- D. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.
- E. Output Rating: Three phase; 10 to **[60 Hz, with voltage proportional to frequency throughout voltage range][66 Hz, with torque constant as speed changes]**; maximum voltage equals input voltage.
- F. Unit Operating Requirements:
1. Input AC Voltage Tolerance: Plus 10 and minus **[10][15]** percent of VFC input voltage rating.
 2. Input AC Voltage Unbalance: Not exceeding **[3][5]** percent.
 3. Input Frequency Tolerance: Plus or minus 3 percent of VFC frequency rating.
 4. Minimum Efficiency: **[96][97]<Insert number>** percent at 60 Hz, full load.
 5. Minimum Displacement Primary-Side Power Factor: **[96][98]<Insert number>** percent under any load or speed condition.
 6. Minimum Short-Circuit Current (Withstand) Rating: **[10][22][65][100]<Insert value>** kA.
 7. Ambient Temperature Rating: Not less than **32 deg F (0 deg C)** and not exceeding **104 deg F (40 deg C)**.
 8. Humidity Rating: Less than 95 percent (noncondensing).
 9. Altitude Rating: Not exceeding **3300 feet (1000 m)**.
 10. Vibration Withstand: Comply with NEMA ICS 61800-2.
 11. Overload Capability: **[1.1][1.5]** times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
 12. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
 13. Speed Regulation: Plus or minus **[5][10]** percent.
 14. Output Carrier Frequency: Selectable; 0.5 to **[15]<insert number>** kHz.
 15. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.
- G. Inverter Logic: Microprocessor based, **[16][32]** bit, isolated from all power circuits.
- H. Isolated Control Interface: Allows VFCs to follow remote-control signal over a minimum 40:1 speed range.
1. Signal: **[Electrical][Pneumatic]**.
- I. Internal Adjustability Capabilities:
1. Minimum Speed: 5 to 25 percent of maximum rpm.
 2. Maximum Speed: 80 to 100 percent of maximum rpm.
 3. Acceleration: **[0.1 to 999.9]<Insert range>** seconds.
 4. Deceleration: **[0.1 to 999.9]<Insert range>** seconds.
 5. Current Limit: 30 to minimum of 150 percent of maximum rating.
 6. **<Insert adjustment and parameters>**.
- J. Self-Protection and Reliability Features:
1. Surge Suppression: **[Factory installed as an integral part of the VFC, complying with UL 1449 SPD, Type 1 or Type 2][Field-mounted surge suppressors complying with Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits," UL 1449 SPD, Type 2]**.
 2. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
 3. Under- and overvoltage trips.
 4. Inverter overcurrent trips.
 5. VFC and Motor-Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFCs and motor thermal characteristics, and for providing VFC

- overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
- 6. Critical frequency rejection, with **[three]<Insert number>** selectable, adjustable deadbands.
- 7. Instantaneous line-to-line and line-to-ground overcurrent trips.
- 8. Loss-of-phase protection.
- 9. Reverse-phase protection.
- 10. Short-circuit protection.
- 11. Motor-temperature fault.
- 12. **<Insert protection or reliability feature>**.

- K. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.
- L. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.
- M. Bidirectional Autospeed Search: Capable of starting VFC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.
- N. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.
- O. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.
- P. Integral Input Disconnecting Means and OCPD: **[UL 489, instantaneous-trip circuit breaker][UL 489, molded-case switch, with power fuse block and current-limiting fuses][UL 489, thermal-magnetic circuit breaker][NEMA KS 1, nonfusible switch, with power fuse block and current-limiting fuses][NEMA KS 1, fusible switch]** with pad-lockable, door-mounted handle mechanism.
 - 1. Disconnect Rating: **[Not less than 115 percent of VFC input current rating][Not less than 115 percent of NFPA 70 motor full-load current rating or VFC input current rating, whichever is larger]**.
 - 2. Auxiliary Contacts: NO or NC, arranged to activate before switch blades open.
 - 3. Auxiliary contacts "a" and "b" arranged to activate with circuit-breaker handle.
 - 4. **[NC][NO]** alarm contact that operates only when circuit breaker has tripped.

2.3 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: VFCs shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. The designated VFCs shall be tested and certified by an NRTL as meeting the ICC-ES AC 156 test procedure requirements.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified **[and the unit will be fully operational after the seismic event].**"

2.4 CONTROLS AND INDICATION

- A. Status Lights: Door-mounted LED indicators displaying the following conditions:
 - 1. Power on.
 - 2. Run.

3. Overvoltage.
 4. Line fault.
 5. Overcurrent.
 6. External fault.
 7. **<Insert condition>**.
- B. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English-language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.
1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
 2. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.
 - a. Control Authority: Supports at least four conditions: Off, local manual control at VFC, local automatic control at VFC, and automatic control through a remote source.
- C. Historical Logging Information and Displays:
1. Real-time clock with current time and date.
 2. Running log of total power versus time.
 3. Total run time.
 4. Fault log, maintaining last **[four]<Insert number>** faults with time and date stamp for each.
 5. **<Insert information or display>**.
- D. Indicating Devices: Digital display[**and additional readout devices as required,**] mounted flush in VFC door and connected to display VFC parameters including, but not limited to:
1. Output frequency (Hz).
 2. Motor speed (rpm).
 3. Motor status (running, stop, fault).
 4. Motor current (amperes).
 5. Motor torque (percent).
 6. Fault or alarming status (code).
 7. PID feedback signal (percent).
 8. DC-link voltage (V dc).
 9. Set point frequency (Hz).
 10. Motor output voltage (V ac).
 11. **<Insert parameter>**.
- E. Control Signal Interfaces:
1. Electric Input Signal Interface:
 - a. A minimum of **[two]<Insert number>** programmable analog inputs: **[0- to 10-V dc][4- to 20-mA dc][Operator-selectable "x"- to "y"-mA dc]<Insert signal parameters>**.
 - b. A minimum of **[six]<Insert number>** multifunction programmable digital inputs.
 2. Pneumatic Input Signal Interface: **3 to 15 psig (20 to 104 kPa)**.
 3. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the DDC system for HVAC or other control systems:
 - a. 0- to 10-V dc.
 - b. 4- to 20-mA dc.

- c. Potentiometer using up/down digital inputs.
 - d. Fixed frequencies using digital inputs.
 - e. **<Insert signal input>**.
4. Output Signal Interface: A minimum of **[one]<Insert number>** programmable analog output signal(s) (**[0- to 10-V dc][4- to 20-mA dc][operator-selectable "x"- to "y"-mA dc]<Insert signal parameters>**), which can be configured for any of the following:
- a. Output frequency (Hz).
 - b. Output current (load).
 - c. DC-link voltage (V dc).
 - d. Motor torque (percent).
 - e. Motor speed (rpm).
 - f. Set point frequency (Hz).
 - g. **<Insert indication>**.
5. Remote Indication Interface: A minimum of **[two]<Insert number>** programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
- a. Motor running.
 - b. Set point speed reached.
 - c. Fault and warning indication (overtemperature or overcurrent).
 - d. PID high- or low-speed limits reached.
 - e. **<Insert indication>**.
- F. PID Control Interface: Provides closed-loop set point, differential feedback control in response to dual feedback signals. Allows for closed-loop control of fans and pumps for pressure, flow, or temperature regulation.
1. Number of Loops: **[One][Two]<Insert number>**.
- G. Interface with DDC System for HVAC: Factory-installed hardware and software shall interface with DDC system for HVAC to monitor, control, display, and record data for use in processing reports. VFC settings shall be retained within VFC's nonvolatile memory.
1. Hardwired Points:
- a. Monitoring: On-off status, **<Insert monitoring point>**.
 - b. Control: On-off operation, **<Insert control point>**.
2. Communication Interface: Comply with **[ASHRAE 135]<Insert type of interface>**. Communication shall interface with DDC system for HVAC to remotely control and monitor lighting from a DDC system for HVAC operator workstation. Control features and monitoring points displayed locally at lighting panel shall be available through the DDC system for HVAC.

2.5 LINE CONDITIONING AND FILTERING

- A. Input Line Conditioning: Based on the manufacturer's harmonic analysis study and report, provide input filtering, as required, to limit total demand (harmonic current) distortion and total harmonic voltage demand at the defined point of common coupling to meet IEEE 519 recommendations.
- B. Output Filtering: **<Insert requirements>**.
- C. EMI/RFI Filtering:

1. CE marked; certify compliance with IEC 61800-3 for [Category C2]<Insert category>.
2. <Insert requirements>.

2.6 BYPASS SYSTEMS

- A. Bypass Operation: Safely transfers motor between power converter output and bypass circuit, manually, automatically, or both. Selector switches set modes and indicator lights indicate mode selected. Unit is capable of stable operation (starting, stopping, and running) with motor completely disconnected from power converter.
- B. Bypass Mode:
 1. Manual operation only; requires local operator selection at VFC. Transfer between power converter and bypass contactor, and retransfer shall only be allowed with the motor at zero speed.
 2. Field-selectable automatic or manual, allows local and remote transfer between power converter and bypass contactor and retransfer, either via manual operator interface or automatic-control system feedback.
- C. Bypass Controller:
 1. Two-Contactor-Style Bypass: Two-contactor-style bypass allows motor operation via the power converter or the bypass controller[; **with input isolating switch and barrier arranged to isolate the power converter and permit safe troubleshooting and testing, both energized and de-energized, while motor is operating in bypass mode**].
 - a. Bypass Contactor: Load-break, [IEC][NEMA]-rated contactor.
 - b. Output Isolating Contactor: Non-load-break, [IEC][NEMA]-rated contactor.
 - c. Isolating Switch: Non-load-break switch arranged to isolate power converter and permit safe troubleshooting and testing of the power converter, both energized and de-energized, while motor is operating in bypass mode; pad-lockable, door-mounted handle mechanism.
 2. Three-Contactor-Style Bypass: Three-contactor-style bypass allows motor operation via the power converter or the bypass controller[; **with input isolating switch and barrier**] arranged to isolate the power converter input and output and permit safe testing[**and troubleshooting**] of the power converter, both energized and de-energized, while motor is operating in bypass mode.
 - a. Bypass Contactor: Load-break, [IEC][NEMA]-rated contactor.
 - b. Input and Output Isolating Contactors: Non-load-break, [IEC][NEMA]-rated contactors.
 - c. Isolating Switch: Non-load-break switch arranged to isolate power converter and permit safe troubleshooting and testing of the power converter, both energized and de-energized, while motor is operating in bypass mode; pad-lockable, door-mounted handle mechanism.
- D. Bypass Contactor Configuration: **[Full-voltage (across-the-line)][Reduced-voltage (autotransformer)]<Insert type>** type.
 1. NORMAL/BYPASS selector switch.
 2. HAND/OFF/AUTO selector switch.
 3. NORMAL/TEST Selector Switch: Allows testing and adjusting of VFC while the motor is running in the bypass mode.
 4. Contactor Coils: Pressure-encapsulated type[**with coil transient suppressors**].
 - a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
 - b. Power Contacts: Totally enclosed, double break, and silver-cadmium oxide; assembled to

allow inspection and replacement without disturbing line or load wiring.

5. Control Circuits: **[120]<Insert number>-V ac**; obtained from **[integral CPT, with primary and secondary fuses]<Insert source of control power>**, with **[CPT][control power source]** of sufficient capacity to operate all integral devices and remotely located pilot, indicating, and control devices.
 - a. CPT Spare Capacity: **[50][100][200]<Insert number> VA**.
6. Overload Relays: NEMA ICS 2.
 - a. Melting-Alloy Overload Relays:
 - 1) Inverse-time-current characteristic.
 - 2) **[Class 10][Class 20][Class 30]** tripping characteristic.
 - 3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 - b. Bimetallic Overload Relays:
 - 1) Inverse-time-current characteristic.
 - 2) **[Class 10][Class 20][Class 30]** tripping characteristic.
 - 3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 - 4) Ambient compensated.
 - 5) Automatic resetting.
 - c. Solid-State Overload Relays:
 - 1) Switch or dial selectable for motor-running overload protection.
 - 2) Sensors in each phase.
 - 3) **[Class 10][Class 20][Class 10/20 selectable]** tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
 - 4) Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
 - 5) Analog communication module.
 - d. **[NC][NO]** isolated overload alarm contact.
 - e. External overload, reset push button.

2.7 OPTIONAL FEATURES

- A. Multiple-Motor Capability: VFC suitable for variable-speed service to multiple motors. Overload protection shuts down VFC and motors served by it, and generates fault indications when overload protection activates.
 1. Configure to allow two or more motors to operate simultaneously at the same speed; separate overload relay for each controlled motor.
 2. Configure to allow two motors to operate separately; operator selectable via local or remote switch or contact closures; single overload relay for both motors; separate output magnetic contactors for each motor.
 3. Configure to allow two motors to operate simultaneously and in a lead/lag mode, with one motor operated at variable speed via the power converter and the other at constant speed via the bypass controller; separate overload relay for each controlled motor.

- B. Damper control circuit with end-of-travel feedback capability.
- C. Sleep Function: Senses a minimal deviation of a feedback signal and stops the motor. On an increase in speed-command signal deviation, VFC resumes normal operation.
- D. Motor Preheat Function: Preheats motor when idle to prevent moisture accumulation in the motor.
- E. Firefighter's Override (Smoke Purge) Input: On a remote contact closure from **[the firefighter's control station][smoke-control fan controller]<Insert location>**, this password-protected input:
 - 1. Overrides all other local and external inputs (analog/digital, serial communication, and all keypad commands).
 - 2. Forces VFC to operate motor, without any other run or speed command, at a field-adjustable, preset speed.
 - 3. Forces VFC to transfer to bypass mode and operate motor at full speed.
 - 4. Causes display of override mode on the VFC display.
 - 5. Reset VFC to normal operation on removal of override signal **[automatically][manually]**.
- F. Remote Indicating Circuit Terminals: Mode selection, controller status, and controller fault.
- G. Remote digital operator kit.
- H. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting a printer **[and a notebook computer]**.
- I. **<Insert feature>**.

2.8 ENCLOSURES

- A. VFC Enclosures: NEMA 250, to comply with environmental conditions at installed location.
 - 1. Dry and Clean Indoor Locations: **[Type 1]<Insert type>**.
 - 2. Outdoor Locations: **[Type 3R][Type 4X]<Insert type>**.
 - 3. **[Kitchen][Wash-Down]** Areas: **[Type 4X]<Insert type>**, **[stainless steel]<Insert material>**.
 - 4. Other Wet or Damp Indoor Locations: **[Type 4]<Insert type>**.
 - 5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.
 - 6. **<Insert enclosure requirements>**.
- B. Plenum Rating: UL 1995; NRTL certification label on enclosure, clearly identifying VFC as "Plenum Rated."

2.9 ACCESSORIES

- A. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in VFC enclosure cover unless otherwise indicated.
 - 1. Push Buttons: **[Covered][Lockable][Shielded][Unguarded]**.
 - 2. Pilot Lights: Push to test.
 - 3. Selector Switches: **[Rotary]<Insert description>** type.
 - 4. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.



- B. [NC][NO][Reversible NC/NO] bypass contactor auxiliary contact(s).
- C. Control Relays: Auxiliary and adjustable [pneumatic][solid-state] time-delay relays.
- D. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.
 - 1. Current Transformers: Continuous current rating, basic impulse insulating level (BIL) rating, burden, and accuracy class suitable for connected circuitry. Comply with IEEE C57.13.
- E. Supplemental Digital Meters:
 - 1. Elapsed-time meter.
 - 2. Kilowatt meter.
 - 3. Kilowatt-hour meter.
- F. Breather and drain assemblies, to maintain interior pressure and release condensation in NEMA 250, [Type 4][Type 4X][Type 12]<Insert type> enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.
- G. Space heaters, with NC auxiliary contacts, to mitigate condensation in NEMA 250, [Type 3R][Type 4X][Type 12]<Insert type> enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.
- H. Cooling Fan and Exhaust System: For NEMA 250, [Type 1][Type 12]<Insert enclosure type>; UL 508 component recognized: Supply fan, with [composite][stainless steel]<Insert material> intake and exhaust grills [and filters]; [120]<Insert number>-V ac; obtained from [integral CPT]<Insert source of control power>.
- I. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.
- J. Spare control-wiring terminal blocks[; unwired][; wired].
- K. <Insert accessory>.

2.10 SOURCE QUALITY CONTROL

- A. Testing: Test and inspect VFCs according to requirements in [NEMA ICS 61800-2]<Insert standard>.
 - 1. Test each VFC while connected to [its specified motor][a motor that is comparable to that for which the VFC is rated].
 - 2. Verification of Performance: Rate VFCs according to operation of functions and features specified.
- B. VFCs will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas, surfaces, and substrates to receive VFCs, with Installer present, for compliance with requirements for installation tolerances, <insert **Project-specific conditions**,> and other conditions affecting performance of the Work.
- B. Examine VFC before installation. Reject VFCs that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.
- D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Wall-Mounting Controllers: Install with tops at uniform height and with disconnect operating handles not higher than **79 inches (2000 mm)** above finished floor, unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."
- B. Floor-Mounting Controllers: Install VFCs on **4-inch (100-mm)** nominal thickness concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."
 - 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch (450-mm)** centers around the full perimeter of concrete base.
 - 2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 4. Install anchor bolts to elevations required for proper attachment to supported equipment.
- C. Roof-Mounting Controllers: Install VFC on roofs with tops at uniform height and with disconnect operating handles not higher than **79 inches (2000 mm)** above finished roof surface unless otherwise indicated, and by bolting units to curbs or mounting on freestanding, lightweight, structural-steel channels bolted to curbs. Seal roof penetrations after raceways are installed.
 - 1. Curbs and roof penetrations are specified in Section 077200 "Roof Accessories."
 - 2. Structural-steel channels are specified in Section 260529 "Hangers and Supports for Electrical Systems."
- D. Seismic Bracing: Comply with requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- F. Install fuses in each fusible-switch VFC.

- G. Install fuses in control circuits if not factory installed. Comply with requirements in Section 262813 "Fuses."
- H. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors are installed.
- I. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.
- J. Comply with NECA 1.

3.3 CONTROL WIRING INSTALLATION

- A. Install wiring between VFCs and remote devices[**and facility's central-control system**]. Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."
- B. Bundle, train, and support wiring in enclosures.
- C. Connect selector switches and other automatic-control devices where applicable.
 - 1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switches are in manual-control position.
 - 2. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor-overload protectors.

3.4 IDENTIFICATION

- A. Identify VFCs, components, and control wiring. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
 - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 - 2. Label each VFC with engraved nameplate.
 - 3. Label each enclosure-mounted control and pilot device.
- B. Operating Instructions: Frame printed operating instructions for VFCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: [**Owner will engage**][**Engage**] a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections[**with the assistance of a factory-authorized service representative**].
- D. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each VFC element, bus, component, connecting supply, feeder, and

- control circuit.
2. Test continuity of each circuit.

E. Tests and Inspections:

1. Inspect VFC, wiring, components, connections, and equipment installation. **[Test and adjust controllers, components, and equipment.]**
2. Test insulation resistance for each VFC element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.
4. Verify that voltages at VFC locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify **[Architect][Construction Manager][Owner]** before starting the motor(s).
5. Test each motor for proper phase rotation.
6. Perform tests according to the Inspection and Test Procedures for Adjustable Speed Drives stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
8. Perform the following infrared (thermographic) scan tests and inspections, and prepare reports:
 - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each VFC. Remove front panels so joints and connections are accessible to portable scanner.
 - b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each VFC 11 months after date of Substantial Completion.
 - c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
9. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

F. VFCs will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports, including a certified report that identifies the VFC and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.6 STARTUP SERVICE

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.
1. Complete installation and startup checks according to manufacturer's written instructions.
 2. **<Insert startup steps if any>.**

3.7 ADJUSTING

- A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.
- B. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

- C. Adjust the trip settings of instantaneous-only circuit breakers and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to 6 times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed 8 times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify **[Architect][Construction Manager][Owner]** before increasing settings.
- D. Set the taps on reduced-voltage autotransformer controllers.
- E. Set field-adjustable circuit-breaker trip ranges **[as specified in Section 260573.16 "Coordination Studies."]**
- F. Set field-adjustable pressure switches.

3.8 PROTECTION

- A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until controllers are ready to be energized and placed into service.
- B. Replace VFCs whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.9 DEMONSTRATION

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

END OF SECTION 26 29 23 00



Task	Specification	Specification Description
26 29 33 13	21 31 16 00	Diesel-Drive, Centrifugal Fire Pumps
26 29 33 13	21 34 13 00	Pressure-Maintenance Pumps



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SECTION 26 31 00 00 - PHOTOVOLTAIC COLLECTORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Manufactured PV units.
2. PV module framing.
3. PV array construction.
4. Inverters.
5. System overcurrent protection.
6. Mounting structures.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.2 DEFINITIONS

- A. CEC: California Energy Commission.
- B. ETFE: Ethylene tetrafluoroethylene.
- C. FEP: Fluorinated ethylene propylene.
- D. IP Code: Required ingress protection to comply with IEC 60529.
- E. MPPT: Maximum power point tracking.
- F. PTC: PVUSA Test Condition. Commonly regarded as a "real-world" measure of PV output. See below for definition of "PVUSA."
- G. PV: Photovoltaic.
- H. PVUSA: Photovoltaics for Utility Systems Applications.
- I. STC: Standard Test Conditions defined in IEC 61215.

1.3 ACTION SUBMITTALS

A. Product Data:

1. Manufactured PV units.
2. PV module framing.

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3. PV array construction.
4. Inverters.
5. System overcurrent protection.
6. Mounting structures.

B. Shop Drawings: For PV modules.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly.
4. Include diagrams for power, signal, and control wiring.

C. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

A. Manufacturers' published instructions.

B. Field Reports:

1. Manufacturer's field reports for field quality-control support.

1.5 CLOSEOUT SUBMITTALS

A. Warranty documentation.

1.6 WARRANTY

A. Manufacturer's Special Warranty: Manufacturer agrees to repair or replace components of PV modules that fail in materials or workmanship within specified warranty period.

1. Manufacturer's materials and workmanship warranties include, but are not limited to, the following:

- a. Faulty operation of PV modules.
- b. **<Insert failure modes>**.

2. Warranty Period: **[Two][Five]<Insert number>** years from date of Substantial Completion.

B. Manufacturer's Special Minimum Power Output Warranty: Manufacturer agrees to repair or replace components of PV modules that fail to exhibit the minimum power output within specified warranty period. Special warranty, applying to modules only, applies to materials only, on a prorated basis, for period specified.

1. Manufacturer's minimum power output warranties include, but are not limited to, the following warranty periods, from date of Substantial Completion:
 - a. Specified minimum power output to **[80]<Insert number>** percent or more, for a period of **[25]<Insert number>** years.

- b. <Insert additional minimum power output special warranty>.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

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

1. **[Aleo Solar]**
2. **[BP Solar USA]**
3. **[Canadian Solar]**
4. **[ET Solar]**
5. **[Evergreen Solar, Inc.]**
6. **[GE Solar; General Electric Company]**
7. **[Kaneka Corporation]**
8. **[Kyocera International, Inc.]**
9. **[Lumos Solar, LLC]**
10. **[Mitsubishi Electric US, Inc.]**
11. **[REC Solar US LLC]**
12. **[SANYO North America Corporation]**
13. **[Schott Solar]**
14. **[Sharp Electronics Corp.]**
15. **[Suniva]**
16. **[SunPower Corporation]**
17. **[Suntech Power]**
18. **[Trina Solar Limited]**
19. **[United Solar Ovonic LLC]**
20. **[Yingli Green Energy Holding Co., Ltd.]**
21. **<Insert manufacturer's name>**

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

1. **[Aleo Solar]**
2. **[BP Solar USA]**
3. **[Canadian Solar]**
4. **[ET Solar]**
5. **[Evergreen Solar, Inc.]**
6. **[GE Solar; General Electric Company]**
7. **[Kaneka Corporation]**
8. **[Kyocera International, Inc.]**
9. **[Lumos Solar, LLC]**
10. **[Mitsubishi Electric US, Inc.]**
11. **[REC Solar US LLC]**
12. **[SANYO North America Corporation]**
13. **[Schott Solar]**
14. **[Sharp Electronics Corp.]**
15. **[Suniva]**
16. **[SunPower Corporation]**
17. **[Suntech Power]**
18. **[Trina Solar Limited]**
19. **[United Solar Ovonic LLC]**

20. [Yingli Green Energy Holding Co., Ltd.]
21. <Insert manufacturer's name>

2.2 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- B. Hazardous Locations: FM Global approved for NFPA 70, Class 1, Division 2, Group C and Group D.

2.3 PV CAPACITIES AND CHARACTERISTICS

- A. Minimum Electrical Characteristics:
 1. Rated Open-Circuit Voltage: <Insert V(dc)>.
 2. Maximum System Voltage: <Insert V(dc)>.
 3. Maximum Power at Voltage (Vpm): <Insert V(dc)>.
 4. Short-Circuit Temperature Coefficient: <Insert mA/deg C>.
 5. Rated Short-Circuit Current (Isc): <Insert amperes>.
 6. Maximum System: <Insert V(dc)>.
 7. Rated Operation Current (Imp): <Insert amperes>.
 8. Maximum Power at STC (Pmax): <Insert watts>.
- B. Additional Electrical Characteristics:
 1. PTC Rating: <Insert watts>.
 2. Peak Power per Unit Area: <Insert watts>.
 3. Tolerance of Pmax: <Insert number> percent.
 4. Minimum Peak Power: <Insert watts>.
 5. Series Fuse Rating: <Insert amperes>.
 6. Module Efficiency: <Insert number> percent.
 7. Temperature Cycling Range: <Insert deg C>.
 8. Humidity, Freeze, Damp Heat Condition: <Insert number> percent RH.
 9. Wind Loading or Surface Pressure: <Insert lb/ft² (N/m²)>.
 10. Maximum Distortion Angle: <Insert degrees>.
 11. Hailstone Impact Withstand: <Insert inch (mm)> diameter at <Insert mile/h (km/h)> wind velocity.
- C. Normal Operating Temperature Characteristics (NOTC):
 1. Temperature at Nominal Operating Cell Temperature: <Insert deg C>.
 2. Temperature Coefficient (NOTC Nominal Power): <Insert deg C>.
 3. Temperature Coefficient (NOTC Open-Circuit Voltage): <Insert deg C>.
 4. Temperature Coefficient (NOTC Short Circuit Current): <Insert deg C>.
 5. Temperature Coefficient (NOTC Maximum Power Voltage): <Insert deg C>.
 6. Temperature Coefficient (NOTC Maximum Power Current): <Insert deg C>.

2.4 PV SYSTEMS DESCRIPTION

- A. Interactive PV System: Collectors connected in parallel to the electrical utility; and capable of providing power for Project and supplying power to a distributed network.

1. A [six]<Insert number>-module array to generate a total nominal rated output of [1000 W]<Insert watts>.
 2. System Components:
 - a. PV modules.
 - b. Array frame.
 - c. Utility-interactive inverter.
 - d. Overcurrent protection, disconnect, and rapid shutdown devices.
 - e. Mounting structure.
 - f. Utility meter.
 - g. <Insert component>.
- B. Hybrid PV System: Collectors connected to provide power to DC and AC loads, connected to utility through interactive inverters or meters, and connected to energy storage.
1. A [six]<Insert number>-module array to generate a total nominal rated output of [1000 W]<Insert watts>.
 2. System Components:
 - a. PV modules.
 - b. Array frame.
 - c. Charge controller.
 - d. Energy storage.
 - e. System control.
 - f. [Inverter][Utility-interactive inverter].
 - g. Overcurrent protection, disconnect, and rapid shutdown devices.
 - h. Mounting structure.
 - i. [Meter][Utility-interactive meter].
 - j. <Insert component>.
- C. Stand-Alone PV System: Collectors connected to provide power to Project DC and AC loads through an energy storage system.
1. A [six]<Insert number>-module array to generate a total nominal rated output of [1000 W]<Insert watts>.
 2. System Components:
 - a. PV modules.
 - b. Array frame.
 - c. Charge controller.
 - d. Energy storage.
 - e. Inverter.
 - f. Overcurrent protection, disconnect, and rapid shutdown devices.
 - g. Mounting structure.

2.5 MANUFACTURED PV UNITS

- A. Cell Materials, Thin Film:
1. Amorphous silicon (a-Si).
 2. Micromorphous silicon (a-Si+uc-Si).
 3. Copper indium (di)selenide (CIS).
 4. Copper indium gallium (di)selenide (CIGS).
 5. Cadmium telluride (CdTe).
 6. Cadmium sulfide.

- B. Cell Materials, Wafer: **[Polycrystalline][Monocrystalline]**.
1. c-Si.
 2. Gallium arsenide (GaAs).
- C. Module Construction:
1. Nominal Size: **32 inch (800 mm)** wide by **64 inch (1600 mm)** long.
 2. Weight: **42.8 lb (19.4 kg)**.
- D. Insulating Substrate Film: **[Flexible][Rigid]**, **[polyester][polyimide]**.
- E. Conducting Substrate Film: **[Flexible][Rigid][Fluoropolymer]**, **[ETFE][FEP]**.
- F. Encapsulant: Ethyl vinyl acetate.
- G. Front Panel: **[Fully tempered glass][0.125 inch (3.2 mm) thick glass][Low iron glass][Antireflective coating glass][Laminating film][Laminating material]**.
- H. Backing Material: **[Tempered glass][0.125 inch (3.2 mm) thick glass][Polyester film][PVC film]**.
1. Layers: **<Insert number>**.
 2. Color: **[White]<Insert color>**.
- I. Bypass Diode Protection: Internal.
- J. Junction Box:
1. Size: **1.56-by-3.96-by-0.52 inch (39.6-by-100.6-by-13.2 mm)**.
 2. Fully potted, vandal resistant.
 3. IP Code: **[IP65][IP66][IP67]<Insert IP code designation>**.
 4. Flammability Test: UL 1703.
- K. Output Cabling:
1. **[0.158 inch (4 mm)]<Insert dimension>**.
 2. Quick, multiconnect, polarized connectors.
 3. Two-Conductor Harness: No traditional return wire is needed from the end of a row back to the source combiner.
- L. Series Fuse Rating: **<Insert amperes>**.

2.6 PV MODULE FRAMING

- A. PV laminates mounted in anodized extruded-aluminum frames.
1. Entire assembly UL listed for electrical and fire safety, **[Class A][Class C]**, according to UL 1703, and complying with IEC 61215.
 2. Frame strength exceeding requirements of certifying agencies in subparagraph above.
 3. Anodized Aluminum Finish: Alloy and temper recommended by framing manufacturer for strength, corrosion resistance, and application of required finish.
 4. High-performance Organic Finish: Manufacturer's standard two-coat, thermocured system consisting of specially formulated inhibitive primer and fluoropolymer color topcoat containing not

- less than 70 percent PVC resin by weight.
- 5. Baked-enamel finish.
- 6. Color: As indicated by manufacturer's designations.

2.7 PV ARRAY CONSTRUCTION

A. Framing:

- 1. Material: **[Extruded aluminum][Galvanized steel][Coated steel]**.
- 2. Maximum System Weight: Less than **4 lb/ft² (19.53 kg/m²)**.
- 3. Minimum Distance to Connectors: **<Insert inch (mm)>**.
- 4. Raceway Cover Plates: **[Plastic][Aluminum][Galvanized steel]**.

B. Flat-Roof Mounting:

- 1. No roof penetrations.
- 2. Self-ballasting.
- 3. Wind-tunnel tested to **110 mile/h (160 km/h)** wind.
- 4. Service Life: **[25]<Insert number>** years.
- 5. Freestanding system.

2.8 INVERTER

A. Inverter Type: **[Central][Microgrid]**.

B. Control Type: **[Pulse-width-modulation control][Maximum power point tracker control]**.

C. Inverter Electrical Characteristics:

- 1. Maximum Recommended PV Input Power: **<Insert kilowatts>**.
- 2. Maximum Open-Circuit Voltage: **<Insert V(dc)>**.
- 3. PV Start Voltage: **<Insert V(dc)>**.
- 4. MPPT Voltage Range: **<Insert V(dc)>**.
- 5. Maximum Input Current: **<Insert amperes>**.
- 6. Number of String Inputs: **<Insert number>**.
- 7. Number of Independent MPPT Circuits: **<Insert value>**.
- 8. Nominal Output Voltage: **<Insert V(dc)>**.
- 9. CEC Rated Power: **<Insert kilowatts>**.
- 10. Maximum Output Current: **<Insert amperes>**.
- 11. Peak Efficiency: **<Insert number>** percent.
- 12. CEC Weighted Efficiency: **<Insert number>** percent.
- 13. CEC Night Tare Loss: **<Insert watts>**.
- 14. DC/AC Terminal Range (AWG): **<Insert range of AWG values>**.
- 15. Communications Interface: **[TIA-485][TIA-232][Ethernet][Zigbee]<Insert type>**.
- 16. Utility Interface: Utility-interactive inverter.

D. Operating Conditions:

- 1. Operating Ambient Temperatures: **Minus 4 to plus 122 deg F (20 to plus 50 deg C)**.
- 2. Storage Temperature: **Minus 40 to plus 122 deg F (minus 40 to plus 50 deg C)**.
- 3. Relative Humidity: Zero to 95 percent, noncondensing.

E. Charge controllers must have the following:

1. Overcurrent protection.
2. Generator input breaker box.
3. Automatic transfer relay.
4. Digital display.
5. Transformer.
6. Disconnect switch.
7. Shunt controller.
8. Shunt regulator.
9. Surge overload protection.

F. Enclosure:

1. UL 50E[, **Type 3R**][, **Type 4X**].
2. Enclosure Material: [**Galvanized steel**][**Steel**].
3. Cooling Methods:
 - a. Fan convection cooling.
 - b. Passive cooling.
4. Protective Functions:
 - a. AC over/undervoltage.
 - b. AC over/underfrequency.
 - c. Ground overcurrent.
 - d. Overtemperature.
 - e. AC and DC overcurrent.
 - f. DC overvoltage.
5. Standard LCD, four lines, 20 characters, with user display and on/off toggle switch.

G. Disconnects: Rated for system voltage and conductor.

H. Regulatory Approvals:

1. IEEE 1547.1.
2. IEEE 1547.3.
3. UL 1741.

I. Characteristics:

1. Inverter Dimensions: **<Insert inch (mm)>**.
2. Inverter Weight: **<Insert lb (kg)>**.

2.9 SYSTEM OVERCURRENT PROTECTION

A. Fuses: **<Insert amperes>**.

B. Circuit Breakers: **<Insert amperes>**.

2.10 MOUNTING STRUCTURES

A. Roof Mount: Extruded aluminum, **[two][four]** rails, tilt legs, and roof standoffs.

- B. Pole Mount: **[Top][Panel tops][Side]**.
- C. Tracking Mounts: **[One][Two]** axis.

2.11 SOURCE QUALITY CONTROL

- A. Product Data: Prepare and submit catalog cuts, brochures, **[diagrams,][schedules,]** and performance data illustrating size, physical appearance, and other characteristics of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for PV panels.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - 3. Sample Warranty: For manufacturer's special materials and workmanship warranty and minimum power output warranty.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrate areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Do not begin installation until mounting surfaces have been properly prepared.
- C. If preparation of mounting surfaces is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.
- D. Examine modules and array frame before installation. Reject modules and arrays that are wet, moisture damaged, or mold damaged.
- E. Examine roofs, supports, and supporting structures for suitable conditions where PV system will be installed.
- F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Coordinate layout and installation of PV panels with **[roof][support]** assembly and other construction.
- B. Support PV panel assemblies independent of supports for other elements such as roof and support assemblies, enclosures, vents, pipes, and conduits. Support assembly to prevent twisting from eccentric loading.
- C. Install PV **[inverters,][energy storage,][charge controller,][rapid shutdown,][and][system control]** in locations indicated on Drawings.
- D. Install weatherseal fittings and flanges where PV panel assemblies penetrate exterior elements such as walls or roofs. Seal around openings to make weathertight. See Section 079200 "Joint Sealants" for materials and application.



- E. Seismic Restraints: Comply with requirements for seismic-restraint devices specified in Section 260548.16 "Seismic Controls for Electric Systems."
- F. Wiring Method: Install cables in raceways.
- G. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

3.3 CONNECTIONS

- A. Coordinate PV panel cabling to equipment enclosures to ensure proper connections.
- B. Coordinate installation of utility-interactive meter with utility.
- C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- D. Make splices, terminations, and taps that are compatible with conductor material[**and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors**].

END OF SECTION 26 31 00 00



Task	Specification	Specification Description
26 31 00 00	26 01 00 00	Supplemental Requirements for Electrical
26 32 13 00	26 32 13 19	Bi-Fuel-Engine-Driven Generator Sets



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SECTION 26 32 13 13 - DIESEL-ENGINE-DRIVEN GENERATOR SETS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Diesel-engine-driven generator sets.
2. Diesel engine.
3. Diesel fuel-oil system.
4. Control and monitoring.
5. Generator overcurrent and fault protection.
6. Generator, exciter, and voltage regulator.
7. Load bank.
8. Outdoor engine generator enclosure.
9. Remote radiator motors.
10. Vibration isolation devices.

B. Related Requirements:

1. Section 262313 "Paralleling Low-Voltage Switchgear" for controls and paralleling equipment for large or multiple parallel engine generators.
2. Section 263343 "Battery Chargers" for remote engine battery chargers.
3. Section 263600 "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine generators.

1.2 DEFINITIONS

- A. EPS: Emergency power supply.
- B. EPSS: Emergency power supply system.
- C. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
2. Include thermal damage curve for generator.
3. Include time-current characteristic curves for generator protective device.
4. Include fuel consumption in **gallons per hour (liters per hour)** at 0.8 power factor at 0.5, 0.75, and 1.0 times generator capacity.
5. Include generator efficiency at 0.8 power factor at 0.5, 0.75, and 1.0 times generator capacity.
6. Include airflow requirements for cooling and combustion air in **cubic feet per minute (cubic meters per minute)** at 0.8 power factor, with air-supply temperature of **95, 80, 70, and 50 deg F (35, 27, 21, and 10 deg C)**. Provide Drawings indicating requirements and limitations for location

of air intake and exhausts.

7. Include generator characteristics, including, but not limited to, kilowatt rating, efficiency, reactances, and short-circuit current capability.

B. Shop Drawings:

1. Include plans and elevations for engine generator and other components specified. Indicate access requirements affected by height of subbase fuel tank.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Identify fluid drain ports and clearance requirements for proper fluid drain.
4. Design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include base weights.
6. Include diagrams for power, signal, and control wiring. Complete schematic, wiring, and interconnection diagrams showing terminal markings for engine generators and functional relationship between all electrical components.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For **[Installer][manufacturer][and][testing agency]**.

B. Seismic Qualification Data: Certificates, for engine generator, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: With engine and generator mounted on rails, identify center of gravity and total weight[, **including full fuel tank**], **[supplied enclosure,][external silencer,][subbase-mounted fuel tank,][skid-mounted load bank,]** and each piece of equipment not integral to the engine generator, and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Source Quality-Control Reports: Including, but not limited to, the following:

1. Certified summary of prototype-unit test report.
2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
3. Certified Summary of Performance Tests: Certify compliance with specified requirement to meet performance criteria for sensitive loads.
4. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
5. Report of sound generation.
6. Report of exhaust emissions showing compliance with applicable regulations.
7. Certified Torsional Vibration Compatibility: Comply with NFPA 110.

D. Field quality-control reports.

E. Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals.
 - 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.
 - b. Operating instructions laminated and mounted adjacent to generator location.
 - c. Training plan.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fuses: One for every 10 of each type and rating, but no fewer than one of each.
 - 2. Indicator Lamps: Two for every six of each type used, but no fewer than two of each.
 - 3. Filters: One set each of lubricating oil, fuel, and combustion-air filters.
 - 4. Tools: Each tool listed by part number in operations and maintenance manual.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.
- B. Testing Agency Qualifications: Accredited by NETA.
 - 1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.8 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: <Insert number> years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 DIESEL-ENGINE-DRIVEN GENERATOR SETS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Caterpillar, Inc.; Electric Power Division]**
 - 2. **[Cummins Power Generation]**
 - 3. **[Generac]**



4. [Hipower Systems]
5. [Kohler Power Systems]
6. [Rolls-Royce Solutions America Inc.]
7. <Insert manufacturer's name>

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

1. [Caterpillar, Inc.; Electric Power Division]
2. [Cummins Power Generation]
3. [Generac]
4. [Hipower Systems]
5. [Kohler Power Systems]
6. [Rolls-Royce Solutions America Inc.]
7. <Insert manufacturer's name>

C. Source Limitations: Obtain packaged engine generators and auxiliary components from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Engine generator housing, [subbase fuel tank,][day tank,] engine generator, batteries, battery racks, silencers, [load banks,] sound attenuating equipment, accessories, and components shall withstand the effects of earthquake motions determined according to [ASCE/SEI 7]<Insert requirement>.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified[and the unit will be fully operational after the seismic event]."
2. Shake-table testing shall comply with ICC-ES AC156. Testing shall be performed with all fluids at worst-case normal levels.[Water shall be substituted for diesel fuel in fuel tank during test.]
3. Component Importance Factor: [1.5][1.0].

B. B11 Compliance: Comply with B11.19.

C. NFPA Compliance:

1. Comply with NFPA 37.
2. Comply with NFPA 70.
3. Comply with NFPA 99.
4. Comply with NFPA 110 requirements for Level [1][2] EPSS.

D. UL Compliance: Comply with UL 2200.

E. Engine Exhaust Emissions: Comply with EPA Tier [2][3][4] requirements and applicable state and local government requirements.

F. Noise Emission: Comply with [applicable state and local government requirements]<Insert Project criteria> for maximum noise level at [adjacent property boundaries]<Insert critical locations> due to sound emitted by engine generator including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

G. Environmental Conditions: Engine generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient Temperature: [41 to 104 deg F (5 to 40 deg C)][5 to 104 deg F (Minus 15 to plus 40 deg C)].
2. Relative Humidity: Zero to 95 percent.
3. Altitude: Sea level to [1000 feet (300 m)]<Insert altitude>.

H. Unusual Service Conditions: Engine generator equipment and installation are required to operate under the following conditions:

1. [High salt-dust content in the air due to sea-spray evaporation]<Insert unusual condition>.

2.3 ENGINE GENERATOR ASSEMBLY DESCRIPTION

- A. Factory-assembled and -tested, water-cooled engine, with brushless generator and accessories.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
- C. Power Rating: [Prime][Industrial][Standby].
- D. Overload Capacity: 110 percent of service load for 1 hour in 12 consecutive hours.
- E. EPSS Class: Engine generator shall be classified as a [Class 2][Class 6][Class 48][Class 96]<Insert classification> according to NFPA 110.
- F. Service Load: <Insert number> kVA.
- G. Power Factor: [0.8]<Insert number>, lagging.
- H. Frequency: 60 Hz.
- I. Voltage: [208][240][480][600][4160]-V ac.
- J. Phase: Three-phase, [three][four] wire, [wye][delta].
- K. Induction Method: [Naturally aspirated][Turbocharged].
- L. Governor: Adjustable isochronous, with speed sensing.
- M. Mounting Frame: Structural steel framework to maintain alignment of mounted components without depending on concrete foundation. Provide lifting attachments sized and spaced to prevent deflection of base during lifting and moving.
 1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and engine generator center of gravity.
- N. Capacities and Characteristics:
 1. Power Output Ratings: Nominal ratings as indicated at 0.8 power factor excluding power required for the continued and repeated operation of the unit and auxiliaries[, with capacity as required to operate as a unit as evidenced by records of prototype testing].
 2. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.
- O. Engine Generator Performance:

1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage from no load to full load.
2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.
3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.
4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
7. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
8. Start Time:
 - a. Comply with NFPA 110, **[Type U][Type 10]** system requirements.
 - b. **[10]<Insert number>** seconds.

P. Engine Generator Performance for Sensitive Loads:

1. Oversizing generator compared with the rated power output of the engine is permissible to meet specified performance.
 - a. Nameplate Data for Oversized Generator: Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.
2. Steady-State Voltage Operational Bandwidth: 1 percent of rated output voltage from no load to full load.
3. Transient Voltage Performance: Not more than 10 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 0.5 second.
4. Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency from no load to full load.
5. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
6. Transient Frequency Performance: Less than 2-Hz variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within three seconds.
7. Output Waveform: At no load, harmonic content measured line to neutral shall not exceed 2 percent total with no slot ripple. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
8. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 300 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or other generator system components.
9. Excitation System: Performance shall be unaffected by voltage distortion caused by nonlinear load.

- a. Provide permanent magnet excitation for power source to voltage regulator.
- 10. Start Time:
 - a. Comply with NFPA 110, [Type U][Type 10] system requirements.
 - b. [10]<Insert number> seconds.

Q. Parallel Engine Generators:

- 1. Automatic reactive output power control and load sharing between engine generators operated in parallel.
- 2. Automatic regulation, automatic connection to a common bus, and automatic synchronization, with manual controls and instruments to monitor and control paralleling functions.
- 3. Protective relays required for equipment and personnel safety.
- 4. Paralleling suppressors to protect excitation systems.
- 5. Reverse power protection.
- 6. Loss of field protection.

2.4 DIESEL ENGINE

A. Fuel: ASTM D975, diesel fuel oil, Grade 2-D S15.

- 1. <Insert specific fuel grade requirements>.

B. Rated Engine Speed: 1800 rpm.

C. Lubrication System: Engine or skid-mounted.

- 1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
- 2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
- 3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

D. Jacket Coolant Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with UL 499[and with NFPA 110 requirements for Level 1 equipment for heater capacity].

E. Integral Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine generator set mounting frame and integral engine-driven coolant pump.

- 1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
- 2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
- 3. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
- 4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
- 5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, UV-, and abrasion-resistant fabric.
 - a. Rating: **50-psig (345-kPa)** maximum working pressure with coolant at **180 deg F (82 deg C)**, and noncollapsible under vacuum.

- b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

- F. Remote Cooling System: Closed loop, liquid cooled, with remote radiator and **[integral engine driven][auxiliary]** coolant pump. Comply with requirements in Section 232113 "Hydronic Piping" for coolant piping.
 - 1. Configuration: **[Vertical][Horizontal]** air discharge.
 - 2. Radiator Core Tubes: **[Aluminum][Nonferrous-metal construction other than aluminum]**.
 - 3. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
 - 4. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
 - 5. Fan: Driven by **[multiple belts from engine shaft][totally enclosed electric motor with sealed bearings]**.
 - 6. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
 - 7. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.

- G. Muffler/Silencer:
 - 1. Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
 - a. Minimum sound attenuation of 25 dB at 500 Hz.
 - b. Sound level measured at a distance of **25 feet (8 m)** from exhaust discharge after installation is complete shall be **[78]<Insert number>** dBA or less.
 - 2. Semicritical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
 - a. Minimum sound attenuation of 18 dB at 500 Hz.
 - b. Sound level measured at a distance of **25 feet (8 m)** from exhaust discharge after installation is complete shall be **[85]<Insert number>** dBA or less.
 - 3. Commercial type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
 - a. Minimum sound attenuation of 12 dB at 500 Hz.
 - b. Sound level measured at a distance of **25 feet (8 m)** from exhaust discharge after installation is complete shall be **[90]<Insert number>** dBA or less.

- H. Air-Intake Filter: **[Standard][Heavy]**-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

- I. Starting System: **[12][24]**-V electric, with negative ground.
 - 1. Components: Sized so they are not damaged during a full engine-cranking cycle with ambient temperature at maximum specified in "Performance Requirements" Article.
 - 2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
 - 3. Cranking Cycle: **[As required by NFPA 110 for system level specified][60 seconds]**.
 - 4. Battery: **[Lead acid][Nickel cadmium]**, with capacity within ambient temperature range specified

- in "Performance Requirements" Article to provide specified cranking cycle at least **[twice][three times]** without recharging.
5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
 6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above **50 deg F (10 deg C)** regardless of external ambient temperature within range specified in "Performance Requirements" Article. Include accessories required to support and fasten batteries in place. Provide ventilation to exhaust battery gases.
 7. Battery Stand: Factory-fabricated, two-tier metal with acid-resistant finish designed to hold the quantity of battery cells required and to maintain the arrangement to minimize lengths of battery interconnections.
 8. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
 9. Battery Charger: Current-limiting, automatic-equalizing, and float-charging type designed for **[lead-acid][nickel-cadmium]** batteries. Unit shall comply with UL 1236 and include the following features:
 - a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
 - b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from **minus 40 to 140 deg F (minus 40 to plus 60 deg C)** to prevent overcharging at high temperatures and undercharging at low temperatures.
 - c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
 - d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
 - e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
 - f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

2.5 DIESEL FUEL-OIL SYSTEM

- A. Comply with NFPA 37.
- B. Piping: Fuel-oil piping shall be Schedule 40 black steel, complying with requirements in Section 231113 "Facility Fuel-Oil Piping." Cast iron, aluminum, copper, and galvanized steel shall not be used in the fuel-oil system.
- C. Main Fuel Pump: Mounted on engine to provide primary fuel flow under starting and load conditions.
- D. Fuel Filtering: Remove water and contaminants larger than 1 micron.
- E. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.
- F. Fuel-Oil Storage Tank: Comply with requirements in **[Section 231313 "Facility Underground Fuel-Oil Storage Tanks."]****[Section 231323 "Facility Aboveground Fuel-Oil Storage Tanks."]**
 1. Fuel Tank Capacity: **[Minimum 133 percent of total fuel required for periodic maintenance operations between fuel refills plus fuel for the hours of continuous operation required for the indicated EPSS Class.]****[As recommended by engine manufacturer for an uninterrupted period of 8 hours' operation at 100 percent of rated power output of engine generator**

system without being refilled]<Insert gallons (liters)>.

2. Duplex Fuel-Oil Transfer Pump: Comply with requirements in Section 231213 "Facility Fuel-Oil Pumps."

G. Day Tank: Comply with UL 142, freestanding, factory-fabricated fuel tank assembly, with integral, float-controlled transfer pump and the following features:

1. Containment: Integral rupture basin with a capacity of 150 percent of nominal capacity of day tank.
 - a. Leak Detector: Locate in rupture basin and connect to provide audible and visual alarm in the event of day-tank leak.
2. Tank Capacity: **[As recommended by engine manufacturer for an uninterrupted period of 4 hours' operation at 100 percent of rated power output of engine generator system without being refilled]<Insert gallons (liters)>.**
3. Pump Capacity: Exceeds maximum flow of fuel drawn by engine-mounted fuel supply pump at 110 percent of rated capacity, including fuel returned from engine.
4. Low-Level Alarm Sensor: Liquid-level device operates alarm contacts at 25 percent of normal fuel level.
5. High-Level Alarm Sensor: Liquid-level device operates alarm and redundant fuel shutoff contacts at midpoint between overflow level and 100 percent of normal fuel level.
6. Piping Connections: Factory-installed fuel supply and return lines from tank to engine; local fuel fill, vent line, overflow line; and tank drain line with shutoff valve.
7. Redundant High-Level Fuel Shutoff: Actuated by high-level alarm sensor in day tank to operate a separate motor-control device that disconnects day-tank pump motor. Sensor shall signal solenoid valve, located in fuel suction line between fuel storage tank and day tank, to close. Both actions shall remain in shutoff state until manually reset. Shutoff action shall initiate an alarm signal to control panel but shall not shut down engine generator.

H. Subbase-Mounted, Double-Wall, Fuel-Oil Tank: Factory installed and piped, complying with UL 142 fuel-oil tank. Features include the following:

1. Tank level indicator.
2. Fuel-Tank Capacity: Minimum 133 percent of total fuel required for planned operation plus fuel for periodic maintenance operations between fuel refills.
3. Leak detection in interstitial space.
4. Vandal-resistant fill cap.
5. Containment Provisions: Comply with requirements of authorities having jurisdiction.

2.6 CONTROL AND MONITORING

- A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of engine generator. When mode-selector switch is switched to the on position, engine generator starts. The off position of same switch initiates engine generator shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.
- B. Manual Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts engine generator. The off position of same switch initiates engine generator shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.

- C. Provide minimum run time control set for **[15][30]<Insert number>** minutes with override only by operation of a remote emergency-stop switch.
- D. Comply with UL 508A.
- E. Configuration:
 - 1. Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the engine generator. Mounting method shall isolate the control panel from engine generator vibration. Panel shall be powered from the engine generator battery.
 - 2. Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common wall-mounted control and monitoring panel. Panel shall be powered from the engine generator battery.
 - 3. Operating and safety indications, protective devices, basic system controls, engine gages, instrument transformers, generator disconnect switch or circuit breaker, and other indicated components shall be grouped in a combination control and power panel. Control and monitoring section of panel shall be isolated from power sections by steel barriers. Panel shall be powered from the engine generator battery. Panel features shall include the following:
 - a. Wall-Mounting Cabinet Construction: Rigid, self-supporting steel unit complying with NEMA ICS 6.
 - b. Switchboard Construction: Freestanding unit complying with Section 262413 "Switchboards." Power bus shall be copper. Bus, bus supports, control wiring, and temperature rise shall comply with UL 891.
 - c. Switchgear Construction: Freestanding unit complying with Section 262300 "Low-Voltage Switchgear."
- F. Control and Monitoring Panel:
 - 1. Digital engine generator controller with integrated LCD display, controls, and microprocessor, capable of local and remote control, monitoring, and programming, with battery backup.
 - 2. Analog control panel with dedicated gages and indicator lights for the instruments and alarms indicated below.
 - 3. Instruments: Located on the control and monitoring panel and viewable during operation.
 - a. Engine lubricating-oil pressure gage.
 - b. Engine-coolant temperature gage.
 - c. DC voltmeter (alternator battery charging).
 - d. Running-time meter.
 - e. AC voltmeter, **[for each phase][connected to a phase selector switch]**.
 - f. AC ammeter, **[for each phase][connected to a phase selector switch]**.
 - g. AC frequency meter.
 - h. Generator-voltage adjusting rheostat.
 - 4. Controls and Protective Devices: Controls, shutdown devices, and common alarm indication, including the following:
 - a. Cranking control equipment.
 - b. Run-Off-Auto switch.
 - c. Control switch not in automatic position alarm.
 - d. Overcrank alarm.
 - e. Overcrank shutdown device.
 - f. Low-water temperature alarm.
 - g. High engine temperature prealarm.
 - h. High engine temperature.

- i. High engine temperature shutdown device.
- j. Overspeed alarm.
- k. Overspeed shutdown device.
- l. Low fuel main tank.

- 1) Low-fuel-level alarm shall be initiated when the level falls below that required for operation for duration required **[for the indicated EPSS class][in "Fuel Tank Capacity" Subparagraph in "Diesel Fuel-Oil System" Article]**.

- m. Coolant low-level alarm.
- n. Coolant low-level shutdown device.
- o. Coolant high-temperature prealarm.
- p. Coolant high-temperature alarm.
- q. Coolant low-temperature alarm.
- r. Coolant high-temperature shutdown device.
- s. EPS load indicator.
- t. Battery high-voltage alarm.
- u. Low cranking voltage alarm.
- v. Battery-charger malfunction alarm.
- w. Battery low-voltage alarm.
- x. Lamp test.
- y. Contacts for local and remote common alarm.
- z. Low-starting air pressure alarm.
- aa. Low-starting hydraulic pressure alarm.
- bb. Remote manual stop shutdown device.
- cc. Air shutdown damper alarm when used.
- dd. Air shutdown damper shutdown device when used.
- ee. Generator overcurrent-protective-device not-closed alarm.
- ff. Hours of operation.
- gg. Engine generator metering, including voltage, current, hertz, kilowatt, kilovolt ampere, and power factor.

- G. Engine Generator Metering: Comply with **[Section 260913 "Electrical Power Monitoring and Control."][Section 262713 "Electricity Metering."][Section 260913 "Electrical Power Monitoring and Control" and Section 262713 "Electricity Metering."]**

- H. Connection to Datalink:

- 1. A separate terminal block, factory wired to Form C dry contacts, for each alarm and status indication.
- 2. Provide connections for datalink transmission of indications to remote data terminals via **[ModBus][LonWorks][Ethernet]<Insert data protocol>**. Data system connections to terminals are covered in Section 260913 "Electrical Power Monitoring and Control."

- I. Common Remote Panel with Common Audible Alarm: Include necessary contacts and terminals in control and monitoring panel. Remote panel shall be powered from the engine generator battery.

- J. Remote Alarm Annunciator: An LED indicator light labeled with proper alarm conditions shall identify each alarm event, and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated.

- 1. Overcrank alarm.
- 2. Low water-temperature alarm.

3. High engine temperature prealarm.
 4. High engine temperature alarm.
 5. Low lube oil pressure alarm.
 6. Overspeed alarm.
 7. Low fuel main tank alarm.
 8. Low coolant level alarm.
 9. Low cranking voltage alarm.
 10. Contacts for local and remote common alarm.
 11. Audible-alarm silencing switch.
 12. Air shutdown damper when used.
 13. Run-Off-Auto switch.
 14. Control switch not in automatic position alarm.
 15. Fuel tank derangement alarm.
 16. Fuel tank high-level shutdown of fuel supply alarm.
 17. Lamp test.
 18. Low-cranking voltage alarm.
 19. Generator overcurrent-protective-device not-closed alarm.
- K. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator unless otherwise indicated.
- L. Remote Emergency-Stop Switch: Flush; wall mounted unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.

2.7 GENERATOR OVERCURRENT AND FAULT PROTECTION

- A. Overcurrent protective devices shall be coordinated to optimize selective tripping when a short circuit occurs.
1. Overcurrent protective devices for the entire EPSS shall be coordinated to optimize selective tripping when a short circuit occurs. Coordination of protective devices shall consider both utility and EPSS as the voltage source.
 2. Overcurrent protective devices for the EPSS shall be accessible only to authorized personnel.
- B. Generator Overcurrent Protective Device:
1. Molded-case circuit breaker, thermal-magnetic type; 100 percent rated; complying with UL 489:
 - a. Tripping Characteristic: Designed specifically for generator protection.
 - b. Trip Rating: Matched to generator output rating.
 - c. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
 - d. Mounting: Adjacent to, or integrated with, control and monitoring panel.
 2. Molded-case circuit breaker, electronic-trip type; 100 percent rated; complying with UL 489:
 - a. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
 - b. Trip Settings: Selected to coordinate with generator thermal damage curve.
 - c. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
 - d. Mounting: Adjacent to, or integrated with, control and monitoring panel.
 3. Insulated-case circuit breaker, electronic-trip type; 100 percent rated; complying with UL 489:



- a. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
- b. Trip Settings: Selected to coordinate with generator thermal damage curve.
- c. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
- d. Mounting: Adjacent to, or integrated with, control and monitoring panel.

4. Molded-case type disconnect switch; 100 percent rated:

- a. Trip Rating: Matched to generator output rating.
- b. Shunt Trip: Connected to trip switch when signaled by generator protector or by other protective devices.

C. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other engine generator protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector performs the following functions:

- 1. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other engine generator malfunction alarms. Contacts shall be available for load shed functions.
- 2. Under single- or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.
- 3. As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the engine generator.
- 4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.

D. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground fault.

- 1. Indicate ground fault with other engine generator alarm indications.
- 2. Trip generator protective device on ground fault.

2.8 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

- A. Comply with NEMA MG 1.
- B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.
- C. Electrical Insulation: **[Class H][or][Class F]**.
- D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required. Provide **[six][12]**-lead alternator.
- E. Range: Provide **[limited][broad][extended]** range of output voltage by adjusting the excitation level.
- F. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.
- G. Enclosure: Drip-proof.

- H. Instrument Transformers: Mounted within generator enclosure.
- I. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified[**and as required by NFPA 110**].
 - 1. Adjusting Rheostat on Control and Monitoring Panel: Provide plus or minus 5 percent adjustment of output-voltage operating band.
 - 2. Maintain voltage within [15][20][30] percent on one step, full load.
 - 3. Provide anti-hunt provision to stabilize voltage.
 - 4. Maintain frequency within [5][10][15] percent and stabilize at rated frequency within [2][5] seconds.
- J. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.
- K. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.
- L. Subtransient Reactance: [12]<Insert number> percent, maximum.

2.9 LOAD BANK

- A. Description:
 - 1. Permanent, outdoor, weatherproof, remote-controlled, forced-air-cooled, [resistive][resistive and reactive] unit capable of providing a balanced three-phase, delta-connected load to engine generator at [100]<Insert number> percent rated-system capacity, at [80]<Insert number> percent power factor, lagging.[**Unit may contain separate resistive and reactive load banks controlled by a common control panel.**] Unit shall be capable of selective control of load in 25 percent steps and with minimum step changes of approximately 5 and 10 percent available.
 - 2. Permanent, radiator-mounted[, resistive] unit capable of providing a balanced three-phase, delta-connected load to engine generator at [50][70]<Insert number> percent rated-system capacity. Unit shall be capable of selective control of load in 25 percent steps of load-bank rating and with minimum step changes of approximately 5 and 10 percent available.
- B. Resistive Load Elements: Corrosion-resistant chromium alloy with ceramic and stainless-steel supports. Elements shall be double insulated and designed for repetitive on-off cycling. Elements shall be mounted in removable aluminized-steel heater cases. Galvanized steel is prohibited. Element's maximum resistance shall be between 100 and 105 percent of rated resistance.
- C. Reactive Load Elements: Epoxy-encapsulated reactor coils.
- D. Load-Bank Heat Dissipation: Integral fan with totally enclosed motor shall provide uniform cooling airflow through load elements. Airflow and coil operating current shall be such that, at maximum load, with ambient temperature at the upper end of specified range, load-bank elements operate at not more than 50 percent of maximum continuous temperature rating of resistance elements.
- E. Load-Element Switching: Remote-controlled contactors switch groups of load elements. Contactor coils are rated 120 V. Contactors shall be located in a separate NEMA 250, Type 3R enclosure within load-bank enclosure, accessible from exterior through hinged doors with tumbler locks.
- F. Contactor Enclosures: Heated by thermostatically controlled strip heaters to prevent condensation.
- G. Load-Bank Enclosures: NEMA 250, Type 3R, aluminized steel complying with NEMA ICS 6. Louvers at cooling-air intake and discharge openings shall prevent entry of rain and snow. Openings for airflow shall be screened with 1/2-inch- (13-mm-) square, galvanized-steel mesh. Reactive load bank shall include automatic shutters at air intake and discharge. Components other than resistive elements shall

receive exterior epoxy coating with compatible primer. Comply with requirements in Section 099600 "High-Performance Coatings."

- H. Protective Devices: Power input circuits to load banks shall be fused, and fuses shall be selected to coordinate with generator circuit breaker. Fuse blocks shall be located in contactor enclosure. Cooling airflow and overtemperature sensors shall automatically shut down and lock out load bank until manually reset. Safety interlocks on access panels and doors shall disconnect load power, control, and heater circuits. Fan motor shall be separately protected by overload and short-circuit devices. Short-circuit devices shall be noninterchangeable fuses with 200,000-A interrupting capacity.
- I. Load-Bank Remote-Control Panel: Separate from load bank in NEMA 250, Type 1 enclosure with a control power switch and pilot light, and switches controlling groups of load elements.
- J. Control Sequence: Control panel may be preset for adjustable single-step loading of generator during automatic exercising.

2.10 OUTDOOR ENGINE GENERATOR ENCLOSURE

- A. Description:
 - 1. Vandal-resistant, sound-attenuating, weatherproof steel housing; wind resistant up to **100 mph (160 km/h)**. Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure.
 - a. Sound Attenuation Level: **<Insert level>**.
 - 2. Prefabricated or pre-engineered, galvanized-steel-clad, integral structural-steel-framed, walk-in enclosure; erected on concrete foundation.
- B. Structural Design and Anchorage: Comply with ASCE/SEI 7 for wind loads up to **100 mph (160 km/h)**.
- C. Seismic Design: Comply with seismic requirements in Section 260548.16 "Seismic Controls for Electrical Systems."
- D. Fire Protection: Provide fire protection according to Section 211000 "Water-Based Fire-Suppression Systems." Provide smoke detector in enclosure; mounted according to NFPA 72.
- E. Hinged Doors: With padlocking provisions.
- F. Space Heater: Thermostatically controlled and sized to prevent condensation.
- G. Lighting: Provide weather-resistant **[fluorescent][LED]** lighting with **[30 fc (330 lx)][50 fc (550 lx)]** average maintained.
- H. Thermal Insulation: Manufacturer's standard materials and thickness selected in coordination with space heater to maintain winter interior temperature within operating limits required by engine generator components.
- I. Muffler Location: **[Within][External to]** enclosure.
- J. Engine-Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for two hours with ambient temperature

at top of range specified in system service conditions.

1. Louvers: Fixed-engine, cooling-air inlet and discharge. Stormproof and drainable louvers prevent entry of rain and snow.
 2. Automatic Dampers: At engine cooling-air inlet and discharge. Dampers shall be closed to reduce enclosure heat loss in cold weather when unit is not operating.
 3. Ventilation: Provide temperature-controlled exhaust fan interlocked to prevent operation when engine is running.
- K. Interior Lights with Switch: Factory-wired, vapor-proof luminaires within housing; arranged to illuminate controls and accessible interior. Arrange for external electrical connection.
1. AC lighting system and connection point for operation when remote source is available.
 2. DC lighting system for operation when remote source and generator are both unavailable.
- L. Convenience Outlets: Factory-wired, GFCI. Arrange for external electrical connection.

2.11 REMOTE RADIATOR MOTORS

- A. Description: NEMA MG 1, Design B, medium-induction, random-wound, squirrel-cage motor.
- B. Efficiency: Energy efficient, as defined in NEMA MG 1.
- C. Service Factor: 1.15.
- D. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
- E. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
- F. Temperature Rise: Match insulation rating.
- G. Code Letter Designation:
 1. Motors [15]<Insert number> HP and Larger: NEMA starting Code F or Code G.
 2. Motors Smaller Than [15]<Insert number> HP: Manufacturer's standard starting characteristic.
- H. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.
- I. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in electrical Sections.

2.12 VIBRATION ISOLATION DEVICES

- A. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.
 1. Material: [Standard neoprene][Natural rubber][Bridge-bearing neoprene, complying with AASHTO M 251] separated by steel shims.
 2. Shore A Scale Durometer Rating: [30][40][45][50][60][65][70]<Insert number>.

3. Number of Layers: **[One][Two][Three][Four]<Insert number>**.
4. Minimum Deflection: **[1 inch (25 mm)]<Insert value>**.

- B. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.
 1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to **1/4-inch- (6-mm-)** thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment-mounting and -leveling bolt that acts as blocking during installation.
 2. Outside Spring Diameter: Not less than 80 percent of compressed height of the spring at rated load.
 3. Minimum Additional Travel: 50 percent of required deflection at rated load.
 4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 6. Minimum Deflection: **[1 inch (25 mm)]<Insert value>**.
- C. Comply with requirements in Section 232116 "Hydronic Piping Specialties" for vibration isolation and flexible connector materials for steel piping.
- D. Comply with requirements in Section 233113 "Metal Ducts" for vibration isolation and flexible connector materials for exhaust shroud and ductwork.
- E. Vibration isolation devices shall not be used to accommodate misalignments or to make bends.

2.13 FINISHES

- A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

2.14 SOURCE QUALITY CONTROL

- A. Prototype Testing: Factory test engine generator using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.
 1. Tests: Comply with IEEE 115[**and with NFPA 110, Level 1 Energy Converters**].
- B. Project-Specific Equipment Tests: Before shipment, factory test engine generator and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:
 1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.
 2. Test generator, exciter, and voltage regulator as a unit.
 3. Full load run.
 4. Maximum power.
 5. Voltage regulation.
 6. Transient and steady-state governing.
 7. Single-step load pickup.
 8. Safety shutdown.
 9. Provide 14 days' advance notice of tests and opportunity for observation of tests by Owner's representative.
 10. Report factory test results within 10 days of completion of test.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine generator performance.
- B. Examine roughing-in for piping systems and electrical connections. Verify actual locations of connections before packaged engine generator installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

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

3.3 INSTALLATION

- A. Comply with NECA 1 and NECA 404.
- B. Comply with packaged engine generator manufacturers' written installation and alignment instructions **and with NFPA 110**.
- C. Equipment Mounting:
 - 1. Install packaged engine generators on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 2. Coordinate size and location of concrete bases for packaged engine generators **and remote radiators mounted on grade**. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
 - 3. Install **[packaged engine generator][engine generator in a walk-in enclosure]** with **[elastomeric isolator pads][restrained spring isolators]** having a minimum deflection of **[1 inch (25 mm)]<Insert static deflection>** on **4-inch- (100-mm-)** high concrete base. Secure **[sets][enclosure]** to anchor bolts installed in concrete bases. Concrete base construction is specified in Section 260548.16 "Seismic Controls for Electrical Systems."
 - 4. Remote Radiators:
 - a. Install remote radiator with **[elastomeric isolator pads][restrained spring isolators]** on **[concrete base on grade][roof equipment supports on roof]**.
 - b. Coordinate size and location of roof curbs, equipment supports, and roof penetrations for remote radiators. These items are specified in Section 077200 "Roof Accessories."
- D. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

- E. Cooling System: Install Schedule 40 black steel piping with welded joints for cooling water piping between engine generator and **[heat exchanger][remote radiator]**. Piping materials and installation requirements are specified in Section 232113 "Hydronic Piping."
 - 1. Install isolating thimbles where exhaust piping penetrates combustible surfaces. Provide a minimum of **9 inches (225 mm)** of clearance from combustibles.
 - 2. Insulate cooling-system piping and components according to requirements in Section 230719 "HVAC Piping Insulation."
- F. Exhaust System: Install Schedule 40 black steel piping with welded joints and connect to engine muffler. Install thimble at wall. Piping shall be same diameter as muffler outlet.
 - 1. Piping materials and installation requirements are specified in Section 232113 "Hydronic Piping."
 - 2. Install flexible connectors and steel piping materials according to requirements in Section 232116 "Hydronic Piping Specialties."
 - 3. Insulate muffler/silencer and exhaust system components according to requirements in Section 230719 "HVAC Piping Insulation."
 - 4. Install isolating thimbles where exhaust piping penetrates combustible surfaces with a minimum of **9 inches (225 mm)** of clearance from combustibles.
- G. Drain Piping: Install condensate drain piping to muffler drain outlet full size of drain connection with a shutoff valve, stainless-steel flexible connector, and Schedule 40 black steel pipe with welded joints.
 - 1. Piping materials and installation requirements are specified in Section 232113 "Hydronic Piping."
 - 2. Drain piping valves, connectors, and installation requirements are specified in Section 232116 "Hydronic Piping Specialties."
- H. Fuel Piping:
 - 1. Diesel storage tanks, tank accessories, piping, valves, and specialties for fuel systems are specified in Section 231113 "Facility Fuel-Oil Piping."
 - 2. Copper and galvanized steel shall not be used in the fuel-oil piping system.
- I. Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.4 CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping and specialties.
- B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow space for service and maintenance.
- C. Connect cooling-system water piping to engine generator and **[remote radiator][heat exchanger]** with flexible connectors.
- D. Connect engine exhaust pipe to engine with flexible connector.
- E. Connect fuel piping to engines with a gate valve and union and flexible connector.
- F. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- G. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

Provide a minimum of one 90-degree bend in flexible conduit routed to the engine generator from a stationary element.

- H. Balance single-phase loads to obtain a maximum of 10 percent unbalance between any two phases.

3.5 IDENTIFICATION

- A. Identify system components according to Section 230553 "Identification for HVAC Piping and Equipment" and Section 260553 "Identification for Electrical Systems."
- B. Install a sign indicating the generator neutral is bonded to the main service neutral at the main service location.

3.6 FIELD QUALITY CONTROL

- A. Testing Agency:
 - 1. Owner will engage a qualified testing agency to perform tests and inspections.
 - 2. Engage a qualified testing agency to perform tests and inspections.
 - 3. Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
 - 4. Perform tests and inspections[**with the assistance of a factory-authorized service representative**].
- B. Tests and Inspections:
 - 1. Perform tests recommended by manufacturer and each visual and mechanical inspection and electrical and mechanical test listed in first two subparagraphs below, as specified in NETA ATS. Certify compliance with test parameters.
 - a. Visual and Mechanical Inspection:
 - 1) Compare equipment nameplate data with Drawings and the Specifications.
 - 2) Inspect physical and mechanical condition.
 - 3) Inspect anchorage, alignment, and grounding.
 - 4) Verify that the unit is clean.
 - b. Electrical and Mechanical Tests:
 - 1) Perform insulation-resistance tests according to IEEE 43.
 - a) Machines Larger Than **200 hp (150 kW)**: Test duration shall be 10 minutes. Calculate polarization index.
 - b) Machines **200 hp (150 kW)** or Less: Test duration shall be one minute. Calculate the dielectric-absorption ratio.
 - 2) Test protective relay devices.
 - 3) Verify phase rotation, phasing, and synchronized operation as required by the application.
 - 4) Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.
 - 5) Perform vibration test for each main bearing cap.
 - 6) Verify correct functioning of the governor and regulator.



2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here, including, but not limited to, single-step full-load pickup test.
 3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
 - a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
 - b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
 - c. Verify acceptance of charge for each element of the battery after discharge.
 - d. Verify that measurements are within manufacturer's specifications.
 4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
 5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine generator system before and during system operation. Check for air, exhaust, and fluid leaks.
 6. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding **40-inch wg (120 kPa)**. Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.
 7. Exhaust Emissions Test: Comply with applicable government test criteria.
 8. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
 9. Harmonic-Content Tests: Measure harmonic content of output voltage at 25 and 100 percent of rated linear load. Verify that harmonic content is within specified limits.
 10. Noise Level Tests: Measure A-weighted level of noise emanating from engine generator installation, including engine exhaust and cooling-air intake and discharge, at **[four]<Insert number> locations [25 feet (8 m) from edge of the generator enclosure][on the property line]<Insert location for measurement>**, and compare measured levels with required values.
- C. Coordinate tests with tests for transfer switches and run them concurrently.
- D. Test instruments shall have been calibrated within the past 12 months, traceable to NIST Calibration Services, and adequate for making positive observation of test results. Make calibration records available for examination on request.
- E. Leak Test: After installation, charge exhaust, coolant, and fuel systems and test for leaks. Repair leaks and retest until no leaks exist.
- F. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated equipment.
- G. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- H. Remove and replace malfunctioning units and **[retest][reinspect]** as specified above.
- I. Retest: Correct deficiencies identified by tests and observations, and retest until specified requirements are met.
- J. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

- K. Infrared Scanning: After Substantial Completion, but not more than 60 days after final acceptance, perform an infrared scan of each power wiring termination and each bus connection while running with maximum load. Remove all access panels so terminations and connections are accessible to portable scanner.
1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan 11 months after date of Substantial Completion.
 2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 3. Record of Infrared Scanning: Prepare a certified report that identifies terminations and connections checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.7 MAINTENANCE SERVICE

- A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include [12]<Insert number> months' full maintenance by skilled employees of manufacturer's authorized service representative. Include quarterly preventive maintenance and exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Parts shall be manufacturer's authorized replacement parts and supplies.

3.8 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators.

END OF SECTION 26 32 13 13



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Task	Specification	Specification Description
26 32 13 13	26 32 13 19	Bi-Fuel-Engine-Driven Generator Sets



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SECTION 26 32 13 19 - BI-FUEL-ENGINE-DRIVEN GENERATOR SETS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bi-fuel-engine-driven generator sets.
2. Bi-fuel engine.
3. Diesel fuel-oil system.
4. Gas fuel system.
5. Control and monitoring.
6. Generator overcurrent and fault protection.
7. Generator, exciter, and voltage regulator.
8. Load bank.
9. Outdoor engine generator enclosure.
10. Remote radiator motors.
11. Vibration isolation devices.

B. Related Requirements:

1. Section 262313 "Paralleling Low-Voltage Switchgear" for controls and paralleling equipment for large or multiple parallel engine generators.
2. Section 263343 "Battery Chargers" for remote engine battery chargers.
3. Section 263600 "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine generators.

1.2 DEFINITIONS

- A. Bi-Fuel: An engine generator that starts using diesel fuel, and upon assumption of the electrical load, transitions to a diesel fuel and natural gas mix.
- B. EPS: Emergency power supply.
- C. EPSS: Emergency power supply system.
- D. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
2. Include thermal damage curve for generator.
3. Include time-current characteristic curves for generator protective device.
4. Include fuel consumption in **[gallons per hour (liters per hour)][and][cubic feet per hour (cubic meters per hour)]** at 0.8 power factor at 0.5, 0.75, and 1.0 times generator capacity.

- a. Include fuel consumption at power factor and loads above at 3:1, 2:1, and 1:1 natural gas to diesel ratio.
5. Include generator efficiency at 0.8 power factor at 0.5, 0.75, and 1.0 times generator capacity.
6. Include airflow requirements for cooling and combustion air in **cubic feet per minute (cubic meters per minute)** at 0.8 power factor, with air-supply temperature of **95, 80, 70, and 50 deg F (35, 27, 21, and 10 deg C)**. Provide Drawings indicating requirements and limitations for location of air intake and exhausts.
7. Include generator characteristics, including, but not limited to, kilowatt rating, efficiency, reactances, and short-circuit current capability.

B. Shop Drawings:

1. Include plans and elevations for engine generator and other components specified. Indicate access requirements affected by height of subbase fuel tank.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Identify fluid drain ports and clearance requirements for proper fluid drain.
4. Design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include base weights.
6. Include diagrams for power, signal, and control wiring. Complete schematic, wiring, and interconnection diagrams showing terminal markings for EPS equipment and functional relationship between all electrical components.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For **[Installer][manufacturer][and][testing agency]**.
- B. Seismic Qualification Data: Certificates, for engine generator, accessories, and components, from manufacturer.
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: With engine and generator mounted on rails, identify center of gravity and total weight **[including full fuel tank], [supplied enclosure],[external silencer],[subbase-mounted fuel tank],[skid-mounted load bank,]** and each piece of equipment not integral to the engine generator, and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Source Quality-Control Reports: Including, but not limited to, the following:
 1. Certified summary of prototype-unit test report.
 2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
 3. Certified Summary of Performance Tests: Certify compliance with specified requirement to meet performance criteria for sensitive loads.
 4. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
 5. Report of sound generation.

6. Report of exhaust emissions showing compliance with applicable regulations.
7. Certified Torsional Vibration Compatibility: Comply with NFPA 110.

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

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals.
 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.
 - b. Operating instructions laminated and mounted adjacent to generator location.
 - c. Training plan.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Fuses: One for every 10 of each type and rating, but no fewer than one of each.
 2. Indicator Lamps: Two for every six of each type used, but no fewer than two of each.
 3. Filters: One set each of lubricating oil, fuel, and combustion-air filters.
 4. Tools: Each tool listed by part number in operations and maintenance manual.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.
- B. Testing Agency Qualifications: Accredited by NETA.
 1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.8 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.
 1. Warranty Period: <Insert number> years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 BI-FUEL-ENGINE-DRIVEN GENERATOR SETS

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

1. **[Caterpillar, Inc.; Electric Power Division]**
2. **[Cummins Power Generation]**
3. **[Generac]**
4. **[Rolls-Royce Solutions America Inc.]**
5. **<Insert manufacturer's name>**

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

1. **[Caterpillar, Inc.; Electric Power Division]**
2. **[Cummins Power Generation]**
3. **[Generac]**
4. **[Rolls-Royce Solutions America Inc.]**
5. **<Insert manufacturer's name>**

- C. Source Limitations: Obtain packaged engine generators and auxiliary components from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Engine generator housing, **[subbase fuel tank,][day tank,]** engine generator, batteries, battery racks, silencers, **[load banks,]**and sound-attenuating equipment, accessories, and components shall withstand the effects of earthquake motions determined according to **[ASCE/SEI 7]<Insert requirement>**.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified **[and the unit will be fully operational after the seismic event].**"
2. Shake-table testing shall comply with ICC-ES AC156. Testing shall be performed with all fluids at worst case normal levels. **[Water shall be substituted for diesel fuel in fuel tank during test.]**
3. Component Importance Factor: **[1.5][1.0]**.

- B. B11 Compliance: Comply with B11.19.

- C. NFPA Compliance:

1. Comply with NFPA 37.
2. Comply with NFPA 70.
3. Comply with NFPA 99.
4. Comply with NFPA 110 requirements for Level **[1][2]** EPSS.

- D. UL Compliance: Comply with UL 2200.

- E. Engine Exhaust Emissions: Comply with EPA Tier **[2][3][4]** requirements and applicable state and local

government requirements.

- F. Noise Emission: Comply with **[applicable state and local government requirements]<Insert Project criteria>** for maximum noise level at **[adjacent property boundaries]<Insert critical locations>** due to sound emitted by engine generator including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.
- G. Environmental Conditions: Engine generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
 - 1. Ambient Temperature: **[41 to 104 deg F (5 to 40 deg C)][5 to 104 deg F (Minus 15 to plus 40 deg C)]**.
 - 2. Relative Humidity: Zero to 95 percent.
 - 3. Altitude: Sea level to **[1000 feet (300 m)]<Insert altitude>**.
- H. Unusual Service Conditions: Engine generator equipment and installation are required to operate under the following conditions:
 - 1. **[High salt-dust content in the air due to sea-spray evaporation]<Insert unusual condition>**.

2.3 ENGINE GENERATOR ASSEMBLY DESCRIPTION

- A. Factory-assembled and -tested, water-cooled engine, with brushless generator and accessories.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended location and use.
- C. Power Rating: **[Prime][Industrial][Standby]**.
- D. Overload Capacity: 110 percent of service load for 1 hour in 12 consecutive hours.
- E. EPSS Class: Engine generator shall be classified as a **[Class 2][Class 6][Class 48][Class 96]<Insert classification>** according to NFPA 110.
- F. Service Load: **<Insert number>** kVA.
- G. Power Factor: **[0.8]<Insert number>**, lagging.
- H. Frequency: 60 Hz.
- I. Voltage: **[208][240][480][600][4160]-V ac**.
- J. Phase: Three-phase, **[three][four]-wire, [wye][delta]**.
- K. Induction Method: **[Naturally aspirated][Turbocharged]**.
- L. Governor: Adjustable isochronous, with speed sensing.
- M. Mounting Frame: Structural steel framework to maintain alignment of mounted components without depending on concrete foundation. Provide lifting attachments sized and spaced to prevent deflection of base during lifting and moving.
 - 1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and engine generator center of gravity.

N. Capacities and Characteristics:

1. Power Output Ratings: Nominal ratings as indicated at 0.8 power factor excluding power required for the continued and repeated operation of the unit and auxiliaries[, **with capacity as required to operate as a unit as evidenced by records of prototype testing**].
2. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.

O. Engine Generator Performance:

1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage from no load to full load.
2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.
3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.
4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
7. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
8. Start Time:
 - a. Comply with NFPA 110, **[Type U][Type 10]** system requirements.
 - b. **[10]<Insert number>** seconds.

P. Engine Generator Performance for Sensitive Loads:

1. Oversizing generator compared with the rated power output of the engine is permissible to meet specified performance.
 - a. Nameplate Data for Oversized Generator: Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.
2. Steady-State Voltage Operational Bandwidth: 1 percent of rated output voltage from no load to full load.
3. Transient Voltage Performance: Not more than 10 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 0.5 second.
4. Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency from no load to full load.
5. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
6. Transient Frequency Performance: Less than 2-Hz variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within three

- seconds.
7. Output Waveform: At no load, harmonic content measured line to neutral shall not exceed 2 percent total with no slot ripple. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
 8. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 300 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or other generator system components.
 9. Excitation System: Performance shall be unaffected by voltage distortion caused by nonlinear load.
 - a. Provide permanent magnet excitation for power source to voltage regulator.
 10. Start Time:
 - a. Comply with NFPA 110, **[Type U][Type 10]** system requirements.
 - b. **[10]<Insert number>** seconds.

Q. Parallel Engine Generators:

1. Automatic reactive output power control and load sharing between engine generators operated in parallel.
2. Automatic regulation, automatic connection to a common bus, and automatic synchronization, with manual controls and instruments to monitor and control paralleling functions.
3. Protective relays required for equipment and personnel safety.
4. Paralleling suppressors to protect excitation systems.
5. Reverse power protection.
6. Loss of field protection.

2.4 BI-FUEL ENGINE

- A. Fuel: ASTM D975, diesel fuel oil, Grade 2-D S15 and natural gas.
 1. **<Insert specific fuel grade requirements>**.
- B. Rated Engine Speed: 1800 rpm.
- C. Lubrication System: Engine or skidmounted.
 1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
 2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
 3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.
- D. Jacket Coolant Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with UL 499[**and with NFPA 110 requirements for Level 1 equipment for heater capacity**].
- E. Integral Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine generator mounting frame and integral engine-driven coolant pump.
 1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
 2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110



- percent load condition.
3. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
 4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
 5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, UV-, and abrasion-resistant fabric.
 - a. Rating: **50-psig (345-kPa)** maximum working pressure with coolant at **180 deg F (82 deg C)**, and noncollapsible under vacuum.
 - b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.
- F. Remote Cooling System: Closed loop, liquid cooled, with remote radiator and **[integral engine-driven][auxiliary]** coolant pump. Comply with requirements in Section 232113 "Hydronic Piping" for coolant piping.
1. Configuration: **[Vertical][Horizontal]** air discharge.
 2. Radiator Core Tubes: **[Aluminum][Nonferrous-metal construction other than aluminum]**.
 3. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
 4. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
 5. Fan: Driven by **[multiple belts from engine shaft][totally enclosed electric motor with sealed bearings]**.
 6. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
 7. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
- G. Muffler/Silencer:
1. Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
 - a. Minimum sound attenuation of 25 dB at 500 Hz.
 - b. Sound level measured at a distance of **25 feet (8 m)** from exhaust discharge after installation is complete shall be **[78]<Insert number>** dBA or less.
 2. Semicritical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
 - a. Minimum sound attenuation of 18 dB at 500 Hz.
 - b. Sound level measured at a distance of **25 feet (8 m)** from exhaust discharge after installation is complete shall be **[85]<Insert number>** dBA or less.
 3. Commercial type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
 - a. Minimum sound attenuation of 12 dB at 500 Hz.
 - b. Sound level measured at a distance of **25 feet (8 m)** from exhaust discharge after installation is complete shall be **[90]<Insert number>** dBA or less.

- H. Air-Intake Filter: **[Standard][Heavy]**-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.
- I. Starting System: **[12][24]**-V electric, with negative ground.
 - 1. Components: Sized so they are not damaged during a full engine-cranking cycle with ambient temperature at maximum specified in "Performance Requirements" Article.
 - 2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
 - 3. Cranking Cycle: **[As required by NFPA 110 for system level specified][60 seconds]**.
 - 4. Battery: **[Lead acid][Nickel cadmium]**, with capacity within ambient temperature range specified in "Performance Requirements" Article to provide specified cranking cycle at least **[twice][three times]** without recharging.
 - 5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
 - 6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above **50 deg F (10 deg C)** regardless of external ambient temperature within range specified in "Performance Requirements" Article. Include accessories required to support and fasten batteries in place. Provide ventilation to exhaust battery gases.
 - 7. Battery Stand: Factory-fabricated, two-tier metal with acid-resistant finish designed to hold the quantity of battery cells required and to maintain the arrangement to minimize lengths of battery interconnections.
 - 8. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
 - 9. Battery Charger: Current-limiting, automatic-equalizing and float-charging type designed for **[lead-acid][nickel-cadmium]** batteries. Unit shall comply with UL 1236 and include the following features:
 - a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
 - b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from **minus 40 to 140 deg F (minus 40 to plus 60 deg C)** to prevent overcharging at high temperatures and undercharging at low temperatures.
 - c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
 - d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
 - e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
 - f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

2.5 DIESEL FUEL-OIL SYSTEM

- A. Comply with NFPA 37.
- B. Piping: Fuel-oil piping shall be Schedule 40 black steel complying with requirements in Section 231113 "Facility Fuel-Oil Piping." Cast iron, aluminum, copper, and galvanized steel shall not be used in the fuel-oil system.
- C. Main Fuel Pump: Mounted on engine to provide primary fuel flow under starting and load conditions.



- D. Fuel Filtering: Remove water and contaminants larger than 1 micron.
- E. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.
- F. Fuel-Oil Storage Tank: Comply with requirements in **[Section 231313 "Facility Underground Fuel-Oil Storage Tanks."][Section 231323 "Facility Aboveground Fuel-Oil Storage Tanks."]**
 - 1. Fuel Tank Capacity: **[Minimum 133 percent of total fuel required for periodic maintenance operations between fuel refills plus fuel for the hours of continuous operation required for the indicated EPSS Class.][As recommended by engine manufacturer for an uninterrupted period of 8 hours' operation at 100 percent of rated power output of engine generator system without being refilled]<Insert gallons (liters)>.**
 - 2. Duplex Fuel-Oil Transfer Pump: Comply with requirements in Section 231213 "Facility Fuel-Oil Pumps."
- G. Day Tank: Comply with UL 142, freestanding, factory-fabricated fuel tank assembly, with integral, float-controlled transfer pump and the following features:
 - 1. Containment: Integral rupture basin with a capacity of 150 percent of nominal capacity of day tank.
 - a. Leak Detector: Locate in rupture basin and connect to provide audible and visual alarm in the event of day-tank leak.
 - 2. Tank Capacity: **[As recommended by engine manufacturer for an uninterrupted period of 4 hours' operation at 100 percent of rated power output of engine generator system without being refilled]<Insert gallons (liters)>.**
 - 3. Pump Capacity: Exceeds maximum flow of fuel drawn by engine-mounted fuel supply pump at 110 percent of rated capacity, including fuel returned from engine.
 - 4. Low-Level Alarm Sensor: Liquid-level device operates alarm contacts at 25 percent of normal fuel level.
 - 5. High-Level Alarm Sensor: Liquid-level device operates alarm and redundant fuel shutoff contacts at midpoint between overflow level and 100 percent of normal fuel level.
 - 6. Piping Connections: Factory-installed fuel supply and return lines from tank to engine; local fuel fill, vent line, overflow line; and tank drain line with shutoff valve.
 - 7. Redundant High-Level Fuel Shutoff: Actuated by high-level alarm sensor in day tank to operate a separate motor-control device that disconnects day-tank pump motor. Sensor shall signal solenoid valve, located in fuel suction line between fuel storage tank and day tank, to close. Both actions shall remain in shutoff state until manually reset. Shutoff action shall initiate an alarm signal to control panel but shall not shut down engine generator.
- H. Subbase-Mounted, Double-Wall, Fuel-Oil Tank: Factory installed and piped, complying with UL 142 fuel-oil tank. Features include the following:
 - 1. Tank level indicator.
 - 2. Fuel-Tank Capacity: Minimum 133 percent of total fuel required for periodic maintenance operations between fuel refills, plus fuel for the hours of continuous operation for indicated EPSS class.
 - 3. Leak detection in interstitial space.
 - 4. Vandal-resistant fill cap.
 - 5. Containment Provisions: Comply with requirements of authorities having jurisdiction.

2.6 GAS FUEL SYSTEM

- A. Natural Gas Piping: Comply with requirements in Section 231123 "Facility Natural Gas Piping."
- B. Gas Train: Comply with NFPA 37.
- C. Engine Fuel System:
 - 1. Natural Gas, Vapor-Withdrawal System:
 - a. Carburetor.
 - b. Secondary Gas Regulators: One for each fuel type, with atmospheric vents piped to building exterior.
 - c. Fuel-Shutoff Solenoid Valves: NRTL-listed, normally closed, safety shutoff valves; one for each fuel source.
 - d. Fuel Filters: One for each fuel type.
 - e. Manual Fuel Shutoff Valves: One for each fuel type.
 - f. Flexible Fuel Connectors: Minimum one for each fuel connection.

2.7 CONTROL AND MONITORING

- A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of engine generator. When mode-selector switch is switched to the on position, engine generator starts. The off position of same switch initiates engine generator shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.
- B. Manual Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts engine generator. The off position of same switch initiates engine generator shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.
- C. Provide minimum run-time control set for **[15][30]<Insert number>** minutes with override only by operating a remote emergency-stop switch.
- D. Comply with UL 508A.
- E. Configuration:
 - 1. Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the engine generator. Mounting method shall isolate the control panel from engine generator vibration. Panel shall be powered from the engine generator battery.
 - 2. Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common wall-mounted control and monitoring panel. Panel shall be powered from the engine generator battery.
 - 3. Operating and safety indications, protective devices, basic system controls, engine gages, instrument transformers, generator disconnect switch or circuit breaker, and other indicated components shall be grouped in a combination control and power panel. Control and monitoring section of panel shall be isolated from power sections by steel barriers. Panel shall be powered from the engine generator battery. Panel features shall include the following:
 - a. Wall-Mounting Cabinet Construction: Rigid, self-supporting steel unit complying with NEMA ICS 6.



- b. Switchboard Construction: Freestanding unit complying with Section 262413 "Switchboards." Power bus shall be copper. Bus, bus supports, control wiring, and temperature rise shall comply with UL 891.
- c. Switchgear Construction: Freestanding unit complying with Section 262300 "Low-Voltage Switchgear."

F. Control and Monitoring Panel:

1. Digital controller with integrated LCD display, controls, and microprocessor, capable of local and remote control, monitoring, and programming, with battery backup.
2. Analog control panel with dedicated gages and indicator lights for the instruments and alarms indicated below.
3. Instruments: Located on the control and monitoring panel and viewable during operation.
 - a. Engine lubricating-oil pressure gage.
 - b. Engine-coolant temperature gage.
 - c. DC voltmeter (alternator battery charging).
 - d. Running-time meter.
 - e. AC voltmeter, **[for each phase][connected to a phase selector switch]**.
 - f. AC ammeter, **[for each phase][connected to a phase selector switch]**.
 - g. AC frequency meter.
 - h. Generator-voltage adjusting rheostat.
4. Controls and Protective Devices: Controls, shutdown devices and common visual alarm indication including the following:
 - a. Cranking control equipment.
 - b. Run-Off-Auto switch.
 - c. Control switch not in automatic position alarm.
 - d. Overcrank alarm.
 - e. Overcrank shutdown device.
 - f. Low water temperature alarm.
 - g. High engine temperature pre-alarm.
 - h. High engine temperature.
 - i. High engine temperature shutdown device.
 - j. Overspeed alarm.
 - k. Overspeed shutdown device.
 - l. Low fuel main tank.
 - 1) Low-fuel-level alarm shall be initiated when the level falls below that required for operation for duration required **[for the indicated EPSS class][in "Fuel Tank Capacity" Subparagraph in "Diesel Fuel-Oil System" Article]**.
 - m. Coolant low-level alarm.
 - n. Coolant low-level shutdown device.
 - o. Coolant high-temperature prealarm.
 - p. Coolant high-temperature alarm.
 - q. Coolant low-temperature alarm.
 - r. Coolant high-temperature shutdown device.
 - s. EPS supplying load indicator.
 - t. Battery high-voltage alarm.
 - u. Low cranking voltage alarm.
 - v. Battery-charger malfunction alarm.
 - w. Battery low-voltage alarm.
 - x. Lamp test.

- y. Contacts for local and remote common alarm.
 - z. Low-starting air pressure alarm.
 - aa. Low-starting hydraulic pressure alarm.
 - bb. Remote manual stop shutdown device.
 - cc. Air shutdown damper alarm when used.
 - dd. Air shutdown damper shutdown device when used.
 - ee. Generator overcurrent-protective-device not-closed alarm.
 - ff. Hours of operation.
 - gg. Engine generator metering, including voltage, current, hertz, kilowatt, kilovolt ampere, and power factor.
- G. Engine Generator Metering: Comply with **[Section 260913 "Electrical Power Monitoring and Control."][Section 262713 "Electricity Metering."][Section 260913 "Electrical Power Monitoring and Control" and Section 262713 "Electricity Metering."]**
- H. Connection to Datalink:
1. A separate terminal block, factory wired to Form C dry contacts, for each alarm and status indication.
 2. Provide connections for datalink transmission of indications to remote data terminals via **[ModBus][LonWorks][Ethernet]<Insert data protocol>**. Data system connections to terminals are covered in Section 260913 "Electrical Power Monitoring and Control."
- I. Common Remote Panel with Common Audible Alarm: Include necessary contacts and terminals in control and monitoring panel. Remote panel shall be powered from the engine generator battery.
- J. Remote Alarm Annunciator: An LED indicator light labeled with proper alarm conditions shall identify each alarm event, and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated.
1. Overcrank alarm.
 2. Coolant low-temperature alarm.
 3. High engine temperature pre-alarm.
 4. High engine temperature alarm.
 5. Low lube oil pressure alarm.
 6. Overspeed alarm.
 7. Low fuel main tank alarm.
 8. Low coolant level alarm.
 9. Low cranking voltage alarm.
 10. Contacts for local and remote common alarm.
 11. Audible-alarm silencing switch.
 12. Air shutdown damper when used.
 13. Run-Off-Auto switch.
 14. Control switch not in automatic position alarm.
 15. Fuel tank derangement alarm.
 16. Fuel tank high-level shutdown of fuel supply alarm.
 17. Lamp test.
 18. Low cranking voltage alarm.
 19. Generator overcurrent-protective-device not-closed alarm.
- K. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.

- L. Remote Emergency-Stop Switch: Flush; wall mounted unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.

2.8 GENERATOR OVERCURRENT AND FAULT PROTECTION

- A. Overcurrent protective devices shall be coordinated to optimize selective tripping when a short circuit occurs.
 - 1. Overcurrent protective devices for the entire EPSS shall be coordinated to optimize selective tripping when a short circuit occurs. Coordination of protective devices shall consider both utility and EPSS as the voltage source.
 - 2. Overcurrent protective devices for the EPSS shall be accessible only to authorized personnel.
- B. Generator Overcurrent Protective Device:
 - 1. Molded-case circuit breaker, thermal-magnetic type; 100 percent rated; complying with UL 489:
 - a. Tripping Characteristic: Designed specifically for generator protection.
 - b. Trip Rating: Matched to generator output rating.
 - c. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
 - d. Mounting: Adjacent to, or integrated with, control and monitoring panel.
 - 2. Molded-case circuit breaker, electronic-trip type; 100 percent rated; complying with UL 489:
 - a. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
 - b. Trip Settings: Selected to coordinate with generator thermal damage curve.
 - c. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
 - d. Mounting: Adjacent to or integrated with control and monitoring panel.
 - 3. Insulated-case circuit breaker, electronic-trip type; 100 percent rated; complying with UL 489:
 - a. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
 - b. Trip Settings: Selected to coordinate with generator thermal damage curve.
 - c. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
 - d. Mounting: Adjacent to, or integrated with, control and monitoring panel.
 - 4. Molded-case type disconnect switch; 100 percent rated:
 - a. Trip Rating: Matched to generator output rating.
 - b. Shunt Trip: Connected to trip switch when signaled by generator protector or by other protective devices.
- C. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other engine generator protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector performs the following functions:
 - 1. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other engine generator malfunction alarms. Contacts shall be available for load shed functions.

2. Under single- or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.
 3. As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the engine generator.
 4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.
- D. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground fault.
1. Indicate ground fault with other engine generator alarm indications.
 2. Trip generator protective device on ground fault.

2.9 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

- A. Comply with NEMA MG 1.
- B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.
- C. Electrical Insulation: **[Class H][or][Class F]**.
- D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required. Provide **[six][12]**-lead alternator.
- E. Range: Provide **[limited][broad][extended]** range of output voltage by adjusting the excitation level.
- F. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.
- G. Enclosure: Dripproof.
- H. Instrument Transformers: Mounted within generator enclosure.
- I. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified **[and as required by NFPA 110]**.
1. Adjusting Rheostat on Control and Monitoring Panel: Provide plus or minus 5 percent adjustment of output-voltage operating band.
 2. Maintain voltage within **[15][20][30]** percent on one step, full load.
 3. Provide anti-hunt provision to stabilize voltage.
 4. Maintain frequency within **[5][10][15]** percent and stabilize at rated frequency within **[2][5]** seconds.
- J. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.
- K. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.
- L. Subtransient Reactance: **[12]<Insert number>** percent, maximum.

2.10 LOAD BANK

- A. Description:

1. Permanent, outdoor, weatherproof, remote-controlled, forced-air-cooled, [**resistive**][**resistive and reactive**] unit capable of providing a balanced three-phase, delta-connected load to engine generator at [100]<Insert number> percent rated-system capacity, at [80]<Insert number> percent power factor, lagging. [**Unit may contain separate resistive and reactive load banks controlled by a common control panel.**] Unit shall be capable of selective control of load in 25 percent steps and with minimum step changes of approximately 5 and 10 percent available.
 2. Permanent, radiator-mounted[, **resistive**] unit capable of providing a balanced three-phase, delta-connected load to engine generator at [50][70]<Insert number> percent rated-system capacity. Unit shall be capable of selective control of load in 25 percent steps of load-bank rating and with minimum step changes of approximately 5 and 10 percent available.
- B. Resistive Load Elements: Corrosion-resistant chromium alloy with ceramic and stainless-steel supports. Elements shall be double insulated and designed for repetitive on-off cycling. Elements shall be mounted in removable aluminized-steel heater cases. Galvanized steel is prohibited. Element's maximum resistance shall be between 100 and 105 percent of rated resistance.
 - C. Reactive Load Elements: Epoxy-encapsulated reactor coils.
 - D. Load-Bank Heat Dissipation: Integral fan with totally enclosed motor shall provide uniform cooling airflow through load elements. Airflow and coil operating current shall be such that, at maximum load, with ambient temperature at the upper end of specified range, load-bank elements operate at not more than 50 percent of maximum continuous temperature rating of resistance elements.
 - E. Load-Element Switching: Remote-controlled contactors switch groups of load elements. Contactor coils are rated 120 V. Contactors shall be located in a separate NEMA 250, Type 3R enclosure within load-bank enclosure, accessible from exterior through hinged doors with tumbler locks.
 - F. Contactor Enclosures: Heated by thermostatically controlled strip heaters to prevent condensation.
 - G. Load-Bank Enclosures: NEMA 250, Type 3R, aluminized steel complying with NEMA ICS 6. Louvers at cooling-air intake and discharge openings shall prevent entry of rain and snow. Openings for airflow shall be screened with 1/2-inch- (13-mm-) square, galvanized-steel mesh. Reactive load bank shall include automatic shutters at air intake and discharge. Components other than resistive elements shall receive exterior epoxy coating with compatible primer. Comply with requirements in Section 099600 "High-Performance Coatings."
 - H. Protective Devices: Power input circuits to load banks shall be fused, and fuses shall be selected to coordinate with generator circuit breaker. Fuse blocks shall be located in contactor enclosure. Cooling airflow and overtemperature sensors shall automatically shut down and lock out load bank until manually reset. Safety interlocks on access panels and doors shall disconnect load power, control, and heater circuits. Fan motor shall be separately protected by overload and short-circuit devices. Short-circuit devices shall be noninterchangeable fuses with 200,000-A interrupting capacity.
 - I. Load-Bank Remote-Control Panel: Separate from load bank in NEMA 250, Type 1 enclosure with a control power switch and pilot light, and switches controlling groups of load elements.
 - J. Control Sequence: Control panel may be preset for adjustable single-step loading of generator during automatic exercising.
- 2.11 OUTDOOR ENGINE GENERATOR ENCLOSURE
- A. Description:
 1. Vandal-resistant, sound-attenuating, weatherproof steel housing, wind resistant up to **100 mph**

- (160 km/h). Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure.
2. Prefabricated or preengineered, galvanized-steel-clad, integral structural-steel-framed, walk-in enclosure; erected on concrete foundation.
- B. Structural Design and Anchorage: Comply with ASCE/SEI 7 for wind loads up to **100 mph (160 km/h)**.
 - C. Seismic Design: Comply with seismic requirements in Section 260548.16 "Seismic Controls for Electrical Systems."
 - D. Fire Protection: Provide fire protection according to Section 211000 "Water-Based Fire-Suppression Systems." Provide smoke detector in enclosure; mounted according to NFPA 72.
 - E. Hinged Doors: With padlocking provisions.
 - F. Space Heater: **[Gaseous][Electric]**. Thermostatically controlled and sized to prevent condensation.
 - G. Lighting: Provide weather-resistant **[fluorescent][LED]** lighting with **[30 fc (330 lx)][50 fc (550 lx)]** average maintained.
 - H. Thermal Insulation: Manufacturer's standard materials and thickness selected in coordination with space heater to maintain winter interior temperature within operating limits required by engine generator components.
 - I. Muffler Location: **[Within][External to]** enclosure.
 - J. Engine Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for two hours with ambient temperature at top of range specified in system service conditions.
 1. Louvers: Fixed-engine, cooling-air inlet and discharge. Stormproof and drainable louvers prevent entry of rain and snow.
 2. Automatic Dampers: At engine cooling-air inlet and discharge. Dampers shall be closed to reduce enclosure heat loss in cold weather when unit is not operating.
 3. Ventilation: Provide temperature-controlled exhaust fan interlocked to prevent operation when engine is running.
 - K. Interior Lights with Switch: Factory-wired, vaporproof fixtures within housing; arranged to illuminate controls and accessible interior. Arrange for external electrical connection.
 1. AC lighting system and connection point for operation when remote source is available.
 2. DC lighting system for operation when remote source and generator are both unavailable.
 - L. Convenience Outlets: Factory-wired, GFCI. Arrange for external electrical connection.
- 2.12 REMOTE RADIATOR MOTORS
- A. Description: NEMA MG 1, Design B, medium-induction, random-wound, squirrel-cage motor.
 - B. Efficiency: Energy efficient, as defined in NEMA MG 1.
 - C. Service Factor: 1.15.

- D. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
- E. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
- F. Temperature Rise: Match insulation rating.
- G. Code Letter Designation:
 - 1. Motors [15]<Insert number> HP and Larger: NEMA starting Code F or Code G.
 - 2. Motors Smaller Than [15]<Insert number> HP: Manufacturer's standard starting characteristic.
- H. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.
- I. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in electrical Sections.

2.13 VIBRATION ISOLATION DEVICES

- A. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.
 - 1. Material: [Standard neoprene][Natural rubber][Bridge-bearing neoprene, complying with AASHTO M 251] separated by steel shims.
 - 2. Shore A Scale Durometer Rating: [30][40][45][50][60][65][70]<Insert number>.
 - 3. Number of Layers: [One][Two][Three][Four]<Insert number>.
 - 4. Minimum Deflection: [1 inch (25 mm)]<Insert value>.
- B. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.
 - 1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
 - 2. Outside Spring Diameter: Not less than 80 percent of compressed height of the spring at rated load.
 - 3. Minimum Additional Travel: 50 percent of required deflection at rated load.
 - 4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 - 6. Minimum Deflection: [1 inch (25 mm)]<Insert value>.
- C. Comply with requirements in Section 232116 "Hydronic Piping Specialties" for vibration isolation and flexible connectors materials for steel piping.
- D. Comply with requirements in Section 233113 "Metal Ducts" for vibration isolation and flexible connector materials for exhaust shroud and ductwork.
- E. Vibration isolation devices shall not be used to accommodate misalignments or to make bends.

2.14 FINISHES

- A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

2.15 SOURCE QUALITY CONTROL

- A. Prototype Testing: Factory test engine generator using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.
 - 1. Tests: Comply with IEEE 115[**and with NFPA 110, Level 1 Energy Converters**].
- B. Project-Specific Equipment Tests: Before shipment, factory test engine generator and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:
 - 1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.
 - 2. Test generator, exciter, and voltage regulator as a unit.
 - 3. Full load run.
 - 4. Maximum power.
 - 5. Voltage regulation.
 - 6. Transient and steady-state governing.
 - 7. Single-step load pickup.
 - 8. Safety shutdown.
 - 9. Provide 14 days' advance notice of tests and opportunity for observation of tests by Owner's representative.
 - 10. Report factory test results within 10 days of completion of test.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine generator performance.
- B. Examine roughing-in for piping systems and electrical connections to verify actual locations of connections before packaged engine generator installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

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

3.3 INSTALLATION

- A. Comply with NECA 1 and NECA 404.
- B. Comply with packaged engine generator manufacturers' written installation and alignment instructions[**and with NFPA 110**].
- C. Equipment Mounting:
 - 1. Install packaged engine generators on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 2. Coordinate size and location of concrete bases for packaged engine generators[**and remote radiators mounted on grade**]. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
 - 3. Install [packaged engine generator][engine generator in a walk-in enclosure] with [elastomeric isolator pads][restrained spring isolators] having a minimum deflection of [1 inch (25 mm)]<Insert static deflection> on 4-inch- (100-mm-) high concrete base. Secure [sets][enclosure] to anchor bolts installed in concrete bases. Concrete base construction is specified in Section 260548.16 "Seismic Controls for Electrical Systems."
 - 4. Remote Radiators:
 - a. Install remote radiator with [elastomeric isolator pads][restrained spring isolators] on [concrete base on grade][roof equipment supports on roof].
 - b. Coordinate size and location of roof curbs, equipment supports, and roof penetrations for remote radiators. These items are specified in Section 077200 "Roof Accessories."
- D. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.
- E. Cooling System: Install Schedule 40 black steel piping with welded joints for cooling water piping between engine generator and [heat exchanger][remote radiator]. Piping materials and installation requirements are specified in Section 232113 "Hydronic Piping."
 - 1. Install isolating thimbles where exhaust piping penetrates combustible surfaces. Provide a minimum of **9 inches (225 mm)** of clearance from combustibles.
 - 2. Insulate cooling system piping and components according to requirements in Section 230719 "HVAC Piping Insulation."
- F. Exhaust System: Install Schedule 40 black steel piping with welded joints and connect to engine muffler. Install thimble at wall. Piping shall be same diameter as muffler outlet.
 - 1. Install flexible connectors and steel piping materials according to requirements in Section 232116 "Hydronic Piping Specialties."
 - 2. Insulate muffler/silencer and exhaust system components according to requirements in Section 230719 "HVAC Piping Insulation."
 - 3. Install isolating thimbles where exhaust piping penetrates combustible surfaces with a minimum of **9 inches (225 mm)** of clearance from combustibles.
- G. Drain Piping: Install condensate drain piping to muffler drain outlet with a shutoff valve, stainless-steel flexible connector, and Schedule 40 black steel pipe with welded joints.
- H. Fuel Piping:
 - 1. Diesel storage tanks, tank accessories, piping, valves, and specialties for fuel systems are

- specified in Section 231113 "Facility Fuel-Oil Piping."
 - 2. Natural gas piping, valves, and specialties for gas distribution are specified in Section 231123 "Facility Natural Gas Piping."
 - 3. Copper and galvanized steel shall not be used in the diesel fuel-oil piping system.
- I. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.4 CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping and specialties.
- B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.
- C. Connect cooling-system water piping to engine generator and **[remote radiator][heat exchanger]** with flexible connectors.
- D. Connect engine exhaust pipe to engine with flexible connector.
- E. Fuel Connections:
 - 1. Connect fuel piping to engines with a gate valve and union and flexible connector.
 - 2. Install manual shutoff valve in a remote location to isolate gas supply to the generator.
 - 3. Vent gas pressure regulators outside building a minimum of **60 inches (1500 mm)** from building openings.
- F. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- G. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Provide a minimum of one 90-degree bend in flexible conduit routed to the generator set from a stationary element.
- H. Balance single-phase loads to obtain a maximum of 10 percent unbalance between any two phases.

3.5 IDENTIFICATION

- A. Identify system components according to Section 230553 "Identification for HVAC Piping and Equipment" and Section 260553 "Identification for Electrical Systems."
- B. Install a sign indicating the generator neutral is bonded to the main service neutral at the main service location.

3.6 FIELD QUALITY CONTROL

- A. Testing Agency:
 - 1. Owner will engage a qualified testing agency to perform tests and inspections.
 - 2. Engage a qualified testing agency to perform tests and inspections.
 - 3. Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

4. Perform tests and inspections[**with the assistance of a factory-authorized service representative**].

B. Tests and Inspections:

1. Perform tests recommended by manufacturer and each visual and mechanical inspection and electrical and mechanical test listed in first two subparagraphs, as specified in NETA ATS. Certify compliance with test parameters.
 - a. Visual and Mechanical Inspection:
 - 1) Compare equipment nameplate data with Drawings and the Specifications.
 - 2) Inspect physical and mechanical condition.
 - 3) Inspect anchorage, alignment, and grounding.
 - 4) Verify that the unit is clean.
 - b. Electrical and Mechanical Tests:
 - 1) Perform insulation-resistance tests according to IEEE 43.
 - a) Machines Larger Than **200 hp (150 kW)**: Test duration shall be 10 minutes. Calculate polarization index.
 - b) Machines **200 hp (150 kW)** or Less: Test duration shall be one minute. Calculate the dielectric-absorption ratio.
 - 2) Test protective relay devices.
 - 3) Verify phase rotation, phasing, and synchronized operation as required by the application.
 - 4) Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.
 - 5) Perform vibration test for each main bearing cap.
 - 6) Verify correct functioning of the governor and regulator.
2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here, including, but not limited to, single-step full-load pickup test.
3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
 - a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
 - b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
 - c. Verify acceptance of charge for each element of the battery after discharge.
 - d. Verify that measurements are within manufacturer's specifications.
4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine generator system before and during system operation. Check for air, exhaust, and fluid leaks.
6. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding **40-inch wg (120 kPa)**. Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.
7. Exhaust Emissions Test: Comply with applicable government test criteria.

8. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
 9. Harmonic-Content Tests: Measure harmonic content of output voltage at 25 and 100 percent of rated linear load. Verify that harmonic content is within specified limits.
 10. Noise Level Tests: Measure A-weighted level of noise emanating from engine generator installation, including engine exhaust and cooling-air intake and discharge, at **[four]<Insert number> locations [25 feet (8 m) from edge of the generator enclosure][on the property line]<Insert location for measurement>**, and compare measured levels with required values.
- C. Coordinate tests with tests for transfer switches and run them concurrently.
 - D. Test instruments shall have been calibrated within the last 12 months, traceable to NIST Calibration Services, and adequate for making positive observation of test results. Make calibration records available for examination on request.
 - E. Leak Test: After installation, charge exhaust, coolant, and fuel systems and test for leaks. Repair leaks and retest until no leaks exist.
 - F. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated equipment.
 - G. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - H. Remove and replace malfunctioning units and **[retest][reinspect]** as specified above.
 - I. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.
 - J. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.
 - K. Infrared Scanning: After Substantial Completion, but not more than 60 days after final acceptance, perform an infrared scan of each power wiring termination and each bus connection while running with maximum load. Remove all access panels so terminations and connections are accessible to portable scanner.
 1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan 11 months after date of Substantial Completion.
 2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 3. Record of Infrared Scanning: Prepare a certified report that identifies terminations and connections checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.7 MAINTENANCE SERVICE

- A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include **[12]<Insert number> months'** full maintenance by skilled employees of manufacturer's authorized service representative. Include quarterly preventive maintenance and exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Parts shall be manufacturer's authorized replacement parts and supplies.



3.8 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators.

END OF SECTION 26 32 13 19

SECTION 26 33 43 00 - BATTERY CHARGERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes battery chargers for emergency engine generators.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of battery charger.
 - 1. Include system overview, construction details, material descriptions, and dimensions of battery charging and monitoring systems.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, performance specifications, and furnished accessories.
- B. Shop Drawings: For battery chargers.
 - 1. Include plans, elevations, sections, and mounting details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field installation, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.
 - 4. Include instructions for Installer.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For manufacturer.
- B. Seismic Qualification Data: Certificates, for battery changers, accessories, and components, from manufacturer.
 - 1. Basis for Certification: Include Certificate of Compliance for nonstructural components and systems. Withstand certification is for below-grade, grade, and roof-level installations, installations in essential facilities, and for life-safety applications, based on actual shake-testing. Certified installation locations shall include mounting directly to structural wall and directly to nonstructural wall.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For battery chargers to include in operation and maintenance manuals.
 - 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Manufacturer's operating specifications and user's guides.
 - b. Data sheet for each battery charger with nameplate information and performance

specifications.

1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Provide certification that manufacturer complies with requirements of ISO 9001.

1.6 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of battery chargers that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: <Insert number> years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. UL Compliance: Comply with UL 1236 for Category BBHH. OEM-supplied, open-frame chargers may be UL recognized to Category BBHH provided they are housed in a listed enclosure.
- C. NFPA Compliance: Comply with NFPA 110.
- D. Environmental Conditions: Battery charger shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
 - 1. Ambient Temperature: **Minus 40 to plus 158 deg F (minus 40 to plus 70 deg C)** with full charger output available up to **104 deg F (40 deg C)**.
 - 2. Relative Humidity: 5 to 95 percent.
 - 3. Altitude: Meets full performance from sea level to **5000 feet (1600 m)**. Chargers installed at higher altitudes may automatically derate output power to prevent overheating of internal components, but shall remain operable.
 - 4. Electromagnetic Immunity: Charger power terminals shall be immune to conducted and radiated electromagnetic energy to IEC 61000-4-12.
 - 5. Vibration Resistance: Charger enclosure rated to IEC 60068-2-6 vibration test; 4-g force from 18 to 500 Hz on 3 axes; and 0.01 power spectral density value from 20 to 500 Hz.
- E. Seismic Performance: Battery chargers shall withstand the effects of earthquake motions determined according to **[IBC 2006][IBC 2009][IBC 2012][IBC 2015][the latest edition of the IBC][ASCE/SEI 7]<Insert requirement>**.
 - 1. Shake-Table Testing: Comply with ICC-ES AC156.
 - 2. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified **and the unit will be fully operational after the seismic event**."
 - 3. Component Importance Factor: **[1.5][1.0]**.
 - 4. Equipment seismic application, spectral response acceleration, short period (Sds) for Project is

[indicated on Drawings]<Insert requirements>.

F. Battery-Charger Power Conversion Energy Efficiency:

1. Certified to California Code of Regulations, Title 20, "Appliance Efficiency Regulations"; <https://cacertappliances.energy.ca.gov/Pages/ApplianceSearch.aspx>.
2. Comply with Oregon Department of Energy standards for appliance energy efficiency.

2.2 BATTERY CHARGERS FOR EMERGENCY ENGINE GENERATORS

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

1. **[Cummins Power Generation]**
2. **[GE Power; General Electric Company]**
3. **[Stored Energy Systems LLC]**
4. **<Insert manufacturer's name>**

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

1. **[Cummins Power Generation]**
2. **[GE Power; General Electric Company]**
3. **[Stored Energy Systems LLC]**
4. **<Insert manufacturer's name>**

C. Source Limitations: Obtain battery chargers from single source from single manufacturer.

D. Battery-Charger Operation: Current-limited, constant-voltage, automatic-boost type charger designed for **[lead-acid][nickel-cadmium]** batteries, with the following features:

1. Automatic Boost Mode: Operates in boost charging mode after battery discharge. Boost duration automatically adjusted depending on the following:
 - a. Differing depths of battery discharge.
 - b. Differing relationships of battery amp-hour capacity to charger ampere output.
 - c. Differing parasitic direct current loads.
2. Output Voltage Regulation: Charger regulates output to within plus or minus 0.5 percent of manufacturer-provided voltage settings despite variations of input voltage, input frequency, and output current.
3. Battery Thermal Compensation: Battery temperature compensation with adjustable slope, factory set at minus 0.18 percent per degree C, and equipped for sensing battery temperature. **[Include battery temperature sensor mounted on battery negative terminal.]**
4. Automatic Dead Battery Recharge: Charger automatically recharges a battery discharged to 0 V at full-rated output current, without the need for user intervention.
5. AC Input: Charger operates from any 47- to 63-Hz ac source with voltage ranging from 90- to 265-V rms.
6. Lead-Acid Battery Longevity and Safety Mode: Charger emulates vehicle duty for which starting batteries are designed to maximize battery life, minimize battery explosion risk, and minimize electrolyte loss in lead-acid batteries:
 - a. Boost Mode Recharge: After recharge is complete in boost mode, charger reverts to a voltage just above battery open-circuit voltage, for the majority of battery-charger operating



- hours, when fully charged. The charger remains in operation to prevent battery discharge.
- b. Float Mode: Charger periodically elevates output voltage to ensure a fully charged battery, charger then returns to just above battery nominal voltage. Charger repeats this cycle until the next battery discharge, when the battery shall be recharged in the boost mode.

- 7. Charger Enclosure: NEMA 250, **[Type 1 (IP20)][Type 3R (IP22)]**, wall mounted and rated for generator duty with charger enclosure vibration resistance. Housing materials: aluminum or stainless steel.

E. Battery-Charger Status Indication and Alarms:

- 1. Output Voltage and Current: Digital or analog meters on front panel, or by conveying performance data to generator control panel via J-1939 datalink. Accuracy: Plus 2 percent for voltage and plus 5 percent for current.
- 2. Alarm Outputs: **[Individual Form C contacts][Single summary Form C contact]**, or by conveying alarms to generator control panel via J-1939 datalink.
 - a. AC voltage failure.
 - b. Low dc voltage.
 - c. High dc voltage.
 - d. Low cranking voltage.

2.3 SOURCE QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to evaluate battery-charger fabricator's quality-control and testing methods.
- B. Testing: Test and inspect battery chargers according to UL 1236 for Category BBHH recharge performance.
- C. Factory Tests: Test and inspect assembled battery chargers to manufacturer's written instructions. Verify NFPA 110 recharge performance by validating that battery charger is listed to UL 1236 Category BBHH on the UL certification database.
- D. Battery charger will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas, mounting locations, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting battery-charger performance.
- B. Examine roughing-in for conduit systems and electrical connections to verify actual locations of connections before battery-charger installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 BATTERY-CHARGER INSTALLATION

- A. Follow manufacturer's written instructions to prevent damage from static electricity. Provide clearances for service and ventilation.
- B. Battery chargers are configured at the factory. If settings need to be field-configured, follow manufacturer's setup written instructions.
- C. Coordinate jumper datalinks with emergency generator control panel capabilities.

3.3 CONNECTIONS

- A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Provide branch-circuit overcurrent protection.
- C. Comply with requirements for branch-circuit protection and service disconnects in Section 262816 "Enclosed Switches and Circuit Breakers."

3.4 IDENTIFICATION

- A. Identify system components according to Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections[**with authorities having jurisdiction**][**with the assistance of a factory-authorized service representative**]:
 - 1. Verify that certification labels are properly installed. Verify NFPA 110 compliance by validating that battery charger is listed to UL 1236 Category BBHH on the UL certification database.
 - 2. Verify that connections are secure and in the proper locations. Ensure wiring is correctly connected between charger and battery.
 - 3. Operational Test: After electrical circuitry has been energized, apply input voltage to confirm proper unit operation.
 - 4. Test and adjust alarms, display indicators, controls, and safeties.
- D. Battery charger will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

3.6 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain battery chargers and related equipment.

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- B. Coordinate this training with that for emergency engine generator equipment.

END OF SECTION 26 33 43 00

SECTION 26 33 43 00A - PUBLIC ADDRESS SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Public address systems.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. Section 078413 "Penetration Firestopping" specifies materials and methods for sealing penetrations of rated walls and partitions referenced by this Section.
5. Section 260526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding equipment referenced by this Section.
6. Section 260529 "Hangers and Supports for Electrical Systems" specifies hangers, supports, and concrete bases referenced by this Section.
7. Section 260548 "Vibration and Seismic Controls for Electrical Systems" specifies vibration isolation and seismic-[**and wind**]-control devices referenced by this Section.
8. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs referenced by this Section.
9. Section 262716 "Electrical Cabinets and Enclosures" specifies rack or frame system enclosures referenced by this Section.
10. Section 270528 "Pathways for Communications Systems"[**and Section 271100 "Communications Equipment Room Fittings"**] specifies additional requirements for raceway materials, routing, locations, and identification of communications equipment and cabling.
11. Section 284600 "Fire Detection and Alarm" specifies fire-alarm system interfaces referenced by this Section.
12. Section 284700 "Mass Notification" specifies mass notification system interfaces referenced by this Section.

1.2 DEFINITIONS

- A. Channels: Separate parallel signal paths, from sources to loudspeakers or loudspeaker zones, with separate amplification and switching that permit selection between paths for speaker alternative program signals.
- B. FAS: Fire alarm system.
- C. I&TFAS: Inspection and testing of fire alarm system.
- D. NICET: National Institute for Certification in Engineering Technologies, a division of the National Society of Professional Engineers.

- E. SPDT: Single pole, double throw.
- F. VU: Volume unit.
- G. Zone: Separate group of loudspeakers and associated supply wiring that may be arranged for selective switching between different channels.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing agency, certifying product's compliance with specified listing criteria.
 - a. If listed manufacturer differs from selling manufacturer, indicate relationship between entities on submittal. Clearly indicate which entity warrants product performance and fitness for purpose.
 - b. Listing criteria identified in approval letter must match specified listing criteria. UL label indicating approval of equipment's enclosure is not considered approval of equipment for intended application.
 - c. Product identification in approval letter must match product branding and model numbers in submittal. Approval letters for discontinued or superseded products are unacceptable for submitted product.
- B. Shop Drawings: For power, signal, and control wiring.
 - 1. Include plans, elevations, sections, and attachment details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Console layouts.
 - 4. Control panels.
 - 5. Rack arrangements.
 - 6. Calculations: For sizing backup battery.
 - 7. Wiring Diagrams: For power, signal, and control wiring.
 - a. Identify terminals to facilitate installation, operation, and maintenance.
 - b. Single-line diagram showing interconnection of components.
 - c. Cabling diagram showing cable routing.
- C. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

- A. Manufacturer's published instructions.
- B. Field Reports:
 - 1. Manufacturer's field reports for field quality-control support.
 - 2. Manufacturer's field reports for system startup support.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Extra stock material.

1.6 QUALIFICATIONS

- A. Fire-Alarm Systems (FAS) Technician Trainee: Having at least six months of experience and possessing active NICET FAS Level I certification. Able to perform limited tasks under direct supervision.
- B. Fire-Alarm Systems (FAS) Associate Engineering Technician: Having at least two years of experience and possessing active NICET FAS Level II certification. Able to review drawings, specifications, codes, and standards; to conduct basic installation activities; and to perform basic troubleshooting.
- C. Fire-Alarm Systems (FAS) Engineering Technician: Having at least five years of experience and possessing active NICET FAS Level III certification. Able to perform system layout activities, to supervise Level I and Level II technicians, to provide submittal packages, and to interact with authorities having jurisdiction.
- D. Fire-Alarm Systems (FAS) Senior Engineering Technician: Having at least 10 years of experience and possessing active NICET FAS Level IV certification. Able to manage multiple projects at once, to interpret codes and standards, to conduct training, and to serve as liaison between authorities having jurisdiction, owners, engineers, and contractors.
- E. Inspection and Testing of Fire-Alarm Systems (I&TFAS) Technician I: Possessing active NICET I&TFAS Level I certification. Able to perform periodic inspections and tests of basic fire-alarm systems and to prepare related records and reports.
- F. Inspection and Testing of Fire-Alarm Systems (I&TFAS) Technician II: Possessing active NICET I&TFAS Level II certification. Able to plan, perform, and coordinate periodic inspections and tests of complex fire-alarm systems (including one or more of suppression interfaces, networked control units, smoke-control interfaces, air-sampling systems, multi-zone voice evacuation systems, or high-rise applications) and to prepare related records and reports.
- G. Fire-Alarm Cable Installer: Entity possessing active qualifications specified in Section 014000 "Quality Requirements" with training and manufacturer certification to install, splice, and terminate fire-alarm cabling.
 - 1. On-site fire-alarm cable installation supervisor must possess active NICET FAS [Senior]Engineering Technician certification.
- H. Fire-Alarm Testing Agency: Entity possessing active credentials from qualified electrical testing laboratory recognized by authorities having jurisdiction.
 - 1. On-site fire-alarm testing supervisor must possess active NICET I&TFAS Technician [I][II] certification.
- I. Communications Design Professional: Design professional possessing active qualifications specified in Section 014000 "Quality Requirements" and the following:
 - 1. Expertise in design of communications infrastructure and distribution equipment.
 - 2. BICSI Registered Communications Distribution Designer (RCDD)[or Outside Plant Designer (OSP)] certification.

- J. Communications Cable Installer: Entity possessing active qualifications specified in Section 014000

"Quality Requirements" and the following:

1. Training and manufacturer certification to install, splice, and terminate communications cabling.
 2. Installation Supervisor: BICSI Technician (TECH) certification.
 3. Copper Installers: **[30 percent]<Insert quantity>** of employees possess BICSI Copper Installer 2 (INSTC) certification. Remaining employees possess BICSI Installer 1 (INST1) certification.
- K. Communications Testing and Inspecting Agency: Entity possessing active credentials from qualified electrical testing laboratory recognized by authorities having jurisdiction.
1. On-site communications testing supervisor must have **[BICSI Technician (TECH)]<Insert certification program>** certification and documented training, and be experienced with testing communications equipment in accordance with **[BICSI]<Insert code enforced by authorities having jurisdiction>** testing standards.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- B. Functional Description:
1. Selectively connect any zone to any available signal channel.
 2. Selectively control sound from microphone outlets and other inputs.
 3. "All-call" feature must connect the all-call sound signal simultaneously to all zones regardless of zone or channel switch settings.
 4. Telephone paging adapter must allow paging by dialing an extension from any local telephone instrument and speaking into the telephone.
 5. Produce a program-signal tone that is amplified and sounded over all speakers, overriding signals currently being distributed.
 6. Reproduce high-quality sound that is free of noise and distortion at all loudspeakers at all times during equipment operation, including standby mode with inputs off, and output free of nonuniform coverage of amplified sound.
 7. Compatibility of Components: Coordinate component features to form an integrated system. Match components and interconnections for optimum performance of specified functions.
 8. Equipment must be modular, using solid-state components, and fully rated for continuous duty unless otherwise indicated. Select equipment for normal operation on input power usually supplied at 110 to 130 V, 60 Hz.
 9. Equipment Mounting: Where rack or cabinet mounting is indicated, equipment must be designed to mount in a **19 inch (483 mm)** housing complying with Section 262716 "Electrical Cabinets and Enclosures."
- C. Seismic and Wind Performance: Installed assembly must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:
1. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events[, **and unit must be fully operational after seismic events**].
 2. Component Importance Factor (Ip): **[1.0][1.5]**.
 3. Component Amplification Factor (ap): **[1.0][2.5]<Insert value>**.

4. Component Response Modification Factor (Rp): **[1.5][2.0][2.5][6.0]<Insert value>**.
5. Component Overstrength Factor (Ω_o): **[1.5][2.5]<Insert value>**.

2.2 PUBLIC ADDRESS SYSTEMS

A. UL AZOT - Public Address System :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Altec Lansing Technologies, Inc]**
 - b. **[Atlas Sound LP]**
 - c. **[Bogen Communications, Inc]**
 - d. **[Bosch Security Systems, Inc.]**
 - e. **[Edwards; Carrier Global Corporation]**
 - f. **[Federal Signal Corporation]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Altec Lansing Technologies, Inc]**
 - b. **[Atlas Sound LP]**
 - c. **[Bogen Communications, Inc]**
 - d. **[Bosch Security Systems, Inc.]**
 - e. **[Edwards; Carrier Global Corporation]**
 - f. **[Federal Signal Corporation]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Obtain public address system from single source from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Audio Equipment: UL CCN AZOT, including UL 62368-1[; **or UL CCN AZJX, including UL 813**][; **or UL CCN AZSQ, including UL 60065**].
 - b. Weather-Resistant Equipment: Marked for use in wet or damp locations.

B. Preamplifiers:

1. Separately mounted.
2. Integral to power amplifier.
3. Output Power: Plus 4 dB above 1 mW at matched power-amplifier load.
4. Total Harmonic Distortion: Less than 1 percent.
5. Frequency Response: Within plus or minus 2 dB from 20 to 20 000 Hz.
6. Input Jacks: Minimum of three. One matched for low-impedance microphone; one USB port; and the other matchable to DVD or CD player, or radio tuner signals without external adapters.
7. Minimum Noise Level: Minus 55 dB below rated output.
8. Controls: On-off, input levels, and master gain.

C. Power Amplifiers:

1. Mounting: **[Console][Rack]**.
2. Output Power: 70 V balanced line. **[80 percent of the sum of wattage settings of connected]<Insert wattage>** for each station and speaker connected in all-call mode of operation, plus a **[10 percent][15 percent][25 percent]** allowance for future stations.
3. Total Harmonic Distortion: Less than 3 percent at rated power output from 50 to 12 000 Hz.
4. Minimum Signal-to-Noise Ratio: 80 dB, at rated output.
5. Frequency Response: Within plus or minus 3 dB from 20 to 12 000 Hz.
6. Output Regulation: Less than 2 dB from full to no load.
7. Controls: On-off, input levels, and low-cut filter.
8. Input Sensitivity: Matched to preamplifier and to provide full-rated output with sound-pressure level of less than 10 dynes/sq. cm impinging on speaker microphone or handset transmitter.

D. Transfer to Standby Amplifier:

1. Monitoring Circuit and Sensing Relay: Detect reduction in output of power amplifier of 40 percent or more and, in such event, transfer load and signal automatically to standby amplifier.

E. Paging Microphone:

1. Type: Dynamic, with **[cardioid][omnidirectional]** polar characteristic.
2. Impedance: **[500 Ω][250 Ω]**.
3. Frequency Response: Uniform, 50 to 15 000 Hz.
4. Sensitivity: Minus 70 dB.
5. Output Level: Minus 58 dB, minimum.
6. Cable: Braided shield cable with **[Amphenol][Neutrik]** XLR connectors. Coordinate impedance with microphone impedance.
7. Mounting: Desk stand with integral-locking, press-to-talk switch.

F. **<Insert requirements for other microphone types>**.

G. Volume Limiter/Compressor Minimum Performance Requirements:

1. Frequency Response: 45 to 15 000 Hz, plus or minus 1 dB minimum.
2. Reduction Ratio: Automatically vary compression ratio, and attack and release times for voice and music inputs.
 - a. Compression Ratio Range: 3:1 to 10:1 minimum.
 - b. Averaging Compressor Attack Time: Up to 500 ms.
 - c. Signal Fast Compression Attack Time: Less than 10 ms.
 - d. Release time: Up to 500 ms.
3. Distortion: 0.5 percent, maximum.
4. Rated Output: Minimum of plus 14 dB.
5. Inputs: Minimum of two inputs with variable front-panel gain controls and VU or decibel meter for input adjustment.
6. Rack mounted.

H. Control Console Enclosure:

1. Cabinet: Modular, **[desktop][desk style]**; complying with EIA/ECA-310-E.
2. Housing: Steel, **0.0478 inch (1.2 mm)** minimum, with removable front and rear panels. Side panels are removable for interconnecting side-by-side mounting.
3. Panel for Equipment and Controls: Rack mounted.
4. Controls:

- a. Switching devices to select signal sources for distribution channels.
 - b. Program selector switch to select source for each program channel.
 - c. Switching devices to select zones for paging.
 - d. All-call selector switch.
 5. Indicators: A visual annunciation for each distribution channel to indicate source being used.
 6. Self-Contained Power and Control Unit: A single assembly of basic control, electronics, and power supply necessary to accomplish specified functions.
 7. Spare Positions: 20 percent spare zone control and annunciation positions on console.
 8. Microphone jack.
- I. Equipment Cabinet Enclosure:
1. Comply with requirements in Section 262716 "Electrical Cabinets and Enclosures."
 2. House amplifiers and auxiliary equipment at each location.
 3. Cabinet Housing:
 - a. Front- and rear-locking doors.
 - b. Arranged for floor or wall mounting as indicated.
 - c. Sized to house all equipment indicated, plus spare capacity.
 - d. Include [20]<Insert number> percent minimum spare capacity for future equipment in addition to space required for[future] DVD or CD player.
 4. Power Provisions: A single switch in cabinet disconnects cabinet power distribution system and electrical outlets, which must be uniformly spaced to accommodate AC power cords for each item of equipment.
 5. Ventilation: A low-noise fan for forced-air cabinet ventilation. Fan must be equipped with a filtered input vent and must be connected to operate from 105 to 130 V(ac), 60 Hz; separately fused and switched; arranged to be powered when main cabinet power switch is on.
- J. Equipment Rack Enclosure:
1. Racks: **19 inch (483 mm)** standard, complying with requirements in Section 262716 "Electrical Cabinets and Enclosures."
 2. Power-Supply Connections: Compatible plugs and receptacles.
 3. Enclosure Panels: Ventilated rear and sides and solid top. Use louvers in panels to ensure adequate ventilation.
 4. Finish: Uniform, baked-enamel factory finish over rust-inhibiting primer.
 5. Power-Control Panel: On front of equipment housing, with master power on-off switch and pilot light; and with cartridge fuse protection for rack equipment power.
 6. Service Light: At top rear of rack with an adjacent control switch.
 7. Vertical Plug Strip: Grounded receptacles, **12 inch (300 mm)** on center; the full height of rack for public address system equipment use only.
 8. Maintenance Receptacles: Duplex convenience outlets supplied independent of vertical plug strip and located in front and bottom rear of rack.
 9. Spare Capacity: [20]<Insert number> percent in rack for future equipment.
- K. Telephone Paging Adapter:
1. Adapters must accept voice signals from telephone extension dialing access and automatically provide amplifier input and program override for preselected zones.
 - a. Minimum Frequency Response: Flat, 200 to 2500 Hz.
 - b. Impedance Matching: Adapter matches telephone line to public address equipment input.
 - c. [Rack][Cabinet] mounted.

L. Tone Generator:

1. Provide clock and program interface with public address system.
2. Signals: Minimum of seven distinct, audible signal types including wail, warble, high/low, alarm, repeating and single-stroke chimes, and tone.
3. Pitch Control: Chimes and tone.
4. Volume Control: All outputs.
5. Activation-Switch Network: Establishes priority and hierarchy of output signals produced by different activation setups.
6. Mounting: **[Rack][Cabinet]**.

M. Monitor Panel:

1. Monitor power amplifiers.
2. Components: VU or dB meter, speaker with volume control, and multiple-position rotary selector switch.
3. Selector Switch and Volume Control: Selective monitoring of output of each separate power amplifier via VU or dB meter and speaker.
4. Mounting: **[Rack][Cabinet]**.

N. Cone-Type Loudspeakers:

1. Minimum Axial Sensitivity: 91 dB at 1 m, with 1 W input.
2. Frequency Response: Within plus or minus 3 dB from 50 to 15 000 Hz.
3. Size: **[6 inch (150 mm)][8 inch (200 mm)]** with **1 inch (25 mm)** voice coil and minimum **5 oz (140 g)** ceramic magnet.
4. Rated Output Level: **[8][10]** W.
5. Minimum Dispersion Angle: 100 degrees.
6. Matching Transformer: Full-power rated with four taps. Maximum insertion loss of 0.5 dB.
7. Surface-Mounted Units: Ceiling, wall, or pendant mounted, as indicated, in steel back boxes, acoustically dampened. Front face of at least **0.0478 inch (1.2 mm)** steel and whole assembly rust proofed and shop primed for field painting.
8. Flush-Ceiling-Mounted Units: In steel back boxes, acoustically dampened. Metal ceiling grille with **[white]<Insert color>** baked enamel.

O. Horn-Type Loudspeakers:

1. Type: Single-horn units, double-reentrant design, with minimum full-range power rating of 15 W.
2. Matching Transformer: Full-power rated with four standard taps. Maximum insertion loss of 0.5 dB.
3. Frequency Response: Within plus or minus 3 dB from 250 to 12 000 Hz.
4. Dispersion Angle: 130 by 110 degrees.
5. Mounting: Integral bracket.
6. Units in Damp, Wet, or Outdoor Locations: Listed and labeled for environment in which they are located.
7. Units in Hazardous (Classified) Locations: Listed and labeled for environment in which they are located. Provide any accessories required to maintain listing.

P. Noise-Operated Gain Controller:

1. Gain controller must be designed to continuously sense space noise level and automatically adjust signal level to local speakers.
2. Frequency Response: 20 to 20 000 Hz, plus or minus 1 dB.
3. Level Adjustment Range: 30 dB minimum.
4. Maximum Distortion: 0.5 percent.

5. Control: Permits adjustment of sensing level of device.

Q. Outlets:

1. Volume Attenuator Station: Wall-plate-mounted autotransformer type with paging priority feature.
 - a. Wattage Rating: 10 W unless otherwise indicated.
 - b. Attenuation per Step: 3 dB, with positive off position.
 - c. Insertion Loss: 0.4 dB maximum.
 - d. Attenuation Bypass Relay: SPDT. Connected to operate and bypass attenuation when all-call, paging, program signal, or prerecorded message features are used. Relay returns to normal position at end of priority transmission.
 - e. Label: "PA Volume."
2. Microphone Outlet: Three-pole, polarized, locking-type, microphone receptacles in single-gang boxes. Equip wall outlets with brushed stainless-steel device plates. Equip floor outlets with gray tapered rubber or plastic cable nozzles and fixed outlet covers.
3. Headphone Outlet (for the Hearing Impaired): Microphone receptacles in single-gang boxes. Equip wall outlets with brushed stainless-steel device plates. Equip floor outlets with gray tapered rubber or plastic cable nozzles and fixed-outlet covers.

R. Battery Backup Power Unit:

1. Rack mounted, consisting of time-delay relay, sealed lead-calcium battery, battery charger, on-off switch, "normal" and "emergency" indicating lights, and adequate capacity to supply maximum equipment power requirements for one hour of continuous full operation.
2. Supplies public address equipment with 12 to 15 V(dc) power automatically during an outage of normal 120 V(ac) power.
3. Float charge batteries when not supplying system and able to transfer automatically to supply system after three to five seconds of continuous outage of normal power, as sensed by time-delay relay.
4. Automatically retransfer system to normal supply when normal power has been reestablished for three to five seconds continuously.

S. Conductors and Cables:

1. Jacketed, twisted pair and twisted multipair, untinned solid copper.
 - a. Insulation for Wire in Conduit: Thermoplastic, not less than **1/32 inch (0.8 mm)** thick.
 - b. Microphone Cables: Neoprene jacketed, not less than **2/64 inch (0.8 mm)** thick, over shield with filled interstices. Shield 34 AWG, tinned, soft-copper strands formed into a braid or approved equivalent foil. Shielding coverage on conductors is not less than 60 percent.
 - c. Plenum Cable: Listed and labeled for plenum installation.

T. Conduits and Boxes:

1. Flexible metal conduit is not permitted.
2. Outlet Boxes: Not less than **2 inch (50 mm)** wide, **3 inch (75 mm)** high, and **2-1/2 inch (64 mm)** deep.

2.3 MAINTENANCE MATERIAL ITEMS

- A. Extra Stock Material: Furnish to Owner extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.[**Include the following:**]

1. Microphone: **[One]<Insert number>**.
2. Microphone Desk Stand(s): **[One]<Insert number>**.

PART 3 - EXECUTION**3.1 INSTALLATION OF COMMUNICATIONS CABLE PATHWAYS**

A. Comply with NECA NEIS 1.

B. Special Installation Techniques:

1. Install manufactured conduit sweeps and long-radius elbows whenever possible.
2. Wiring Method:
 - a. Install cables in pathways and cable trays except within consoles, cabinets, desks, and counters[, **and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used**]. Conceal pathway and cables except in unfinished spaces.
 - 1) Install plenum cable in environmental air spaces, including plenum ceilings.
 - 2) Install pathways and boxes for communications cabling.
 - b. Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
3. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.
4. Terminate conductors; no cable may contain unterminated elements. Make terminations only at outlets and terminals.
5. Splices, Taps, and Terminations: Arrange on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Cables may not be spliced.
6. Secure and support cables at intervals not exceeding **30 inch (760 mm)** and not more than **6 inch (150 mm)** from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
7. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
8. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
9. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps may not be used.
10. Open-Cable Installation:
 - a. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
 - b. Suspend speaker cable not in a wireway or pathway a minimum of **8 inch (200 mm)** above ceiling by cable supports not more than **[60 inch (1524 mm)]<Insert dimension>** apart.
 - c. Do not run cables through structural members or in contact with pipes, ducts, or other potentially damaging items.
11. Separation of Wires: Separate speaker-microphone, line-level, speaker-level, and power wiring runs. Install in separate pathways or, where exposed or in same enclosure, separate conductors at least **12 inch (300 mm)** apart for speaker microphones and adjacent parallel power and telephone wiring. Separate other communication equipment conductors as recommended by

equipment manufacturer.

3.2 INSTALLATION OF PUBLIC ADDRESS SYSTEM

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:
 - 1. Electrical Construction: ICC IBC, ICC IFB, NFPA 1, NFPA 70, and NECA NEIS 1.
 - 2. Fire-Alarm and Premises Security Work: NFPA 72, NFPA 731, and NECA NEIS 305.
 - 3. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
 - 4. Communications Work: BICSI N1.
 - 5. Consult Architect for resolution of conflicting requirements.
- C. Special Installation Techniques:
 - 1. Coordinate layout and installation of system components and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.
 - 2. Match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.
 - 3. Identification of Conductors and Cables: Color-code conductors and apply wire and cable marking tape to designate wires and cables so they identify media in coordination with system wiring diagrams.
 - 4. Equipment Cabinets and Racks:
 - a. Group items of same function together, either vertically or side by side, and arrange controls symmetrically. Mount monitor panel above the amplifiers.
 - b. Arrange all inputs, outputs, interconnections, and test points so they are accessible at rear of rack for maintenance and testing, with each item removable from rack without disturbing other items or connections.
 - c. Blank Panels: Cover empty space in equipment racks so entire front of rack is occupied by panels.
 - 5. Volume Limiter/Compressor: Equip each zone with a volume limiter/compressor. Install in central equipment cabinet. Arrange to provide a constant input to power amplifiers.
 - 6. Wall-Mounted Outlets: Flush mounted.
 - 7. Floor-Mounted Outlets: Conceal in floor and install cable nozzles through outlet covers. Secure outlet covers in place. Trim with carpet in carpeted areas.
 - 8. Conductor Sizing: Unless otherwise indicated, size speaker circuit conductors from racks to loudspeaker outlets not smaller than 18 AWG and conductors from microphone receptacles to amplifiers not smaller than 22 AWG.
 - 9. Weatherproof Equipment: For units that are mounted outdoors, in damp locations, or where exposed to weather, install consistent with requirements of weatherproof rating.
 - 10. Speaker-Line Matching Transformer Connections: Make initial connections using tap settings indicated on the Drawings.
- D. Interfaces with Other Work:
 - 1. Seal penetrations of rated walls and partitions.
 - 2. Identification: Provide labels for public address system equipment and associated electrical equipment.
 - a. Identify field-installed conductors, interconnecting wiring, and components.

- b. Label each enclosure with engraved metal or laminated-plastic nameplate.
- c. Provide warning signs and arc-flash hazard warning labels for electrical equipment.

3. Grounding and Bonding:

- a. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
- b. Signal Ground Terminal: Locate at main equipment cabinet. Isolate from power system and equipment grounding.
- c. Install grounding electrodes.

3.3 FIELD QUALITY CONTROL OF PUBLIC ADDRESS SYSTEM

A. Administrant for Communications Tests and Inspections:

- 1. **[Owner][Tenant]** will engage qualified communications testing and inspecting agency to administer and perform tests and inspections.
- 2. Engage qualified communications testing and inspecting agency to administer and perform tests and inspections.
- 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
- 4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].

B. Administrant for Fire-Alarm Tests and Inspections:

- 1. **[Owner][Tenant]** will engage qualified fire-alarm testing and inspecting agency to administer and perform tests and inspections.
- 2. Engage qualified fire-alarm testing and inspecting agency to administer and perform tests and inspections.
- 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
- 4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].

C. Acceptance Testing Preparation:

- 1. **<Insert requirements>**.

D. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.

E. Tests and Inspections:

- 1. Schedule tests with at least seven days' advance notice of test performance.
- 2. After installing public address system and after electrical circuitry has been energized, test for compliance with requirements.
- 3. Operational Test: Perform tests that include originating program and page messages at microphone outlets, preamplifier program inputs, and other inputs. Verify proper routing and volume levels and that system is free of noise and distortion.
- 4. Signal-to-Noise Ratio Test: Measure signal-to-noise ratio of complete system at normal gain settings as follows:

- a. Disconnect microphone at connector or jack closest to it and replace it in the circuit with a

signal generator using a 1000 Hz signal. Replace all other microphones at corresponding connectors with dummy loads, each equal in impedance to microphone it replaces. Measure signal-to-noise ratio.

- b. Repeat test for each separately controlled zone of loudspeakers.
 - c. Minimum acceptance ratio is 50 dB.
5. Distortion Test: Measure distortion at normal gain settings and rated power. Feed signals at frequencies of 50, 200, 400, 1000, 3000, 8000, and 12 000 Hz into each preamplifier channel. For each frequency, measure distortion in the paging and all-call amplifier outputs. Maximum acceptable distortion at any frequency is 3 percent total harmonics.
 6. Acoustic Coverage Test: Feed pink noise into system using octaves centered at 500 and 4000 Hz. Use sound-level meter with octave-band filters to measure level at five locations in each zone. For spaces with seated audiences, maximum permissible variation in level is plus or minus 2 dB. In addition, the levels between locations in same zone and between locations in adjacent zones must not vary more than plus or minus 3 dB.
 7. Power Output Test: Measure electrical power output of each power amplifier at normal gain settings of 50, 1000, and 12 000 Hz. Maximum variation in power output at these frequencies must not exceed plus or minus 1 dB.
 8. Signal Ground Test: Measure and report ground resistance at public address equipment signal ground.
 9. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified. Prepare a list of final tap settings of paging speaker-line matching transformers.
- F. Nonconforming Work:
1. Public address system will be considered defective if it does not pass tests and inspections.
 2. Remove and replace defective units and retest.
- G. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.
1. Include a record of final speaker-line matching transformer-tap settings and signal ground-resistance measurement certified by Installer.
- H. Manufacturer Services: Engage factory-authorized service representative to [support][supervise] field tests and inspections.
1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.
- 3.4 STARTUP SERVICE
- A. Perform startup service.
1. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements.
 2. Complete installation and startup checks according to manufacturer's written instructions.
- B. Manufacturer Services: Engage factory-authorized service representative to [support][supervise] system startup.
1. Manufacturer's Field Reports for System Startup Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.



3.5 ADJUSTING

- A. On-Site Assistance: Engage a factory-authorized service representative to provide on-site assistance in adjusting sound levels, resetting transformer taps, and adjusting controls to meet occupancy conditions.
- B. Occupancy Adjustments: When requested within [12]<Insert number> months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to [two]<Insert number> visits to the Project during other-than-normal occupancy hours for this purpose.

3.6 CLOSEOUT ACTIVITIES

- A. Training:
 - 1. **[With assistance from factory-authorized service representatives, train][Train]** Owner's maintenance personnel to adjust, operate, and maintain the public address system and equipment. Refer to Section 017900 "Demonstration and Training."

3.7 PROTECTION

- A. After installation, protect public address system equipment from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 26 33 43 00A



Task	Specification	Specification Description
26 33 43 00	27 52 23 00	Nurse Call Code Blue Systems



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SECTION 26 33 53 00 - STATIC UNINTERRUPTIBLE POWER SUPPLY

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. UPS systems.
2. Surge suppression.
3. Rectifier-charger.
4. Inverter.
5. Controls and indications.
6. Static bypass transfer switch.
7. Maintenance bypass/isolation switch.
8. Output distribution section.
9. Output isolation transformer.
10. Remote status and alarm panel.
11. Remote monitoring.
12. Battery.
13. Basic battery monitoring.
14. Additional battery monitoring.
15. Battery-cycle warranty monitoring.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of UPS.

1. UPS systems.
2. Surge suppression.
3. Rectifier-charger.
4. Inverter.
5. Controls and indications.
6. Static bypass transfer switch.
7. Maintenance bypass/isolation switch.
8. Output distribution section.
9. Output isolation transformer.
10. Remote status and alarm panel.
11. Remote monitoring.
12. Battery.
13. Basic battery monitoring.
14. Additional battery monitoring.
15. Battery-cycle warranty monitoring.

B. Shop Drawings: For UPS.

1. Include plans, elevations, sections, and **[mounting][attachment]** details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Show access, workspace, and clearance requirements; details of control panels; and battery arrangement.
4. Include diagrams for power, signal, and control wiring.

C. Field quality-control reports.**1.3 INFORMATIONAL SUBMITTALS****A. Manufacturers' published instructions.****B. Field Reports:**

1. Factory test reports.
2. Manufacturer's field reports for field quality-control support.

1.4 CLOSEOUT SUBMITTALS

- A. Performance Test Reports:** Indicate test results compared with specified performance requirements, and provide justification and resolution of differences if values do not agree.

1.5 WARRANTY FOR UPS SYSTEM

- A. Special Installer Extended Warranty:** Installer warrants that fabricated and installed UPS system performs in accordance with specified requirements and agrees to repair or replace components or products that fail to perform as specified within extended-warranty period.
1. Extended-Warranty Period: **[Two][Three][Four]<Insert number>** years from date of Substantial Completion; full coverage for labor, materials, and equipment.
- B. Special Manufacturer Extended Warranty:** Manufacturer warrants that UPS system performs in accordance with specified requirements and agrees to provide repair or replacement of components or products that fail to perform as specified within extended-warranty period.
1. Extended-Warranty Period: **[Three][Four][Five]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for labor, materials, and equipment.

1.6 WARRANTY FOR BATTERIES

- A. Special Manufacturer Extended Warranty for Batteries:** Manufacturer warrants that batteries perform in accordance with specified requirements and agrees to provide repair or replacement of batteries that fail to perform as specified within extended-warranty period.
1. Initial Extended-Warranty Period for Ni-Cd Batteries: **[Five]<Insert number>** years from date of Substantial Completion; full coverage for materials only, free on board **[origin][destination]**,

- freight prepaid.
2. Follow-On Extended-Warranty Period for Ni-Cd Batteries: **[15]<Insert number>** years from date of Substantial Completion; prorated coverage for materials only, free on board **[origin][destination]**, freight prepaid.
 3. Additional Warranted Cycle Life Criteria for Standard Valve Regulated (Sealed) Lead Acid Batteries: Equal to or greater than that represented in manufacturer's published table, but not less than the following, based on annual average battery temperature of **77 deg F**:
 - a. For discharge rate not faster than eight hours, discharge duration not longer than eight hours, and voltage at end of discharge not less than 1.67 V, warranted life must be not fewer than six discharge cycles.
 - b. For discharge rate not faster than 30 minutes, discharge duration not longer than 30 minutes, and voltage at end of discharge not less than 1.67 V, warranted life must be not fewer than 20 discharge cycles.
 - c. For discharge rate not faster than 15 minutes, discharge duration not longer than 45 seconds, and voltage at end of discharge not less than 1.67 V, warranted life must be not fewer than 120 discharge cycles.
 4. Additional Warranted Cycle Life Criteria for Premium Valve Regulated (Sealed) Lead Acid Batteries: Equal to or greater than that represented in manufacturer's published table, but not less than the following, based on annual average battery temperature of **77 deg F**:
 - a. For discharge rate not faster than eight hours, discharge duration not longer than eight hours, and voltage at end of discharge not less than 1.67 V, warranted life must be not fewer than 40 discharge cycles.
 - b. For discharge rate not faster than 30 minutes, discharge duration not longer than 30 minutes, and voltage at end of discharge not less than 1.67 V, warranted life must be not fewer than 125 discharge cycles.
 - c. For discharge rate not faster than 15 minutes, discharge duration not longer than 90 seconds, and voltage at end of discharge not less than 1.67 V, warranted life must be not fewer than 750 discharge cycles.
 5. Additional Warranted Cycle Life Criteria for Flooded (Wet Cell or Open) Lead Acid Batteries: Equal to or greater than that represented in manufacturer's published table, but not less than the following, based on annual average battery temperature of **77 deg F** and preventive maintenance performed in accordance with manufacturer's published instructions:
 - a. For discharge rate not faster than eight hours, discharge duration not longer than eight hours, and voltage at end of discharge not less than 1.75 V, warranted life must be not fewer than 40 discharge cycles.
 - b. For discharge rate not faster than one hour, discharge duration not longer than one hour, and voltage at end of discharge not less than 1.75 V, warranted life must be not fewer than 80 discharge cycles.
 - c. For discharge rate not faster than 15 minutes, discharge duration not longer than 45 seconds, and voltage at end of discharge not less than 1.67 V, warranted life must be not fewer than 2700 discharge cycles.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. UL Compliance: Listed and labeled, by qualified electrical testing laboratory recognized by authorities having jurisdiction, in accordance with UL 1778.

- B. NFPA Compliance: UPS components must be listed and labeled, by qualified electrical testing laboratory recognized by authorities having jurisdiction, as suitable for installation in computer rooms in accordance with NFPA 75.
- C. The UPS must perform as specified in this article while supplying rated full-load current, composed of any combination of linear and nonlinear load, up to 100 percent nonlinear load with a maximum load crest factor of 3.0, under the following conditions or combinations of the following conditions:
1. Inverter is switched to battery source.
 2. Steady-state AC input voltage deviates up to plus or minus **[10][15]** percent from nominal voltage.
 3. Steady-state input frequency deviates up to plus or minus 5 percent from nominal frequency.
 4. THD of input voltage is 15 percent or more with a minimum crest factor of 3.0, and the largest single harmonic component is a minimum of 5 percent of the fundamental value.
 5. Load is **[30][50][100]** percent unbalanced continuously.
- D. Minimum Duration of Supply: If battery is sole energy source supplying rated full-load UPS current at 80 percent power factor, duration of supply is **[five][10][15]<Insert duration>** minutes.
- E. Input Voltage Tolerance: System steady-state and transient output performance remains within specified tolerances when steady-state AC input voltage varies plus 10 percent and minus **[15][20][30]** percent from nominal voltage.
- F. Overall UPS Efficiency: Equal to or greater than **[94][95]<Insert number>** percent at 100 percent load, **[94][95]<Insert number>** percent at 75 percent load, and **[93][94]<Insert number>** percent at 25 percent load.
- G. Maximum Acoustical Noise: **<Insert value>**, "A" weighting, emanating from any UPS component under any condition of normal operation, measured **<Insert distance>** from nearest surface of component enclosure.
- H. Maximum Energizing Inrush Current: **[Six times the full-load current][Eight times the full-load current][Soft start linear input current rise to 100 percent over a 1- to 40-second period, factory set at 10 seconds]**.
- I. AC Output-Voltage Regulation for Loads 100 Percent Unbalanced: Maximum of plus or minus 2 percent over the full range of battery voltage.
- J. AC Output-Voltage Regulation for Loads 100 Percent Balanced: Maximum of plus or minus 1 percent over the full range of battery voltage.
- K. Output Frequency: 60 Hz, plus or minus 0.1 percent over the full range of input voltage, load, and battery voltage.
- L. Limitation of harmonic distortion of input current to the UPS must be as follows:
1. Rectifier-charger circuits must limit THD to 5 percent, maximum, at rated full-load UPS current, for power sources with X/R ratio between 2 and 30. Provide tuned harmonic filter if required to meet harmonic distortion limit.
 2. THD is limited to a maximum of 32 percent, at rated full-load UPS current, for power sources with X/R ratio between 2 and 30.
- M. Maximum Harmonic Content of Output-Voltage Waveform: 5 percent RMS total and 3 percent RMS for any single harmonic, for **[100 percent rated nonlinear load current][rated full load with THD up to 50 percent]**, with a load crest factor of 3.0.

- N. Minimum Overload Capacity of UPS at Rated Voltage: 125 percent of rated full load for 10 minutes, 200 percent for 60 seconds in normal operation, and 150 percent for 30 seconds in battery operating mode.
- O. Maximum Output-Voltage Transient Excursions from Rated Value: For the following instantaneous load changes, stated as percentages of rated full UPS load, voltage must remain within stated percentages of rated value and recover to, and remain within, plus or minus 2 percent of that value within 50 ms:
 - 1. 50 Percent: Plus or minus 3 percent.
 - 2. 100 Percent: Plus or minus 5 percent.
 - 3. Loss of AC Input Power: Plus or minus 1 percent.
 - 4. Restoration of AC Input Power: Plus or minus 1 percent.
- P. Input Power Factor: A minimum of **[0.90][0.95]** lagging when supply voltage and current are at nominal rated values and the UPS is supplying rated full-load current without additional filters.
- Q. Output Power Factor Rating: Loads with power factor of 0.9 leading to 0.8 lagging must not require derating of the UPS. For loads with power factors outside this range, derate the UPS output as follows:
 - 1. Derate the UPS a maximum of 5 percent for 0.7 PF lagging.
 - 2. Derate the UPS a maximum of 10 percent for 0.6 PF lagging.
 - 3. Derate the UPS a maximum of 15 percent for 0.5 PF lagging.
 - 4. Derate the UPS a maximum of 20 percent for a range of 0.4 to 0.1 PF lagging.
- R. EMI Emissions: Comply with FCC rules and regulations and with 47 CFR 15 for Class A equipment.

2.2 UPS SYSTEMS

- A. Description: Self-contained, battery backup device and accessories that provides three-phase electrical power in the event of failure or sag in the normal power system.
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[ABB, Electrification Business]**
 - 2. **[APC by Schneider Electric]**
 - 3. **[Eaton]**
 - 4. **[Liebert; Vertiv Holdings Co.]**
 - 5. **[Mitsubishi Electric Automation, Inc]**
 - 6. **[Staco Energy Products Co.]**
 - 7. **[Toshiba International Corporation]**
 - 8. **<Insert manufacturer's name>**
- C. Electronic Equipment: Solid-state devices using hermetically sealed, semiconductor elements. Devices include rectifier-charger, inverter, static bypass transfer switch, and system controls.
- D. Enclosures: Comply with UL 50E, Type 1, unless otherwise indicated.
- E. Configuration: **[Single-cabinet][Multicabinet][Field-assembled, multicabinet]** modular style units.
- F. Control Assemblies: Mount on modular plug-ins, readily accessible for maintenance.
- G. Maintainability Features: Mount rectifier-charger and inverter sections and the static bypass transfer switch on modular plug-ins, readily accessible for maintenance.

- H. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- I. Capacity Upgrade Capability: Arrange wiring, controls, and modular component plug-in provisions to permit future **[25]<Insert number>** percent increase in UPS capacity.
- J. Seismic-Restraint Design: UPS assemblies, subassemblies, and components (and fastenings and supports, mounting, and anchorage devices for them) must be designed and fabricated to withstand static and seismic forces.
- K. UPS Cabinet Ventilation: Redundant fans or blowers draw in ambient air near the bottom of cabinet and discharge it near the top rear.
- L. Output Circuit Neutral Bus, Conductor, and Terminal Ampacity: Rated phase current times a multiple of 1.73, minimum.

2.3 OUTPUT ISOLATION TRANSFORMER

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[APC by Schneider Electric]**
 - 2. **[Eaton]**
 - 3. **<Insert manufacturer's name>**
- B. Description: **[Shielded unit][Unit]** with low forward transfer impedance up to 3 kHz, minimum. Include the following features:
 - 1. Comply with applicable portions of UL 1561, including requirements for nonlinear load current-handling capability for a K-factor of approximately **[4][9][13][20]**.
 - 2. Output Impedance at Fundamental Frequency: Between 3 and 4 percent.
 - 3. Regulation: 5 percent, maximum, at rated nonlinear load current.
 - 4. Full-Load Efficiency at Rated Nonlinear Load Current: 96 percent, minimum.
 - 5. Electrostatic Shielding of Windings: Independent for each winding.
 - 6. Coil Leads: Physically arranged for minimum interlead capacitance.
 - 7. Shield Grounding Terminal: Separately mounted; labeled "Shield Ground."
 - 8. Capacitive Coupling between Primary and Secondary: 33 pF, maximum, over a frequency range of 20 Hz to 1 MHz.

2.4 BATTERY

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[C&D Technologies, Inc.]**
 - 2. **[Eaton]**
 - 3. **[EnerSys]**
 - 4. **[Exide Technologies]**
 - 5. **[Panasonic Corporation of North America]**
 - 6. **<Insert manufacturer's name>**

B. General Characteristics:

1. Valve-regulated, recombinant, lead-calcium units, factory assembled in an isolated compartment of UPS cabinet, complete with battery disconnect switch.
 - a. Arrange for drawout removal of battery assembly from cabinet for testing and inspecting.
2. Valve-regulated, premium, heavy-duty, recombinant, lead-calcium units, complete with battery disconnect switch and intercell connectors.
 - a. Factory assembled in an isolated compartment of UPS cabinet.
 - b. Mount on **[two-tier],[three-tier,]** acid-resistant, painted steel racks.
 - c. Arrange for drawout removal of battery assembly from cabinet for testing and inspecting.
3. Flooded, lead-calcium, heavy-duty industrial units in styrene acrylonitrile containers. Mount on **[two-tier],[three-tier,]** acid-resistant, painted steel racks. Assembly includes battery disconnect switch, intercell connectors, hydrometer syringe, and thermometer with specific gravity-correction scales.
4. Flooded cell, heavy-duty, industrial, Ni-Cd units in polypropylene containers. Mount on **[two-tier],[three-tier,]** acid-resistant, painted steel racks, complete with battery disconnect switch and intercell connectors.
5. Valve-regulated, heavy-duty, industrial, recombinant, pocket plate design, Ni-Cd units in polypropylene containers, complete with battery disconnect switch and intercell connectors.
 - a. Factory assembled in an isolated compartment of UPS cabinet.
 - b. Mount on **[two-tier],[three-tier,]** acid-resistant, painted steel racks.
 - c. Arrange for drawout removal of battery assembly from cabinet for testing and inspecting.

- C. Seismic-Restraint Design: Battery racks, cabinets, assemblies, subassemblies, and components (and fastenings and supports, mounting, and anchorage devices for them) must be designed and fabricated to withstand static and seismic forces.

2.5 BASIC BATTERY MONITORING

- A. Basic Battery Monitoring: Continuous, real-time capture of battery performance data.
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Alber]**
 2. **[APC by Schneider Electric]**
 3. **[BTECH, Inc]**
 4. **[Canara]**
 5. **[Eaton]**
 6. **[Liebert; Vertiv Holdings Co.]**
 7. **[Midtronics, Inc]**
 8. **[Power Systems Specialists, Inc.]**
 9. **[Staco Energy Products Co.]**
 10. **<Insert manufacturer's name>**
- C. Battery Ground-Fault Detector: Initiates alarm when resistance to ground of positive or negative bus of battery is less than 5000 Ω .
- D. Battery compartment high-temperature detector initiates an alarm when smoke or a temperature greater

than **167 deg F** occurs within the compartment.

- E. Battery compartment smoke/high-temperature detector initiates an alarm when smoke or a temperature greater than **167 deg F** occurs within the compartment.
- F. Annunciation of Alarms: At UPS control panel and remotely.

2.6 SOURCE QUALITY CONTROL

- A. Product Data: Prepare and submit catalog cuts, brochures, **[diagrams,][schedules,]** and performance data illustrating size, physical appearance, and other characteristics of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for UPS.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - 3. Product Certificates: For each product, from manufacturer.
 - 4. Sample Warranties: For manufacturer's special warranties.
- B. Factory Tests:
 - 1. Owner will witness required factory tests. Notify Architect at least 14 days before date of tests and indicate their approximate duration.
 - 2. Factory Tests and Inspections: Test and inspect UPS system, by, or under supervision of, qualified electrical testing laboratory recognized by authorities having jurisdiction, in accordance with NETA ATS before delivering to site. Affix label with name and date of **[manufacturer's][qualified electrical testing laboratory's]** certification of system compliance.
 - a. Factory test complete UPS system before shipment. Use **[actual batteries that are part of final installation][the same type of batteries that are part of final installation][simulated battery testing]**. Include the following:
 - 1) Test and demonstration of all functions, controls, indicators, sensors, and protective devices.
 - 2) Full-load test.
 - 3) Transient-load response test.
 - 4) Overload test.
 - 5) Power failure test.
 - 3. Nonconforming Work:
 - a. Equipment that does not pass tests and inspections will be considered defective.
 - 4. Factory Test Reports: Prepare and submit factory test and inspection reports. Include the following data:
 - a. Description of input source and output loads used. Describe actions required to simulate source load variation and various operating conditions and malfunctions.
 - b. List of indications, parameter values, and system responses considered satisfactory for each test action. Include tabulation of actual observations during test.
 - c. List of instruments and equipment used in factory tests.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters **[and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used]**. Conceal raceway and cables except in unfinished spaces.
 - 1. Install plenum cable in environmental air spaces, including plenum ceilings.
 - 2. Comply with requirements for cable trays specified in Section 260536 "Cable Trays for Electrical Systems."
 - 3. Comply with requirements for raceways and boxes specified in Section 260533.13 "Conduits for Electrical Systems."
 - 4. Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- B. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
- C. Equipment Mounting: Install UPS on concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."
 - 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18 inch** centers around the full perimeter of concrete base **6 inch** from the outer edge of the base.
 - 2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 4. Install anchor bolts to elevations required for proper attachment to supported equipment.
- D. Maintain minimum clearances and workspace at equipment in accordance with manufacturer's published instructions and NFPA 70.
- E. Connections: Interconnect system components. Make connections to supply and load circuits in accordance with manufacturer's wiring diagrams unless otherwise indicated. Apply oxide inhibitor on battery terminals.

3.2 FIELD QUALITY CONTROL

- A. Acceptance Testing Preparation:
 - 1. **<Insert requirements>**.
- B. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.
- C. Tests and Inspections:
 - 1. Inspect interiors of enclosures, including the following:
 - a. Inspect anchorage, alignment, grounding, and required clearances.
 - b. Component type and labeling verification.
 - c. Ratings of installed components.

2. Test electrical and mechanical interlock systems for correct operation and sequencing.
3. Inspect bolted electrical connections for high resistance using one or more of the following methods:
 - a. Use of low-resistance ohmmeter in accordance with Section 7.22.2.2 of NETA ATS.
 - b. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published instructions or Table 100.12 of NETA ATS.
 - c. Perform thermographic survey in accordance with Section 9 of NETA ATS.
4. Test static transfer from inverter to bypass and back. Use normal load, if possible.
5. Test DC undervoltage trip level on inverter input breaker. Set in accordance with manufacturer's published instructions.
6. Verify synchronizing indicators for static switch and bypass switches.
7. Test insulated-case and molded-case breakers.
 - a. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer's published instructions. In the absence of manufacturer's published instructions, use Table 100.1 of NETA ATS.
 - b. Perform insulation-resistance tests on all control wiring for ground. Applied potential must be 500 V(dc) for 300 V rated cable and 1000 V(dc) for 600 V rated cable. Test duration must be one minute. For units with solid-state components, follow manufacturer's recommendation.
 - c. Use primary current injection to determine long time and short time, ground fault, and instantaneous pickup, Use secondary current injection to test trip functions.
 - d. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published instructions.
 - e. Verify operation of charging mechanism.
 - f. Verify correct operation of auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, antipump function, and trip unit battery condition. Reset all trip logs and indicators.
8. Test automatic transfer switches.
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter, if applicable, in accordance with Section 7.22.3.1 of NETA ATS.
 - b. Perform insulation-resistance tests on all control wiring for ground. Applied potential must be 500 V(dc) for 300 V rated cable and 1000 V(dc) for 600 V rated cable. Test duration must be one minute. For units with solid-state components or for control devices that cannot tolerate the applied voltage, follow manufacturer's recommendation.
 - c. Perform a contact/pole-resistance test.
 - d. Verify settings and operation of control devices.
 - e. Calibrate and set all relays and timers in accordance with Section 7.9 of NETA ATS.
 - f. Verify phase rotation, phasing, and synchronized operation as required by the application.
 - g. Perform automatic transfer tests.
 - 1) Simulate loss of normal power.
 - 2) Return to normal power.
 - 3) Simulate loss of emergency power.
 - 4) Simulate all forms of single-phase conditions.
 - h. Verify correct operation and timing of the following functions:
 - 1) Normal source voltage-sensing and frequency-sensing relays.

- 2) Time delay on transfer.
 - 3) Alternative source voltage-sensing and frequency-sensing relays.
 - 4) Automatic transfer operation.
 - 5) Interlocks and limit switch function.
 - 6) Time delay and retransfer on normal power restoration.
 9. Test direct current system's batteries.
 - a. Verify adequacy of battery support racks, mounting, anchorage, alignment, grounding, and clearances.
 - b. **[Verify electrolyte level. Measure electrolyte level, specific gravity, and temperature.]**
 - c. Inspect spill containment installation. Measure charger float and equalizing voltage levels. Adjust to battery manufacturer's recommended settings.
 - d. Verify all charger functions and alarms.
 - e. Measure each cell voltage and total battery voltage with charger energized and in float mode of operation.
 - f. Perform a load test in accordance with manufacturer's published instructions or IEEE 450.
 - g. Measure charger float and equalizing voltage levels. Adjust to battery manufacturer's recommended settings.
 - h. Test values.
 - 1) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - 2) Charger float and equalize voltage levels must be in accordance with battery manufacturer's published instructions.
 - 3) The results of charger functions and alarms must be in accordance with manufacturer's published instructions.
 - 4) Cell voltages must be within 0.05 V of each other or in accordance with manufacturer's published instructions.
 - 5) Cell internal ohmic values (resistance, impedance, or conductance) must not vary by more than 25 percent between identical cells that are in a fully charged state.
 - 6) Results of load tests must be in accordance with manufacturer's published instructions or IEEE 450.
 10. Test communication of status and alarms to remote monitoring equipment.
 11. Load the system using a variable-load bank to simulate kilovolt amperes, kilowatts, and power factor of loads for unit's rating. Use instruments calibrated within the previous **[six months]<Insert time>** in accordance with NIST standards.
 - a. Simulate malfunctions to verify protective device operation.
 - b. Test duration of supply on emergency, low-battery voltage shutdown, and transfers and restoration due to normal source failure.
 - c. Test harmonic content of input and output current at 25, 50, and 100 percent of rated loads.
 - d. Test output voltage under specified transient-load conditions.
 - e. Test efficiency at 50, 75, and 100 percent of rated loads.
 - f. Test remote status and alarm panel functions.
 - g. Test battery-monitoring system functions.
- D. Seismic-restraint tests and inspections must include the following:
1. Inspect type, size, quantity, arrangement, and proper installation of mounting or anchorage devices.
 2. Test mounting and anchorage devices in accordance with requirements in Section 260548.16 "Seismic Controls for Electrical Systems."



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- E. Nonconforming Work:
1. The UPS system will be considered defective if it does not pass tests and inspections.
 2. Remove and replace defective units and retest.
- F. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports. Include references to manufacturers' published instructions and other test and inspection criteria. Include results of tests, inspections, and retests.

END OF SECTION 26 33 53 00

SECTION 26 35 33 00 - POWER FACTOR CORRECTION EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. UPS systems.
2. Surge suppression.
3. Rectifier-charger.
4. Inverter.
5. Controls and indications.
6. Static bypass transfer switch.
7. Maintenance bypass/isolation switch.
8. Output distribution section.
9. Output isolation transformer.
10. Remote status and alarm panel.
11. Remote monitoring.
12. Battery.
13. Basic battery monitoring.
14. Additional battery monitoring.
15. Battery-cycle warranty monitoring.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.2 DEFINITIONS

- A. GTO: Gate turn-off thyristor.
- B. IGBT: Isolated gate bipolar transistor.
- C. PF: Power factor.
- D. pF: Picofarads.
- E. THD: Total harmonic distortion.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of UPS.

1. UPS systems.
2. Surge suppression.

3. Rectifier-charger.
4. Inverter.
5. Controls and indications.
6. Static bypass transfer switch.
7. Maintenance bypass/isolation switch.
8. Output distribution section.
9. Output isolation transformer.
10. Remote status and alarm panel.
11. Remote monitoring.
12. Battery.
13. Basic battery monitoring.
14. Additional battery monitoring.
15. Battery-cycle warranty monitoring.

B. Shop Drawings: For UPS.

1. Include plans, elevations, sections, and **[mounting][attachment]** details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Show access, workspace, and clearance requirements; details of control panels; and battery arrangement.
4. Include diagrams for power, signal, and control wiring.

C. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

A. Manufacturers' published instructions.

B. Field Reports:

1. Factory test reports.
2. Manufacturer's field reports for field quality-control support.

1.5 CLOSEOUT SUBMITTALS

- A. Performance Test Reports: Indicate test results compared with specified performance requirements, and provide justification and resolution of differences if values do not agree.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
- B. Spare Parts: Furnish to Owner spare parts, for repairing UPS system, that are packaged with protective covering for storage on-site and identified with labels describing contents. **[Include the following:]**
1. Fuses: **[One]<Insert number>** for every **[10]<Insert number>** of each type and rating, but no fewer than **[one][one set]<Insert number>** of each.

C. Consumable Items:

1. After completion of field quality control, startup, commissioning, adjusting, and closeout activities, replace air filters.
2. Furnish to Owner extra consumable items for storage on-site, identified with labels describing contents. [**Include the following:**]
 - a. Cabinet Ventilation Filters: [One]<Insert number> complete set(s).

1.7 WARRANTY FOR UPS SYSTEM

- A. Special Installer Extended Warranty: Installer warrants that fabricated and installed UPS system performs in accordance with specified requirements and agrees to repair or replace components or products that fail to perform as specified within extended-warranty period.
1. Extended-Warranty Period: [Two][Three][Four]<Insert number> years from date of Substantial Completion; full coverage for labor, materials, and equipment.
- B. Special Manufacturer Extended Warranty: Manufacturer warrants that UPS system performs in accordance with specified requirements and agrees to provide repair or replacement of components or products that fail to perform as specified within extended-warranty period.
1. Extended-Warranty Period: [Three][Four][Five]<Insert number> years from date of Substantial Completion; [full][prorated] coverage for labor, materials, and equipment.

1.8 WARRANTY FOR BATTERIES

- A. Special Manufacturer Extended Warranty for Batteries: Manufacturer warrants that batteries perform in accordance with specified requirements and agrees to provide repair or replacement of batteries that fail to perform as specified within extended-warranty period.
1. Initial Extended-Warranty Period for Ni-Cd Batteries: [Five]<Insert number> years from date of Substantial Completion; full coverage for materials only, free on board [origin][destination], freight prepaid.
 2. Follow-On Extended-Warranty Period for Ni-Cd Batteries: [15]<Insert number> years from date of Substantial Completion; prorated coverage for materials only, free on board [origin][destination], freight prepaid.
 3. Additional Warranted Cycle Life Criteria for Standard Valve Regulated (Sealed) Lead Acid Batteries: Equal to or greater than that represented in manufacturer's published table, but not less than the following, based on annual average battery temperature of 77 deg F (25 deg C):
 - a. For discharge rate not faster than eight hours, discharge duration not longer than eight hours, and voltage at end of discharge not less than 1.67 V, warranted life must be not fewer than six discharge cycles.
 - b. For discharge rate not faster than 30 minutes, discharge duration not longer than 30 minutes, and voltage at end of discharge not less than 1.67 V, warranted life must be not fewer than 20 discharge cycles.
 - c. For discharge rate not faster than 15 minutes, discharge duration not longer than 45 seconds, and voltage at end of discharge not less than 1.67 V, warranted life must be not fewer than 120 discharge cycles.
 4. Additional Warranted Cycle Life Criteria for Premium Valve Regulated (Sealed) Lead Acid Batteries: Equal to or greater than that represented in manufacturer's published table, but not less than the following, based on annual average battery temperature of 77 deg F (25 deg C):

- a. For discharge rate not faster than eight hours, discharge duration not longer than eight hours, and voltage at end of discharge not less than 1.67 V, warranted life must be not fewer than 40 discharge cycles.
 - b. For discharge rate not faster than 30 minutes, discharge duration not longer than 30 minutes, and voltage at end of discharge not less than 1.67 V, warranted life must be not fewer than 125 discharge cycles.
 - c. For discharge rate not faster than 15 minutes, discharge duration not longer than 90 seconds, and voltage at end of discharge not less than 1.67 V, warranted life must be not fewer than 750 discharge cycles.
5. Additional Warranted Cycle Life Criteria for Flooded (Wet Cell or Open) Lead Acid Batteries: Equal to or greater than that represented in manufacturer's published table, but not less than the following, based on annual average battery temperature of **77 deg F (25 deg C)** and preventive maintenance performed in accordance with manufacturer's published instructions:
 - a. For discharge rate not faster than eight hours, discharge duration not longer than eight hours, and voltage at end of discharge not less than 1.75 V, warranted life must be not fewer than 40 discharge cycles.
 - b. For discharge rate not faster than one hour, discharge duration not longer than one hour, and voltage at end of discharge not less than 1.75 V, warranted life must be not fewer than 80 discharge cycles.
 - c. For discharge rate not faster than 15 minutes, discharge duration not longer than 45 seconds, and voltage at end of discharge not less than 1.67 V, warranted life must be not fewer than 2700 discharge cycles.

PART 2 - PRODUCTS

2.1 OPERATIONAL REQUIREMENTS

- A. Automatic operation includes the following:
 1. Double Conversion, Standard Efficiency:
 - a. Normal Conditions: Load is supplied with power flowing from the normal power input terminals, through the rectifier-charger and inverter, with the battery connected in parallel with the rectifier-charger output.
 - b. Abnormal Supply Conditions: If normal supply deviates from specified and adjustable voltage, voltage waveform, or frequency limits, the battery supplies energy to maintain constant, regulated inverter power output to the load without switching or disturbance.
 - c. Power Failure: If normal power fails, energy supplied by the battery through the inverter continues supply-regulated power to the load without switching or disturbance.
 2. Double Conversion, Line Interactive:
 - a. Normal Conditions: Load is supplied with power flowing from the normal power input terminals, with the rectifier-charger and inverter turned off and the battery disconnected.
 - b. Abnormal Supply Conditions: If normal supply deviates from specified and adjustable voltage, voltage waveform, or frequency limits, the rectifier-charger and inverter turn on and the battery supplies energy to provide constant, regulated inverter power output to the load with minimum of 98 percent UPS system efficiency.
 - c. Power Failure: If normal power fails, there is a maximum 4 μ s delay while the rectifier-charger and inverter turn on and the battery supplies energy to re-establish constant, regulated power output to the load.

3. Double Conversion, IGBT:
 - a. Normal Conditions: Load is supplied with power flowing from the normal power input terminals, through the rectifier-charger and inverter, with the battery connected in parallel with the rectifier-charger output. High-efficiency carrier stored trench IGBT, in both rectifier-charger and inverter circuits, provides a minimum of 97 percent efficiency for the UPS system at full load and a minimum of 94 percent efficiency at 50 percent load.
 - b. Abnormal Supply Conditions: If normal supply deviates from specified and adjustable voltage, voltage waveform, or frequency limits, the battery supplies energy to provide constant, regulated inverter power output to the load.
 - c. Power Failure: If normal power fails, the rectifier-charger and inverter use energy from the battery to supply constant, regulated power output to the load without switching or disturbance.
 4. When power is restored at the normal supply terminals of the system, controls must automatically synchronize the inverter with the external source before transferring the load. The rectifier-charger must supply power to the load through the inverter and simultaneously recharge the battery.
 5. If the battery becomes discharged and normal supply is available, the rectifier-charger must charge the battery. The rectifier-charger must automatically shift to float-charge mode on reaching full charge.
 6. If any element of the UPS system fails and power is available at the normal supply terminals of the system, the static bypass transfer switch must switch the load to the normal AC supply circuit without disturbance or interruption.
 7. The output power converters must produce up to 300 percent of rated full-load current for short-circuit clearing. The inverter must sustain steady-state overload conditions of up to 200 percent of rated full-load current for 60 seconds in normal operation.
 8. The inverter must be capable of sustaining 150 percent of system capacity for 30 seconds while powered from the battery.
 9. Should overloads persist past the time limitations, the automatic static transfer switch must switch the load to the bypass output of the UPS. When the fault has cleared, the static bypass transfer switch must return the load to the UPS system.
 10. If the battery is disconnected, the UPS must supply power to the load from the normal supply with no degradation of its regulation of voltage and frequency of the output bus.
- B. Manual operation includes the following:
1. Turning the inverter off causes the static bypass transfer switch to transfer the load directly to the normal AC supply circuit without disturbance or interruption.
 2. Turning the inverter on causes the static bypass transfer switch to transfer the load to the inverter.
- C. Maintenance Bypass/Isolation Switch Operation: Switch is interlocked so it cannot be operated unless the static bypass transfer switch is in the bypass mode. Device provides manual selection among the three conditions described below without interrupting supply to the load during switching:
1. Full Isolation: Load is supplied, bypassing the UPS. Normal UPS AC input circuit, static bypass transfer switch, and UPS load terminals are completely disconnected from external circuits.
 2. Maintenance Bypass: Load is supplied, bypassing the UPS. UPS AC supply terminals are energized to permit operational checking, but system load terminals are isolated from the load.
 3. Normal: Normal UPS AC supply terminals are energized and the load is supplied through the static bypass transfer switch and the UPS rectifier-charger and inverter, or the battery and the inverter.

2.2 PERFORMANCE REQUIREMENTS

- A. UL Compliance: Listed and labeled, by qualified electrical testing laboratory recognized by authorities having jurisdiction, in accordance with UL 1778.
- B. NFPA Compliance: UPS components must be listed and labeled, by qualified electrical testing laboratory recognized by authorities having jurisdiction, as suitable for installation in computer rooms in accordance with NFPA 75.
- C. The UPS must perform as specified in this article while supplying rated full-load current, composed of any combination of linear and nonlinear load, up to 100 percent nonlinear load with a maximum load crest factor of 3.0, under the following conditions or combinations of the following conditions:
 - 1. Inverter is switched to battery source.
 - 2. Steady-state AC input voltage deviates up to plus or minus **[10][15]** percent from nominal voltage.
 - 3. Steady-state input frequency deviates up to plus or minus 5 percent from nominal frequency.
 - 4. THD of input voltage is 15 percent or more with a minimum crest factor of 3.0, and the largest single harmonic component is a minimum of 5 percent of the fundamental value.
 - 5. Load is **[30][50][100]** percent unbalanced continuously.
- D. Minimum Duration of Supply: If battery is sole energy source supplying rated full-load UPS current at 80 percent power factor, duration of supply is **[five][10][15]<Insert duration>** minutes.
- E. Input Voltage Tolerance: System steady-state and transient output performance remains within specified tolerances when steady-state AC input voltage varies plus 10 percent and minus **[15][20][30]** percent from nominal voltage.
- F. Overall UPS Efficiency: Equal to or greater than **[94][95]<Insert number>** percent at 100 percent load, **[94][95]<Insert number>** percent at 75 percent load, and **[93][94]<Insert number>** percent at 25 percent load.
- G. Maximum Acoustical Noise: **<Insert value>**, "A" weighting, emanating from any UPS component under any condition of normal operation, measured **<Insert distance>** from nearest surface of component enclosure.
- H. Maximum Energizing Inrush Current: **[Six times the full-load current][Eight times the full-load current][Soft start linear input current rise to 100 percent over a 1- to 40-second period, factory set at 10 seconds]**.
- I. AC Output-Voltage Regulation for Loads 100 Percent Unbalanced: Maximum of plus or minus 2 percent over the full range of battery voltage.
- J. AC Output-Voltage Regulation for Loads 100 Percent Balanced: Maximum of plus or minus 1 percent over the full range of battery voltage.
- K. Output Frequency: 60 Hz, plus or minus 0.1 percent over the full range of input voltage, load, and battery voltage.
- L. Limitation of harmonic distortion of input current to the UPS must be as follows:
 - 1. Rectifier-charger circuits must limit THD to 5 percent, maximum, at rated full-load UPS current, for power sources with X/R ratio between 2 and 30. Provide tuned harmonic filter if required to meet harmonic distortion limit.
 - 2. THD is limited to a maximum of 32 percent, at rated full-load UPS current, for power sources with X/R ratio between 2 and 30.

- M. Maximum Harmonic Content of Output-Voltage Waveform: 5 percent RMS total and 3 percent RMS for any single harmonic, for **[100 percent rated nonlinear load current][rated full load with THD up to 50 percent]**, with a load crest factor of 3.0.
- N. Minimum Overload Capacity of UPS at Rated Voltage: 125 percent of rated full load for 10 minutes, 200 percent for 60 seconds in normal operation, and 150 percent for 30 seconds in battery operating mode.
- O. Maximum Output-Voltage Transient Excursions from Rated Value: For the following instantaneous load changes, stated as percentages of rated full UPS load, voltage must remain within stated percentages of rated value and recover to, and remain within, plus or minus 2 percent of that value within 50 ms:
 - 1. 50 Percent: Plus or minus 3 percent.
 - 2. 100 Percent: Plus or minus 5 percent.
 - 3. Loss of AC Input Power: Plus or minus 1 percent.
 - 4. Restoration of AC Input Power: Plus or minus 1 percent.
- P. Input Power Factor: A minimum of **[0.90][0.95]** lagging when supply voltage and current are at nominal rated values and the UPS is supplying rated full-load current without additional filters.
- Q. Output Power Factor Rating: Loads with power factor of 0.9 leading to 0.8 lagging must not require derating of the UPS. For loads with power factors outside this range, derate the UPS output as follows:
 - 1. Derate the UPS a maximum of 5 percent for 0.7 PF lagging.
 - 2. Derate the UPS a maximum of 10 percent for 0.6 PF lagging.
 - 3. Derate the UPS a maximum of 15 percent for 0.5 PF lagging.
 - 4. Derate the UPS a maximum of 20 percent for a range of 0.4 to 0.1 PF lagging.
- R. EMI Emissions: Comply with FCC rules and regulations and with 47 CFR 15 for Class A equipment.

2.3 UPS SYSTEMS

- A. Description: Self-contained, battery backup device and accessories that provides three-phase electrical power in the event of failure or sag in the normal power system.
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[ABB, Electrification Business]**
 - 2. **[APC by Schneider Electric]**
 - 3. **[Eaton]**
 - 4. **[Liebert; Vertiv Holdings Co.]**
 - 5. **[Mitsubishi Electric Automation, Inc]**
 - 6. **[Staco Energy Products Co.]**
 - 7. **[Toshiba International Corporation]**
 - 8. **<Insert manufacturer's name>**
- C. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[ABB, Electrification Business]**
 - 2. **[APC by Schneider Electric]**
 - 3. **[Eaton]**
 - 4. **[Liebert; Vertiv Holdings Co.]**
 - 5. **[Mitsubishi Electric Automation, Inc]**

6. **[Staco Energy Products Co.]**
7. **[Toshiba International Corporation]**
8. **<Insert manufacturer's name>**

- D. Electronic Equipment: Solid-state devices using hermetically sealed, semiconductor elements. Devices include rectifier-charger, inverter, static bypass transfer switch, and system controls.
- E. Enclosures: Comply with UL 50E, Type 1, unless otherwise indicated.
- F. Configuration: **[Single-cabinet][Multicabinet][Field-assembled, multicabinet]** modular style units.
- G. Control Assemblies: Mount on modular plug-ins, readily accessible for maintenance.
- H. Maintainability Features: Mount rectifier-charger and inverter sections and the static bypass transfer switch on modular plug-ins, readily accessible for maintenance.
- I. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- J. Capacity Upgrade Capability: Arrange wiring, controls, and modular component plug-in provisions to permit future **[25]<Insert number>** percent increase in UPS capacity.
- K. Seismic-Restraint Design: UPS assemblies, subassemblies, and components (and fastenings and supports, mounting, and anchorage devices for them) must be designed and fabricated to withstand static and seismic forces.
- L. UPS Cabinet Ventilation: Redundant fans or blowers draw in ambient air near the bottom of cabinet and discharge it near the top rear.
- M. Output Circuit Neutral Bus, Conductor, and Terminal Ampacity: Rated phase current times a multiple of 1.73, minimum.

2.4 SURGE SUPPRESSION

- A. Protect internal UPS components from surges that enter at each AC power input connection including main disconnect switch, static bypass transfer switch[, **and maintenance bypass/isolation switch**]. Protect rectifier-charger, inverter, controls, and output components.
 1. Use factory-installed surge suppressors tested in accordance with IEEE C62.41.1 and IEEE C62.41.2, **[Category B][Category C]**.
 2. Additional Surge Protection: Protect internal UPS components from low-frequency, high-energy voltage surges described in IEEE C62.41.1 and IEEE C62.41.2. Design the circuits connecting with external power sources and select circuit elements, conductors, conventional surge suppressors, and rectifier components and controls so input assemblies will have adequate mechanical strength and thermal and current-carrying capacity to withstand stresses imposed by 400 Hz, 180 percent voltage surges described in IEEE C62.41.1 and IEEE C62.41.2.

2.5 RECTIFIER-CHARGER

- A. Description: Voltage source converter, **[six][12]**-pulse **[IGBT][GTO]** rectifier.

- B. Capacity: Adequate to supply the inverter during rated full output load conditions and simultaneously recharge the battery from fully discharged condition to 95 percent of full charge within 10 times the rated discharge time for duration of supply under battery power at full load.
- C. Output Ripple: Limited by output filtration to less than 0.5 percent of rated current, peak to peak.
- D. Control Circuits: Immune to frequency variations within rated frequency ranges of normal and emergency power sources.
 - 1. Response Time: Field adjustable for maximum compatibility with local generator-set power source.
- E. Battery Float-Charging Conditions: Comply with battery manufacturer's published instructions for battery terminal voltage and charging current required for maximum battery life. The battery charger must be matched to the battery type supplied.
- F. Ni-Cd Battery Charger: Sense full charge by measuring the rate of temperature increase. Battery charging must be terminated when the rate of temperature rise reaches **1.8 deg F (1 deg C)** per minute. If the battery reaches **140 deg F (60 deg C)** prior to reaching this rate of temperature rise, charging must terminate. Chargers that determine full charge by voltage measurement to sense a 10 mV drop per cell when reaching full charge are also acceptable.

2.6 INVERTER

- A. Description:
 - 1. Pulse-width modulated, **[carrier stored trench IGBT][IGBT]** with sinusoidal output.
 - 2. Include a bypass phase synchronization window adjustment to optimize compatibility with local engine-generator-set power source.

2.7 CONTROLS AND INDICATIONS

- A. Description: Group displays, indications, and basic system controls on a common control panel on front of UPS enclosure.
- B. Minimum displays, indicating devices, and controls include those in lists below. Provide sensors, transducers, terminals, relays, and wiring required to support listed items. Alarms include audible signals and visual displays.
- C. Indications: **[Labeled LED][Plain-language messages on a digital LCD]**.
 - 1. Quantitative indications must include the following:
 - a. Input voltage, each phase, line to line.
 - b. Input current, each phase, line to line.
 - c. Bypass input voltage, each phase, line to line.
 - d. Bypass input frequency.
 - e. System output voltage, each phase, line to line.
 - f. System output current, each phase.
 - g. System output frequency.
 - h. DC bus voltage.
 - i. Battery current and direction (charge/discharge).
 - j. Elapsed time discharging battery.

2. Basic status condition indications must include the following:

- a. Normal operation.
- b. Load-on bypass.
- c. Load-on battery.
- d. Inverter off.
- e. Alarm condition.

3. Alarm indications must include the following:

- a. Bypass AC input overvoltage or undervoltage.
- b. Bypass AC input overfrequency or underfrequency.
- c. Bypass AC input and inverter out of synchronization.
- d. Bypass AC input wrong-phase rotation.
- e. Bypass AC input single-phase condition.
- f. Bypass AC input filter fuse blown.
- g. Internal frequency standard in use.
- h. Battery system alarm.
- i. Control power failure.
- j. Fan failure.
- k. UPS overload.
- l. Battery-charging control faulty.
- m. Input overvoltage or undervoltage.
- n. Input transformer overtemperature.
- o. Input circuit breaker tripped.
- p. Input wrong-phase rotation.
- q. Input single-phase condition.
- r. Approaching end of battery operation.
- s. Battery undervoltage shutdown.
- t. Maximum battery voltage.
- u. Inverter fuse blown.
- v. Inverter transformer overtemperature.
- w. Inverter overtemperature.
- x. Static bypass transfer switch overtemperature.
- y. Inverter power supply fault.
- z. Inverter transistors out of saturation.
- aa. Identification of faulty inverter section/leg.
- bb. Inverter output overvoltage or undervoltage.
- cc. UPS overload shutdown.
- dd. Inverter current sensor fault.
- ee. Inverter output contactor open.
- ff. Inverter current limit.

4. Controls must include the following:

- a. Inverter on-off.
- b. UPS start.
- c. Battery test.
- d. Alarm silence/reset.
- e. Output-voltage adjustment.

D. Dry-form "C" contacts must be available for remote indication of the following conditions:

- 1. UPS on battery.
- 2. UPS on-line.

3. UPS load-on bypass.
4. UPS in alarm condition.
5. UPS off (maintenance bypass closed).

- E. Emergency Power off Switch: Capable of local operation and operation by means of activation by external dry contacts.

2.8 STATIC BYPASS TRANSFER SWITCH

- A. Description: Solid-state switching device providing uninterrupted transfer with a contactor or electrically operated circuit breaker to automatically provide electrical isolation for the switch.
- B. Switch Rating: Continuous duty at the rated full-load UPS current, minimum.
- C. Input SPD: **[80][160]** kA.

2.9 MAINTENANCE BYPASS/ISOLATION SWITCH

- A. Description: Manually operated switch or arrangement of switching devices with mechanically actuated contact mechanism arranged to route the flow of power to the load around the rectifier-charger, inverter, and static bypass transfer switch.
1. Switch must be electrically and mechanically interlocked to prevent interrupting power to the load when switching to bypass mode.
 2. Switch must electrically isolate other UPS components to permit safe servicing.
 3. Switch must electrically isolate the rectifier-charger, inverter, and static bypass transfer switch from the load, but must allow primary power to the UPS for testing.
- B. Comply with NEMA PB 2 and UL 891.
- C. Switch Rating: Continuous duty at rated full-load UPS current.
- D. Mounting Provisions: **[Internal to system cabinet][Separate wall- or floor-mounted unit]**.
- E. Key interlock with key that is released only when the rectifier-charger and inverter are bypassed by the static bypass transfer switch. Key must be required to unlock maintenance bypass/isolation switch before switching from open (normal) position to closed position. Lock must be designed specifically for mechanical and electrical component interlocking.

2.10 OUTPUT DISTRIBUTION SECTION

- A. Panelboards: Comply with Section 262416 "Panelboards," except provide assembly integral to UPS cabinet.

2.11 OUTPUT ISOLATION TRANSFORMER

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

2. **[Eaton]**
3. **<Insert manufacturer's name>**

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

1. **[APC by Schneider Electric]**
2. **[Eaton]**
3. **<Insert manufacturer's name>**

C. Description: **[Shielded unit][Unit]** with low forward transfer impedance up to 3 kHz, minimum. Include the following features:

1. Comply with applicable portions of UL 1561, including requirements for nonlinear load current-handling capability for a K-factor of approximately **[4][9][13][20]**.
2. Output Impedance at Fundamental Frequency: Between 3 and 4 percent.
3. Regulation: 5 percent, maximum, at rated nonlinear load current.
4. Full-Load Efficiency at Rated Nonlinear Load Current: 96 percent, minimum.
5. Electrostatic Shielding of Windings: Independent for each winding.
6. Coil Leads: Physically arranged for minimum interlead capacitance.
7. Shield Grounding Terminal: Separately mounted; labeled "Shield Ground."
8. Capacitive Coupling between Primary and Secondary: 33 pF, maximum, over a frequency range of 20 Hz to 1 MHz.

2.12 REMOTE STATUS AND ALARM PANEL

A. Description: Labeled LEDs on panel faceplate indicating **[five]<Insert quantity>** basic status conditions. Audible signal indicates alarm conditions. Silencing switch in face of panel silences signal without altering visual indication.

1. Cabinet and Faceplate: Surface or flush mounted to suit mounting conditions indicated.

2.13 REMOTE MONITORING

A. Description: Communication module in unit control panel provides capability for remote monitoring of status, parameters, and alarms specified in "Controls and Indications" Article. The remote computer and the connecting signal wiring are not included in this Section. Include the following features:

1. Connectors and network interface units for data transmission via TIA-485, Ethernet, or web-based link.
2. Software designed for control and monitoring of UPS functions and to provide on-screen explanations, interpretations, diagnosis, action guidance, and instructions for use of monitoring indications and development of meaningful reports. Permit storage and analysis of power-line transient records. Designs for Windows applications, software, and computer are not included in this Section.
3. Software and Hardware: Compatible with that specified in Section 260913 "Electrical Power Monitoring and Control."

2.14 BATTERY

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

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

1. [C&D Technologies, Inc.]
2. [Eaton]
3. [EnerSys]
4. [Exide Technologies]
5. [Panasonic Corporation of North America]
6. <Insert manufacturer's name>

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

1. [C&D Technologies, Inc.]
2. [Eaton]
3. [EnerSys]
4. [Exide Technologies]
5. [Panasonic Corporation of North America]
6. <Insert manufacturer's name>

- C. General Characteristics:

1. Valve-regulated, recombinant, lead-calcium units, factory assembled in an isolated compartment of UPS cabinet, complete with battery disconnect switch.
 - a. Arrange for drawout removal of battery assembly from cabinet for testing and inspecting.
2. Valve-regulated, premium, heavy-duty, recombinant, lead-calcium units, complete with battery disconnect switch and intercell connectors.
 - a. Factory assembled in an isolated compartment of UPS cabinet.
 - b. Mount on [two-tier],[three-tier,] acid-resistant, painted steel racks.
 - c. Arrange for drawout removal of battery assembly from cabinet for testing and inspecting.
3. Flooded, lead-calcium, heavy-duty industrial units in styrene acrylonitrile containers. Mount on [two-tier],[three-tier,] acid-resistant, painted steel racks. Assembly includes battery disconnect switch, intercell connectors, hydrometer syringe, and thermometer with specific gravity-correction scales.
4. Flooded cell, heavy-duty, industrial, Ni-Cd units in polypropylene containers. Mount on [two-tier],[three-tier,] acid-resistant, painted steel racks, complete with battery disconnect switch and intercell connectors.
5. Valve-regulated, heavy-duty, industrial, recombinant, pocket plate design, Ni-Cd units in polypropylene containers, complete with battery disconnect switch and intercell connectors.
 - a. Factory assembled in an isolated compartment of UPS cabinet.
 - b. Mount on [two-tier],[three-tier,] acid-resistant, painted steel racks.
 - c. Arrange for drawout removal of battery assembly from cabinet for testing and inspecting.

- D. Seismic-Restraint Design: Battery racks, cabinets, assemblies, subassemblies, and components (and fastenings and supports, mounting, and anchorage devices for them) must be designed and fabricated to withstand static and seismic forces.

2.15 BASIC BATTERY MONITORING

- A. Basic Battery Monitoring: Continuous, real-time capture of battery performance data.

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

1. **[Alber]**
2. **[APC by Schneider Electric]**
3. **[BTECH, Inc]**
4. **[Canara]**
5. **[Eaton]**
6. **[Liebert; Vertiv Holdings Co.]**
7. **[Midtronics, Inc]**
8. **[Power Systems Specialists, Inc.]**
9. **[Staco Energy Products Co.]**
10. **<Insert manufacturer's name>**

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

1. **[Alber]**
2. **[APC by Schneider Electric]**
3. **[BTECH, Inc]**
4. **[Canara]**
5. **[Eaton]**
6. **[Liebert; Vertiv Holdings Co.]**
7. **[Midtronics, Inc]**
8. **[Power Systems Specialists, Inc.]**
9. **[Staco Energy Products Co.]**
10. **<Insert manufacturer's name>**

- D. Battery Ground-Fault Detector: Initiates alarm when resistance to ground of positive or negative bus of battery is less than 5000 Ω .
- E. Battery compartment high-temperature detector initiates an alarm when smoke or a temperature greater than **167 deg F (75 deg C)** occurs within the compartment.
- F. Battery compartment smoke/high-temperature detector initiates an alarm when smoke or a temperature greater than **167 deg F (75 deg C)** occurs within the compartment.
- G. Annunciation of Alarms: At UPS control panel and remotely.

2.16 ADDITIONAL BATTERY MONITORING

- A. Monitoring features and components must include the following:
1. Factory-wired sensing leads to cell and battery terminals and cell temperature sensors.
 2. Connections for data transmission via TIA-485 link, **[and][network interface and]** external signal wiring to **[computer][electrical power monitoring and control equipment]**. External signal wiring and computer are not specified in this Section.
 3. USB ports for printer and accessories.
 4. PC-based software designed to store and analyze battery data, compile reports on individual-cell parameters and total battery performance trends, and provide data for scheduling and prioritizing battery maintenance.
- B. Operation: Automatically measure and electronically record the following parameters on a routine

schedule and during battery discharge events. During discharge events, record measurements timed to nearest second; including measurements of the following parameters:

1. Total battery voltage and ambient temperature.
2. Individual-cell voltage, impedance, and temperature, and string current. During battery-discharging events such as utility outages, measures battery and cell voltages, battery string current and records values versus time to nearest second.
3. Individual-cell electrolyte levels.

2.17 BATTERY-CYCLE WARRANTY MONITORING

- A. Description: Electronic device, acceptable to battery manufacturer as a basis for warranty action, for monitoring of charge-discharge cycle history of batteries covered by cycle-life warranties.
- B. Operation: Automatically measure and record each discharge event, classify it according to duration category and total discharges in accordance with warranty criteria, and display remaining warranted battery life on front panel display.
- C. Additional monitoring functions and features must include the following:
 1. Measuring and Recording: Total voltage at battery terminal. Initiate an alarm for excursions outside the proper float-voltage level.
 2. Monitoring: Ambient temperature at battery; initiate an alarm if temperature deviates from normally acceptable range.
 3. Keypad on Device Front Panel: Provide access to monitored data using front panel display.
 4. Alarm Contacts: Arrange to initiate **[local][remote]** alarm for **[battery discharge events][abnormal temperature][abnormal battery voltage or temperature]**.
 5. Memory: Store recorded data in nonvolatile electronic memory.
 6. Ethernet Port: Permits downloading of data to a PC.

2.18 SOURCE QUALITY CONTROL

- A. Product Data: Prepare and submit catalog cuts, brochures, **[diagrams,][schedules,]** and performance data illustrating size, physical appearance, and other characteristics of product.
 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for UPS.
 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 3. Product Certificates: For each product, from manufacturer.
 4. Sample Warranties: For manufacturer's special warranties.
- B. Factory Tests:
 1. Owner will witness required factory tests. Notify Architect at least 14 days before date of tests and indicate their approximate duration.
 2. Factory Tests and Inspections: Test and inspect UPS system, by, or under supervision of, qualified electrical testing laboratory recognized by authorities having jurisdiction, in accordance with NETA ATS before delivering to site. Affix label with name and date of **[manufacturer's][qualified electrical testing laboratory's]** certification of system compliance.
 - a. Factory test complete UPS system before shipment. Use **[actual batteries that are part of final installation][the same type of batteries that are part of final installation][simulated battery testing]**. Include the following:

- 1) Test and demonstration of all functions, controls, indicators, sensors, and protective devices.
 - 2) Full-load test.
 - 3) Transient-load response test.
 - 4) Overload test.
 - 5) Power failure test.
3. Nonconforming Work:
 - a. Equipment that does not pass tests and inspections will be considered defective.
4. Factory Test Reports: Prepare and submit factory test and inspection reports. Include the following data:
 - a. Description of input source and output loads used. Describe actions required to simulate source load variation and various operating conditions and malfunctions.
 - b. List of indications, parameter values, and system responses considered satisfactory for each test action. Include tabulation of actual observations during test.
 - c. List of instruments and equipment used in factory tests.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for conditions affecting performance of the UPS.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.
- C. Verify installation conditions are representative of the conditions used in the coordination studies for the electrical system. Provide fuse protection in accordance with Section 262813 "Fuses" if required for coordination with UPS overcurrent protective device requirements.

3.2 INSTALLATION

- A. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters[**and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used**]. Conceal raceway and cables except in unfinished spaces.
 1. Install plenum cable in environmental air spaces, including plenum ceilings.
 2. Comply with requirements for cable trays specified in Section 260536 "Cable Trays for Electrical Systems."
 3. Comply with requirements for raceways and boxes specified in Section 260533.13 "Conduits for Electrical Systems."
 4. Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- B. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
- C. Equipment Mounting: Install UPS on concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18 inch (450 mm)** centers around the full perimeter of concrete base **6 inch (150 mm)** from the outer edge of the base.
 2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 4. Install anchor bolts to elevations required for proper attachment to supported equipment.
- D. Maintain minimum clearances and workspace at equipment in accordance with manufacturer's published instructions and NFPA 70.
- E. Connections: Interconnect system components. Make connections to supply and load circuits in accordance with manufacturer's wiring diagrams unless otherwise indicated. Apply oxide inhibitor on battery terminals.

3.3 GROUNDING

A. Separately Derived Systems:

1. If not part of a listed power supply for a data-processing room, comply with NFPA 70 requirements for connecting to grounding electrodes and for bonding to metallic piping near isolation transformer. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."
2. If part of a listed power supply for a data-processing room, comply with manufacturer's published instructions that include grounding requirements in excess of NFPA 70 requirements for connecting to grounding electrodes and for bonding to metallic piping near isolation transformer. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.4 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
1. Identify each battery cell individually.

3.5 BATTERY EQUALIZATION

- A. Equalize charging of battery cells in accordance with manufacturer's published instructions. Record individual-cell voltages.

3.6 FIELD QUALITY CONTROL

- A. Acceptance Testing Preparation:
1. **<Insert requirements>**.
- B. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.
- C. Tests and Inspections:

1. Inspect interiors of enclosures, including the following:
 - a. Inspect anchorage, alignment, grounding, and required clearances.
 - b. Component type and labeling verification.
 - c. Ratings of installed components.
2. Test electrical and mechanical interlock systems for correct operation and sequencing.
3. Inspect bolted electrical connections for high resistance using one or more of the following methods:
 - a. Use of low-resistance ohmmeter in accordance with Section 7.22.2.2 of NETA ATS.
 - b. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published instructions or Table 100.12 of NETA ATS.
 - c. Perform thermographic survey in accordance with Section 9 of NETA ATS.
4. Test static transfer from inverter to bypass and back. Use normal load, if possible.
5. Test DC undervoltage trip level on inverter input breaker. Set in accordance with manufacturer's published instructions.
6. Verify synchronizing indicators for static switch and bypass switches.
7. Test insulated-case and molded-case breakers.
 - a. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer's published instructions. In the absence of manufacturer's published instructions, use Table 100.1 of NETA ATS.
 - b. Perform insulation-resistance tests on all control wiring for ground. Applied potential must be 500 V(dc) for 300 V rated cable and 1000 V(dc) for 600 V rated cable. Test duration must be one minute. For units with solid-state components, follow manufacturer's recommendation.
 - c. Use primary current injection to determine long time and short time, ground fault, and instantaneous pickup. Use secondary current injection to test trip functions.
 - d. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published instructions.
 - e. Verify operation of charging mechanism.
 - f. Verify correct operation of auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, antipump function, and trip unit battery condition. Reset all trip logs and indicators.
8. Test automatic transfer switches.
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter, if applicable, in accordance with Section 7.22.3.1 of NETA ATS.
 - b. Perform insulation-resistance tests on all control wiring for ground. Applied potential must be 500 V(dc) for 300 V rated cable and 1000 V(dc) for 600 V rated cable. Test duration must be one minute. For units with solid-state components or for control devices that cannot tolerate the applied voltage, follow manufacturer's recommendation.
 - c. Perform a contact/pole-resistance test.
 - d. Verify settings and operation of control devices.
 - e. Calibrate and set all relays and timers in accordance with Section 7.9 of NETA ATS.
 - f. Verify phase rotation, phasing, and synchronized operation as required by the application.
 - g. Perform automatic transfer tests.
 - 1) Simulate loss of normal power.
 - 2) Return to normal power.

- 3) Simulate loss of emergency power.
 - 4) Simulate all forms of single-phase conditions.
 - h. Verify correct operation and timing of the following functions:
 - 1) Normal source voltage-sensing and frequency-sensing relays.
 - 2) Time delay on transfer.
 - 3) Alternative source voltage-sensing and frequency-sensing relays.
 - 4) Automatic transfer operation.
 - 5) Interlocks and limit switch function.
 - 6) Time delay and retransfer on normal power restoration.
9. Test direct current system's batteries.
 - a. Verify adequacy of battery support racks, mounting, anchorage, alignment, grounding, and clearances.
 - b. **[Verify electrolyte level. Measure electrolyte level, specific gravity, and temperature.]**
 - c. Inspect spill containment installation. Measure charger float and equalizing voltage levels. Adjust to battery manufacturer's recommended settings.
 - d. Verify all charger functions and alarms.
 - e. Measure each cell voltage and total battery voltage with charger energized and in float mode of operation.
 - f. Perform a load test in accordance with manufacturer's published instructions or IEEE 450.
 - g. Measure charger float and equalizing voltage levels. Adjust to battery manufacturer's recommended settings.
 - h. Test values.
 - 1) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - 2) Charger float and equalize voltage levels must be in accordance with battery manufacturer's published instructions.
 - 3) The results of charger functions and alarms must be in accordance with manufacturer's published instructions.
 - 4) Cell voltages must be within 0.05 V of each other or in accordance with manufacturer's published instructions.
 - 5) Cell internal ohmic values (resistance, impedance, or conductance) must not vary by more than 25 percent between identical cells that are in a fully charged state.
 - 6) Results of load tests must be in accordance with manufacturer's published instructions or IEEE 450.
10. Test communication of status and alarms to remote monitoring equipment.
11. Load the system using a variable-load bank to simulate kilovolt amperes, kilowatts, and power factor of loads for unit's rating. Use instruments calibrated within the previous **[six months]<Insert time>** in accordance with NIST standards.
 - a. Simulate malfunctions to verify protective device operation.
 - b. Test duration of supply on emergency, low-battery voltage shutdown, and transfers and restoration due to normal source failure.
 - c. Test harmonic content of input and output current at 25, 50, and 100 percent of rated loads.
 - d. Test output voltage under specified transient-load conditions.
 - e. Test efficiency at 50, 75, and 100 percent of rated loads.
 - f. Test remote status and alarm panel functions.
 - g. Test battery-monitoring system functions.

- D. Seismic-restraint tests and inspections must include the following:
1. Inspect type, size, quantity, arrangement, and proper installation of mounting or anchorage devices.
 2. Test mounting and anchorage devices in accordance with requirements in Section 260548.16 "Seismic Controls for Electrical Systems."
- E. Nonconforming Work:
1. The UPS system will be considered defective if it does not pass tests and inspections.
 2. Remove and replace defective units and retest.
- F. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports. Include references to manufacturers' published instructions and other test and inspection criteria. Include results of tests, inspections, and retests.

3.7 PERFORMANCE TESTING

- A. Engage the services of a qualified power quality specialist to perform tests and activities indicated[**for each UPS system**].
- B. Monitoring and Testing Schedule: Perform monitoring and testing in [**a single 10-day period**][**four 10-day periods, each in a different season of the year**]<Insert period>.
1. Schedule monitoring and testing activity with Owner, through Architect, with at least 14 days' advance notice.
 2. Schedule monitoring and testing after Substantial Completion, when the UPS is supplying power to its intended load.
- C. Monitoring and Testing Instruments: Three-phase, recording, power monitors. Instruments must provide continuous simultaneous monitoring of electrical parameters at UPS input terminals and at input terminals of loads served by the UPS. Instruments must monitor, measure, and graph voltage current and frequency simultaneously and provide full-graphic recordings of the values of those parameters before and during power-line disturbances that cause the values to deviate from normal beyond the adjustable threshold values. Instruments must be capable of recording either on paper or on magnetic media and have a minimum accuracy of plus or minus 2 percent for electrical parameters. Parameters to be monitored include the following:
1. Current: Each phase and neutral and grounding conductors.
 2. Voltage: Phase to phase, phase to neutral, phase to ground, and neutral to ground.
 3. Frequency transients.
 4. Voltage swells and sags.
 5. Voltage Impulses: Phase to phase, phase to neutral, phase to ground, and neutral to ground.
 6. High-frequency noise.
 7. Radio-frequency interference.
 8. THD of the above currents and voltages.
 9. Harmonic content of currents and voltages above.
 10. Battery cell temperature during charging.
 11. Ambient temperature.
- D. Monitoring and Testing Procedures[**for Each Test Period**]:
1. Exploratory Period: For the first [**two**]<Insert number> days[**of the first scheduled monitoring and testing period**], make recordings at various circuit locations and with various parameter-

- threshold and sampling-interval settings. Make these measurements with the objective of identifying optimum UPS, power system, load, and instrumentation setup conditions for subsequent test and monitoring operations.
2. Remainder of Test Period: Perform continuous monitoring of at least two circuit locations selected on the basis of data obtained during exploratory period.
 - a. Set thresholds and sampling intervals for recording data at values selected to optimize data on performance of the UPS for values indicated, and to highlight the need to adjust, repair, or modify the UPS, distribution system, or load component that may influence its performance or that may require better power quality.
 - b. Perform load and UPS power source switching and operate the UPS on generator power during portions of test period in accordance with directions of Owner's power quality specialist.
 - c. Operate the UPS and its loads in each mode of operation permitted by UPS controls and by the power distribution system design.
 - d. Using loads and devices available as part of the facility's installed systems and equipment[**and a temporarily connected portable generator set**], create and simulate unusual operating conditions, including outages, voltage swells and sags, and voltage, current, and frequency transients. Maintain normal operating loads in operation on system to maximum extent possible during tests.
 - e. Using temporarily connected resistive/inductive load banks[**and a temporarily connected portable generator set**], create and simulate unusual operating conditions, including outages, voltage swells and sags, and voltage, current, and frequency transients. Maintain normal operating loads in operation on system to maximum extent possible during tests.
 - f. Make adjustments and repairs to UPS, distribution, and load equipment to correct deficiencies disclosed by monitoring and testing; repeat appropriate monitoring and testing to verify success of corrective action.
- E. Coordination with Specified UPS Monitoring Functions: Obtain printouts of built-in monitoring functions specified for the UPS and its components in this Section that are simultaneously recorded with portable instruments in this article.
1. Provide the temporary use of an appropriate PC and printer equipped with required connections and software for recording and printing if such units are not available on-site.
 2. Coordinate printouts with recordings for monitoring performed in accordance with this article, and resolve and report any anomalies in and discrepancies between the two sets of records.
- F. Monitoring and Testing Assistance by Contractor:
1. Open UPS and electrical distribution and load equipment and wiring enclosures to make monitoring and testing points accessible for temporary monitoring probe and sensor placement and removal as requested.
 2. Observe monitoring and testing operations; ensure that UPS and distribution and load equipment warranties are not compromised.
 3. Perform switching and control of various UPS units, electrical distribution systems, and load components as directed by power quality specialist. Specialist must design this portion of monitoring and testing operations to expose the UPS to various operating environments, conditions, and events while response is observed, electrical parameters are monitored, and system and equipment deficiencies are identified.
 4. Make repairs and adjustments to the UPS and to electrical distribution system and load components, and retest and repeat monitoring as needed to verify validity of results and correction of deficiencies.
 5. Engage the services of the UPS manufacturer's factory-authorized service representative periodically during performance testing operations for repairs, adjustments, and consultations.
- G. Documentation: Record test point and sensor locations, instrument settings, and circuit and load

conditions for each monitoring summary and power disturbance recording. Coordinate simultaneous recordings made on UPS input and load circuits.

- H. Analysis of Recorded Data and Report: Review and analyze test observations and recorded data and submit a detailed written report. Include the following in **[each]** report:
1. Descriptions of corrective actions performed during monitoring and survey work and their results.
 2. Recommendations for further action to provide optimum performance by the UPS and appropriate power quality for non-UPS loads. Include a statement of priority ranking and a cost estimate for each recommendation that involves system or equipment revisions.
 3. Copies of monitoring summary graphics and graphics illustrating harmonic content of significant voltages and currents.
 4. Copies of graphics of power disturbance recordings that illustrate findings, conclusions, and recommendations.
 5. Recommendations for operating, adjusting, or revising UPS controls.
 6. Recommendations for alterations to the UPS installation.
 7. Recommendations for adjusting or revising generator-set or automatic transfer switch installations or their controls.
 8. Recommendations for power distribution system revisions.
 9. Recommendations for adjusting or revising electrical loads, their connections, or controls.
- I. Interim and Final Reports: Provide an interim report at the end of each test period and a final comprehensive report at the end of final test and analysis period.

END OF SECTION 26 35 33 00



Task	Specification	Specification Description
26 35 33 16	26 09 13 00	Electrical Power Monitoring
26 35 33 16	26 35 33 00	Power Factor Correction Equipment



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SECTION 26 36 00 00 - TRANSFER SWITCHES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Contactor-type automatic transfer switches.
2. Molded-case-type automatic transfer switches.
3. Nonautomatic transfer switches.
4. Transfer switch accessories.

1.2 ACTION SUBMITTALS

A. Product Data:

1. Contactor-type automatic transfer switches.
2. Molded-case-type automatic transfer switches.
3. Nonautomatic transfer switches.
4. Transfer switch accessories.

B. Product Data Submittals: For each product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for transfer switches.
2. Include rated capacities, operating characteristics, electrical characteristics, and accessories.

C. Shop Drawings:

1. Include plans, elevations, sections, details showing minimum clearances, conductor entry provisions, gutter space, and installed features and devices.
2. Include material lists for each switch specified.
3. Single-Line Diagram: Show connections between transfer switch, **[bypass/isolation switch]**, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.
4. Riser Diagram: Show interconnection wiring between transfer switches, bypass/isolation switches, annunciators, and control panels.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For **[manufacturer-authorized service representative]****[testing agency]**.

B. Seismic Qualification Data: Certificates, for transfer switches, accessories, and components, from manufacturer.

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



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

- C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Features and operating sequences, both automatic and manual.
 - b. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications:

1. Member company of NETA.
 - a. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.6 FIELD CONDITIONS

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

1.7 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of transfer switch or transfer switch components that fail in materials or workmanship within specified warranty period.
 1. Warranty Period: **[12 months][18 months][Two years]<Insert time>** from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NEMA ICS 1.
- C. Comply with NFPA 99.
- D. Comply with NFPA 110.
- E. Comply with UL 1008 unless requirements of these Specifications are stricter.
- F. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.
- G. Tested Fault-Current Closing and Short-Circuit Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.
 - 1. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.
 - 2. Short-time withstand capability for **[three][30]<Insert number>** cycles.
- H. Repetitive Accuracy of Solid-State Controls: All settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.
- I. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.62. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.
- J. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism. Switches for emergency or standby purposes shall be mechanically and electrically interlocked in both directions to prevent simultaneous connection to both power sources unless closed transition.
- K. Service-Rated Transfer Switch:
 - 1. Comply with UL 869A and UL 489.
 - 2. Provide terminals for bonding the grounding electrode conductor to the grounded service conductor.
 - 3. In systems with a neutral, the bonding connection shall be on the neutral bus.
 - 4. Provide removable link for temporary separation of the service and load grounded conductors.
 - 5. Surge Protective Device: Service rated.
 - 6. Ground-Fault Protection: Comply with UL 1008 for **[normal bus][normal and alternative buses]**.
 - 7. Service Disconnecting Means: Externally operated, manual **[mechanically][electrically]** actuated.
- L. Neutral Switching: Where four-pole switches are indicated, provide **[neutral pole switched simultaneously with phase poles][overlapping neutral contacts]**.



- M. Neutral Terminal: Solid and fully rated unless otherwise indicated.
- N. Oversize Neutral: Ampacity and switch rating of neutral path through units indicated for oversize neutral shall be double the nominal rating of circuit in which switch is installed.
- O. Heater: Equip switches exposed to outdoor temperatures and humidity, and other units indicated, with an internal heater. Provide thermostat within enclosure to control heater.
- P. Battery Charger: For generator starting batteries.
 - 1. Float type, rated **[2][10]** A.
 - 2. Ammeter to display charging current.
 - 3. Fused ac inputs and dc outputs.
- Q. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels shall have communication capability matched with remote device.
- R. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, by color-code or by numbered or lettered wire and cable **[with printed][tape][shrinkable sleeve]** markers at terminations. Color-coding and wire and cable markers are specified in Section 260553 "Identification for Electrical Systems."
 - 1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
 - 2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
 - 3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.
 - 4. Accessible via **[rear][front]** access.
- S. Enclosures: General-purpose NEMA 250, **[Type 1][Type 3R][Type 4X][Type 12]**, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

2.2 CONTACTOR-TYPE AUTOMATIC TRANSFER SWITCHES

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[ABB, Electrification Business]**
 - 2. **[ASCO Power Technologies]**
 - 3. **[Caterpillar, Inc.; Electric Power Division]**
 - 4. **[Cummins Power Generation]**
 - 5. **[Eaton]**
 - 6. **[Generac]**
 - 7. **[Hubbell Utility Solutions; Hubbell Incorporated]**
 - 8. **[Kohler Power Systems]**
 - 9. **[Rolls-Royce Solutions America Inc.]**
 - 10. **[Russelectric, Inc]**
 - 11. **[Vertiv; Vertiv Holdings Co.]**
 - 12. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. [ABB, Electrification Business]
 2. [ASCO Power Technologies]
 3. [Caterpillar, Inc.; Electric Power Division]
 4. [Cummins Power Generation]
 5. [Eaton]
 6. [Generac]
 7. [Hubbell Utility Solutions; Hubbell Incorporated]
 8. [Kohler Power Systems]
 9. [Rolls-Royce Solutions America Inc.]
 10. [Russelectric, Inc]
 11. [Vertiv; Vertiv Holdings Co.]
 12. <Insert manufacturer's name>
- C. Comply with Level 1 equipment according to NFPA 110.
- D. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are unacceptable.
 2. Switch Action: Double throw; mechanically held in both directions.
 3. Contacts: Silver composition or silver alloy for load-current switching. Contactor-style automatic transfer-switch units, rated 600 A and higher, shall have separate arcing contacts.
 4. Conductor Connectors: Suitable for use with conductor material and sizes.
 5. Material: [Tin-plated aluminum][Hard-drawn copper, 98 percent conductivity].
 6. Main and Neutral Lugs: [Compression][Mechanical] type.
 7. Ground Lugs and Bus-Configured Terminators: [Compression][Mechanical] type.
 8. Ground bar.
 9. Connectors shall be marked for conductor size and type according to UL 1008.
 10. <Insert features>.
- E. Automatic Open-Transition Transfer Switches: Interlocked to prevent the load from being closed on both sources at the same time.
1. Sources shall be mechanically and electrically interlocked to prevent closing both sources on the load at the same time.
- F. Automatic Delayed-Transition Transfer Switches: Pauses or stops in intermediate position to momentarily disconnect both sources, with transition controlled by programming in the automatic transfer-switch controller. Interlocked to prevent the load from being closed on both sources at the same time.
1. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals for alternative source. Adjustable from zero to six seconds, and factory set for one second.
 2. Sources shall be mechanically and electrically interlocked to prevent closing both sources on the load at the same time.
 3. Fully automatic break-before-make operation with center off position.
 4. Fully automatic break-before-make operation with transfer when two sources have near zero phase difference.
- G. Automatic Closed-Transition Transfer Switches: Connect both sources to load momentarily. Transition is controlled by programming in the automatic transfer-switch controller.
1. Fully automatic make-before-break operation when transferring between two available power sources.



2. Load transfer without interruption, through momentary interconnection of both power sources not exceeding 100 ms.
 3. Initiation of No-Interruption Transfer: Controlled by in-phase monitor and sensors confirming both sources are present and acceptable.
 - a. Initiation occurs without active control of generator.
 - b. Automatic transfer-switch controller takes active control of generator to match frequency, phase angle, and voltage.
 - c. Controls ensure that closed-transition load transfer closure occurs only when the two sources are within plus or minus 5 electrical degrees maximum, and plus or minus 5 percent maximum voltage difference.
 4. Failure of power source serving load initiates automatic break-before-make transfer.
- H. Manual Switch Operation, Load-Breaking: Under load, with door closed and with either or both sources energized. Transfer time is same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.
- I. Manual Switch Operation, Non-Load-Breaking: Unloaded. Control circuit automatically disconnects from electrical operator during manual operation.
- J. Electric Nonautomatic Switch Operation: Electrically actuated by push buttons designated "Normal Source" and "Alternative Source." Switch shall be capable of transferring load in either direction with either or both sources energized.
- K. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval shall be adjustable from 1 to 30 seconds.
- L. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.
- M. Automatic Transfer-Switch Controller Features:
1. Controller operates through a period of loss of control power.
 2. Undervoltage Sensing for Each Phase of Normal **[and Alternate]** Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage shall be adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
 3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
 4. Time Delay for Retransfer to Normal Source: Adjustable from zero to 30 minutes, and factory set for 10 minutes. Override shall automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
 5. Test Switch: Simulate normal-source failure.
 6. Switch-Position Pilot Lights: Indicate source to which load is connected.
 7. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.
 - a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
 - b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."

8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
9. Transfer Override Switch: Overrides automatic retransfer control so transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
11. Engine Shutdown Contacts:
 - a. Instantaneous; shall initiate shutdown sequence at remote engine-generator controls after retransfer of load to normal source.
 - b. Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
12. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods shall be adjustable from 10 to 30 minutes. Factory settings shall be for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:
 - a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
 - b. Push-button programming control with digital display of settings.
 - c. Integral battery operation of time switch when normal control power is unavailable.

N. Large-Motor-Load Power Transfer:

1. In-Phase Monitor: Factory-wired, internal relay controls transfer so contacts close only when the two sources are synchronized in phase and frequency. Relay shall compare phase relationship and frequency difference between normal and emergency sources and initiate transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer shall be initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.
2. Motor Disconnect and Timing Relay Controls: Designated starters in loss of power scenario shall disconnect motors before transfer and reconnect them selectively at an adjustable time interval after transfer. Control connection to motor starters shall be through wiring external to automatic transfer switch. Provide adjustable time delay between 1 and 60 seconds for reconnecting individual motor loads. Provide relay contacts rated for motor-control circuit inrush and for actual seal currents to be encountered.
3. Programmed Neutral Switch Position: Switch operator with programmed neutral position arranged to provide a midpoint between the two working switch positions, with an intentional, time-controlled pause at midpoint during transfer. Adjustable pause from 0.5 to 30 seconds minimum, and factory set for 0.5 second unless otherwise indicated. Time delay occurs for both transfer directions. Disable pause unless both sources are live.

2.3 MOLDED-CASE-TYPE AUTOMATIC TRANSFER SWITCHES

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 1. **[ABB, Electrification Business]**
 2. **[Caterpillar, Inc.; Electric Power Division]**

3. [Cummins Power Generation]
4. [Eaton]
5. [Emerson Electric Co., Automation Solutions]
6. [Generac]
7. [Kohler Power Systems]
8. [Lake Shore Electric Corporation]
9. <Insert manufacturer's name>

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

1. [ABB, Electrification Business]
2. [Caterpillar, Inc.; Electric Power Division]
3. [Cummins Power Generation]
4. [Eaton]
5. [Emerson Electric Co., Automation Solutions]
6. [Generac]
7. [Kohler Power Systems]
8. [Lake Shore Electric Corporation]
9. <Insert manufacturer's name>

C. Comply with Level 1 equipment according to NFPA 110.

D. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.

1. Limitation: Switches using contactor-based components are unacceptable.
2. Switch Action: Double throw; mechanically held in both directions.
3. Contacts: Silver composition or silver alloy for load-current switching.
4. Conductor Connectors: Suitable for use with conductor material and sizes.
5. Material: [Tin-plated aluminum][Hard-drawn copper, 98 percent conductivity].
6. Main and Neutral Lugs: [Compression][Mechanical] type.
7. Ground Lugs and Bus-Configured Terminators: [Compression][Mechanical] type.
8. Ground bar.
9. Connectors shall be marked for conductor size and type according to UL 1008.
10. <Insert features>.

E. Automatic Open-Transition Transfer Switches: Interlocked to prevent the load from being closed on both sources at the same time.

1. Sources shall be mechanically and electrically interlocked to prevent closing both sources on the load at the same time.

F. Automatic Delayed-Transition Transfer Switches: Pauses or stops in intermediate position to momentarily disconnect both sources, with transition controlled by programming in the automatic transfer-switch controller. Interlocked to prevent the load from being closed on both sources at the same time.

1. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals for alternative source. Adjustable from zero to six seconds, and factory set for one second.
2. Sources shall be mechanically and electrically interlocked to prevent closing both sources on the load at the same time.
3. Fully automatic break-before-make operation with center off position.
4. Fully automatic break-before-make operation with transfer when two sources have near zero

phase difference.

- G. Automatic Closed-Transition Transfer Switches: Connect both sources to load momentarily. Transition is controlled by programming in the automatic transfer-switch controller.
 - 1. Fully automatic make-before-break operation when transferring between two available power sources.
 - 2. Load transfer without interruption, through momentary interconnection of both power sources not exceeding 100 ms.
 - 3. Initiation of No-Interruption Transfer: Controlled by in-phase monitor and sensors confirming both sources are present and acceptable.
 - a. Initiation occurs without active control of generator.
 - b. Automatic transfer-switch controller takes active control of generator to match frequency, phase angle, and voltage.
 - c. Controls ensure that closed-transition load transfer closure occurs only when the two sources are within plus or minus 5 electrical degrees maximum, and plus or minus 5 percent maximum voltage difference.
 - 4. Failure of power source serving load initiates automatic break-before-make transfer.
- H. Manual Switch Operation, Load-Breaking: Under load, with door closed and with either or both sources energized. Transfer time is same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.
- I. Manual Switch Operation, Non-Load-Breaking: Unloaded. Control circuit automatically disconnects from electrical operator during manual operation.
- J. Electric Nonautomatic Switch Operation: Electrically actuated by push buttons designated "Normal Source" and "Alternative Source." Switch shall be capable of transferring load in either direction with either or both sources energized.
- K. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval shall be adjustable from 1 to 30 seconds.
- L. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.
- M. Transfer Switches Based on Molded-Case-Switch Components: Comply with UL 489 and UL 869A.
- N. Automatic Transfer-Switch Controller Features:
 - 1. Controller operates through a period of loss of control power.
 - 2. Undervoltage Sensing for Each Phase of Normal **[and Alternative]**Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage shall be adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
 - 3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
 - 4. Time Delay for Retransfer to Normal Source: Adjustable from zero to 30 minutes, and factory set for 10 minutes. Override shall automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
 - 5. Test Switch: Simulate normal-source failure.
 - 6. Switch-Position Pilot Lights: Indicate source to which load is connected.



7. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.
 - a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
 - b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."
8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
9. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
11. Engine Shutdown Contacts:
 - a. Instantaneous; shall initiate shutdown sequence at remote engine-generator controls after retransfer of load to normal source.
 - b. Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
12. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods shall be adjustable from 10 to 30 minutes. Factory settings shall be for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:
 - a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
 - b. Push-button programming control with digital display of settings.
 - c. Integral battery operation of time switch when normal control power is unavailable.

O. Large-Motor-Load Power Transfer:

1. In-Phase Monitor: Factory-wired, internal relay controls transfer so contacts close only when the two sources are synchronized in phase and frequency. Relay shall compare phase relationship and frequency difference between normal and emergency sources and initiate transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer shall be initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.
2. Motor Disconnect and Timing Relay Controls: Designated starters in loss of power scenario shall disconnect motors before transfer and reconnect them selectively at an adjustable time interval after transfer. Control connection to motor starters shall be through wiring external to automatic transfer switch. Provide adjustable time delay between 1 and 60 seconds for reconnecting individual motor loads. Provide relay contacts rated for motor-control circuit inrush and for actual seal currents to be encountered.
3. Programmed Neutral Switch Position: Switch operator with programmed neutral position arranged to provide a midpoint between the two working switch positions, with an intentional, time-controlled pause at midpoint during transfer. Adjustable pause from 0.5 to 30 seconds minimum, and factory set for 0.5 second unless otherwise indicated. Time delay occurs for both transfer directions. Disable pause unless both sources are live.

2.4 NONAUTOMATIC TRANSFER SWITCHES

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[ASCO Power Technologies]**
 2. **[Caterpillar, Inc.; Electric Power Division]**
 3. **[Cummins Power Generation]**
 4. **[Eaton]**
 5. **[ESL Power Systems, Inc.]**
 6. **[Russelectric, Inc]**
 7. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[ASCO Power Technologies]**
 2. **[Caterpillar, Inc.; Electric Power Division]**
 3. **[Cummins Power Generation]**
 4. **[Eaton]**
 5. **[ESL Power Systems, Inc.]**
 6. **[Russelectric, Inc]**
 7. **<Insert manufacturer's name>**
- C. Electrically Operated: Electrically actuated by push buttons designated "Normal Source" and "Alternative Source." Switch shall be capable of transferring load in either direction with either or both sources energized.
- D. Manual and Electrically Operated: Electrically actuated by push buttons designated "Normal Source" and "Alternative Source." Manual handle provides quick-make, quick-break manual-switching action. Switch shall be capable of electrically or manually transferring load in either direction with either or both sources energized. Control circuit disconnects from electrical operator during manual operation.
- E. Double-Throw Switching Arrangement: Incapable of pauses or intermediate position stops during switching sequence.
- F. Pilot Lights: Indicate source to which load is connected.
- G. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and alternative-source sensing circuits.
1. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
 2. Emergency Power Supervision: Red light with nameplate engraved "Alternative Source Available."
- H. Unassigned Auxiliary Contacts: Switch shall have one set of normally closed contacts for each switch position, rated 10 A at 240-V ac.
- I. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
1. Switch Action: Double throw; mechanically held in both directions.
 2. Contacts: Silver composition or silver alloy for load-current switching.
 3. Conductor Connectors: Suitable for use with conductor material and sizes.
 4. Material: **[Tin-plated aluminum][Hard-drawn copper, 98 percent conductivity]**.



5. Main and Neutral Lugs: [**Compression**][**Mechanical**] type.
6. Ground Lugs and Bus-Configured Terminators: [**Compression**][**Mechanical**] type.
7. Ground bar.
8. Connectors shall be marked for conductor size and type according to UL 1008.
9. <Insert features>.

2.5 TRANSFER SWITCH ACCESSORIES

A. Bypass/Isolation Switches:

1. Source Limitations: Same manufacturer as transfer switch in which installed.
2. Comply with requirements for Level 1 equipment according to NFPA 110.
3. Description: Manual type, arranged to select and connect either source of power directly to load, isolating transfer switch from load and from both power sources. Include the following features for each combined automatic transfer switch and bypass/isolation switch:
 - a. Means to lock bypass/isolation switch in the position that isolates transfer switch with an arrangement that permits complete electrical testing of transfer switch while isolated. Interlocks shall prevent transfer-switch operation, except for testing or maintenance, while automatic transfer switch is isolated.
 - b. Provide means to make power available to transfer-switch control circuit for testing and maintenance purposes.
 - c. Drawout Arrangement for Transfer Switch: Provide physical separation from live parts and accessibility for testing and maintenance operations. Transfer switch and bypass/isolation switch shall be in isolated compartments.
 - d. Transition:
 - 1) Provide closed-transition operation when transferring from main transfer switch to bypass/isolation switch on the same power source.
 - 2) Provide [**open**][**closed**]-transition operation when transferring between power sources.
 - e. Bypass/Isolation Switch Current, Voltage, Closing, and Short-Circuit Withstand Ratings: Equal to or greater than those of associated automatic transfer switch, and with same phase arrangement and number of poles.
 - f. Contact temperatures of bypass/isolation switches shall not exceed those of automatic transfer-switch contacts when they are carrying rated load.
 - g. Manual Control: Constructed so load bypass and transfer-switch isolation can be performed by one person in no more than two operations in 15 seconds or less. Operating handles shall be externally operated.
 - h. Automatic and Nonautomatic Control: Automatic transfer-switch controller shall also control the bypass/isolation switch.
 - i. Legend: Manufacturer's standard legend for control labels and instruction signs shall describe operating instructions.
 - j. Maintainability: Fabricate to allow convenient removal of major components from front without removing other parts or main power conductors.
4. Interconnection of Bypass/Isolation Switches with Automatic Transfer Switches: Factory-installed copper bus bars; plated at connection points and braced for the indicated available short-circuit current.

B. Remote Annunciator System:

1. Source Limitations: Same manufacturer as transfer switch in which installed.

2. Functional Description: Remote annunciator panel shall annunciate conditions for indicated transfer switches.
3. Annunciation panel display shall include the following indicators:
 - a. Sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
 - b. Switch position.
 - c. Switch in test mode.
 - d. Failure of communication link.
4. Annunciator Panel: LED-lamp type with audible signal and silencing switch.
 - a. Indicating Lights: Grouped for each transfer switch monitored.
 - b. Label each group, indicating transfer switch it monitors, location of switch, and identity of load it serves.
 - c. Mounting: Flush, modular, steel cabinet unless otherwise indicated.
 - d. Lamp Test: Push-to-test or lamp-test switch on front panel.

C. Remote Annunciator and Control System:

1. Source Limitations: Same manufacturer as transfer switch in which installed.
2. Include the following functions for indicated transfer switches:
 - a. Indication of sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
 - b. Indication of switch position.
 - c. Indication of switch in test mode.
 - d. Indication of failure of digital communication link.
 - e. Key-switch or user-code access to control functions of panel.
 - f. Control of switch-test initiation.
 - g. Control of switch operation in either direction.
 - h. Control of time-delay bypass for transfer to normal source.
3. Malfunction of annunciator, annunciation and control panel, or communication link shall not affect functions of automatic transfer switch. In the event of failure of communication link, automatic transfer switch automatically shall revert to standalone, self-contained operation. Automatic transfer-switch sensing, controlling, or operating function shall not depend on remote panel for proper operation.
4. Remote Annunciation and Control Panel: Solid-state components. Include the following features:
 - a. Controls and indicating lights grouped together for each transfer switch.
 - b. Label each indicating light control group. Indicate transfer switch it controls, location of switch, and load it serves.
 - c. Digital Communication Capability: Matched to that of transfer switches supervised.
 - d. Mounting: Flush, modular, steel cabinet unless otherwise indicated.

2.6 SOURCE QUALITY CONTROL

- A. Factory Tests: Test and inspect components, assembled switches, and associated equipment according to UL 1008. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.
- B. Prepare test and inspection reports.

1. For each of the tests required by UL 1008, performed on representative devices, for **[emergency][legally required]** systems. Include results of test for the following conditions:
 - a. Overvoltage.
 - b. Undervoltage.
 - c. Loss of supply voltage.
 - d. Reduction of supply voltage.
 - e. Alternative supply voltage or frequency is at minimum acceptable values.
 - f. Temperature rise.
 - g. Dielectric voltage-withstand; before and after short-circuit test.
 - h. Overload.
 - i. Contact opening.
 - j. Endurance.
 - k. Short circuit.
 - l. Short-time current capability.
 - m. Receptacle withstand capability.
 - n. Insulating base and supports damage.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Floor-Mounting Switch: Anchor to floor by bolting.
 1. Install transfer switches on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 2. Comply with requirements for seismic control devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."
 3. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.
 4. Provide workspace and clearances required by NFPA 70.
- B. Annunciator and Control Panel Mounting: Flush in wall unless otherwise indicated.
- C. Identify components according to Section 260553 "Identification for Electrical Systems."
- D. Set field-adjustable intervals and delays, relays, and engine exerciser clock.
- E. Comply with NECA 1.

3.2 CONNECTIONS

- A. Wiring to Remote Components: Match type and number of cables and conductors to generator sets, **[motor controls]**, control, and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.
- B. Wiring Method: Install cables in raceways and cable trays except within electrical enclosures. Conceal raceway and cables except in unfinished spaces.
 1. Comply with requirements for raceways specified in Section 260533.13 "Conduits for Electrical Systems."

- C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.
- D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- F. Connect twisted pair cable according to Section 260523 "Control-Voltage Electrical Power Cables."
- G. Connect twisted pair cable according to Section 271513 "Communications Copper Horizontal Cabling."
- H. Route and brace conductors according to manufacturer's written instructions[.][**and Section 260529 "Hangers and Supports for Electrical Systems."**] Do not obscure manufacturer's markings and labels.
- I. Brace and support equipment according to Section 260548.16 "Seismic Controls for Electrical Systems."
- J. Final connections to equipment shall be made with liquidtight, flexible metallic conduit no more than **18 inches (457 mm)** in length.

3.3 FIELD QUALITY CONTROL

- A. Adminstrant for Tests and Inspections:
 - 1. Owner will engage qualified testing agency to administer and perform tests and inspections.
 - 2. Engage qualified testing agency to administer and perform tests and inspections.
 - 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
 - 4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].
- B. Tests and Inspections:
 - 1. After installing equipment, test for compliance with requirements according to NETA ATS.
 - 2. Visual and Mechanical Inspection:
 - a. Compare equipment nameplate data with Drawings and Specifications.
 - b. Inspect physical and mechanical condition.
 - c. Inspect anchorage, alignment, grounding, and required clearances.
 - d. Verify that the unit is clean.
 - e. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
 - f. Verify that manual transfer warnings are attached and visible.
 - g. Verify tightness of all control connections.
 - h. Inspect bolted electrical connections for high resistance using one of the following methods, or both:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data.
 - i. Perform manual transfer operation.
 - j. Verify positive mechanical interlocking between normal and alternate sources.
 - k. Perform visual and mechanical inspection of surge arresters.

- I. Inspect control power transformers.
 - 1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
 - 2) Verify that primary and secondary fuse or circuit-breaker ratings match Drawings.
 - 3) Verify correct functioning of drawout disconnecting contacts, grounding contacts, and interlocks.
3. Electrical Tests:
 - a. Perform insulation-resistance tests on all control wiring with respect to ground.
 - b. Perform a contact/pole-resistance test. Compare measured values with manufacturer's acceptable values.
 - c. Verify settings and operation of control devices.
 - d. Calibrate and set all relays and timers.
 - e. Verify phase rotation, phasing, and synchronized operation.
 - f. Perform automatic transfer tests.
 - g. Verify correct operation and timing of the following functions:
 - 1) Normal source voltage-sensing and frequency-sensing relays.
 - 2) Engine start sequence.
 - 3) Time delay on transfer.
 - 4) Alternative source voltage-sensing and frequency-sensing relays.
 - 5) Automatic transfer operation.
 - 6) Interlocks and limit switch function.
 - 7) Time delay and retransfer on normal power restoration.
 - 8) Engine cool-down and shutdown feature.
4. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.
 - a. Check for electrical continuity of circuits and for short circuits.
 - b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
 - c. Verify that manual transfer warnings are properly placed.
 - d. Perform manual transfer operation.
5. After energizing circuits, perform each electrical test for transfer switches stated in NETA ATS and demonstrate interlocking sequence and operational function for each switch at least three times.
 - a. Simulate power failures of normal source to automatic transfer switches and retransfer from emergency source with normal source available.
 - b. Simulate loss of phase-to-ground voltage for each phase of normal source.
 - c. Verify time-delay settings.
 - d. Verify pickup and dropout voltages by data readout or inspection of control settings.
 - e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
 - f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for one pole deviating by more than 50 percent from other poles.
 - g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.
6. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery

from both sources.

- a. Verify grounding connections and locations and ratings of sensors.
- C. Coordinate tests with tests of generator and run them concurrently.
- D. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.
- E. Transfer switches will be considered defective if they do not pass tests and inspections.
- F. Remove and replace malfunctioning units and retest as specified above.
- G. Prepare test and inspection reports.
- H. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.
 - 1. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - 2. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
 - 3. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.

3.4 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment.
- B. Training shall include testing ground-fault protective devices and instructions to determine when the ground-fault system shall be retested. Include instructions on where ground-fault sensors are located and how to avoid negating the ground-fault protection scheme during testing and circuit modifications.
- C. Coordinate this training with that for generator equipment.

END OF SECTION 26 36 00 00



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Task	Specification	Specification Description
26 36 13 00	26 28 16 00	Enclosed Switches And Circuit Breakers
26 36 13 00	26 36 00 00	Transfer Switches
26 36 23 00	26 28 16 00	Enclosed Switches And Circuit Breakers
26 36 23 00	26 36 00 00	Transfer Switches



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SECTION 26 43 13 00 - SURGE PROTECTIVE DEVICES FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Type 1 surge protective devices (SPDs).
2. Type 2 surge protective devices (SPDs).
3. Type 3, Type 4, and Type 5 surge protective devices (SPDs).
4. Enclosures.
5. Conductors and cables.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
3. Section 262413 "Switchboards" for integral SPDs installed by switchboard manufacturer.
4. Section 262416 "Panelboards" for integral SPDs installed by panelboard manufacturer.
5. Section 262726 "Wiring Devices" for integral SPDs installed by receptacle manufacturer.

1.2 DEFINITIONS

- A.** In: Nominal discharge current.
- B.** Maximum Continuous Operating Voltage (MCOV): The maximum designated RMS value of the power frequency voltage that may be continuously applied to the mode of protection of an SPD.
- C.** Metal-Oxide Varistor (MOV): An electronic component with a significant bidirectional, nonlinear current-voltage characteristic.
- D.** Mode(s), Modes of Protection, or Protection Modes: Electrical paths where the SPD offers defense against transient overvoltages. Examples include: line to neutral (L-N), line to ground (L-G), line to line (L-L), and neutral to ground (N-G).
- E.** SCCR: Short-circuit current rating.
- F.** Type 1 SPDs: Permanently connected SPDs intended for installation between the secondary of the service transformer and the line side of the service disconnect overcurrent device.
- G.** Type 2 SPDs: Permanently connected SPDs intended for installation on the load side of the service disconnect overcurrent device, including SPDs located at the branch panel.
- H.** Type 3 SPDs: Point of utilization SPDs.

- I. Type 4 SPDs: Component SPDs, including discrete components, as well as assemblies.
- J. Type 5 SPDs: Discrete component surge suppressors, such as MOVs that may be mounted on a printed wiring board, connected by its leads or provided within an enclosure with mounting means and wiring terminations.
- K. Voltage Protection Rating (VPR): A rating selected from UL 1449 list of preferred values assigned to each mode of protection.

1.3 ACTION SUBMITTALS

A. Product Data:

- 1. For each type of product.
 - a. Include electrical characteristics, specialties, and accessories for SPDs.
 - b. Certification of compliance with UL 1449 by qualified electrical testing laboratory recognized by authorities having jurisdiction including the following information:
 - 1) Tested values for VPRs.
 - 2) In ratings.
 - 3) MCOV, type designations.
 - 4) OCPD requirements.
 - 5) Manufacturer's model number.
 - 6) System voltage.
 - 7) Modes of protection.

B. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

A. Sample Warranty: For manufacturer's special warranty.

1.5 WARRANTY

- A. Special Manufacturer Extended Warranty: Manufacturer warrants that SPDs perform in accordance with specified requirements and agrees to provide repair or replacement of SPDs that fail to perform as specified within extended warranty period.
 - 1. Initial Extended Warranty Period: **[Five]<Insert number>** year(s) from date of Substantial Completion, for labor, materials, and equipment.
 - 2. Follow-On Extended Warranty Period: **[10]<Insert number>** year(s) from date of Substantial Completion, for materials only, f.o.b. the nearest shipping point to Project site.

PART 2 - PRODUCTS

2.1 TYPE 1 SURGE PROTECTIVE DEVICES (SPDs)

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

1. **[ABB, Electrification Business]**
2. **[Advanced Protection Technologies Inc. (APT)]**
3. **[ALLTEC LLC]**
4. **[Citel, Inc.]**
5. **[DITEK Surge Protection]**
6. **[Eaton]**
7. **[Intermatic, Inc]**
8. **[Leviton Manufacturing Co., Inc.]**
9. **[Liebert; Vertiv Holdings Co.]**
10. **[Mersen USA]**
11. **[Schneider Electric USA, Inc.]**
12. **[Siemens Industry, Inc., Energy Management Division]**
13. **[SSI, an ILSCO Company]**
14. **<Insert manufacturer's name>**

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

1. **[ABB, Electrification Business]**
2. **[Advanced Protection Technologies Inc. (APT)]**
3. **[ALLTEC LLC]**
4. **[Citel, Inc.]**
5. **[DITEK Surge Protection]**
6. **[Eaton]**
7. **[Intermatic, Inc]**
8. **[Leviton Manufacturing Co., Inc.]**
9. **[Liebert; Vertiv Holdings Co.]**
10. **[Mersen USA]**
11. **[Schneider Electric USA, Inc.]**
12. **[Siemens Industry, Inc., Energy Management Division]**
13. **[SSI, an ILSCO Company]**
14. **<Insert manufacturer's name>**

- C. Source Limitations: Obtain devices from single source from single manufacturer.

- D. General Characteristics:

1. Reference Standards: UL 1449, Type 1.
2. MCOV: Not less than 125 percent of nominal system voltage for 208Y/120 V and 120/240 V power systems, and not less than 115 percent of nominal system voltage for 480Y/277 V power systems.
3. Peak Surge Current Rating: Minimum single-pulse surge current withstand rating per phase must not be less than **[160][200][240][320]<Insert value>** kA. Peak surge current rating must be arithmetic sum of the ratings of individual MOVs in a given mode.
4. Protection modes and UL 1449 VPR for grounded wye circuits with **[480Y/277 V][208Y/120 V]**, three-phase, four-wire circuits must not exceed the following:

Surge Protective Devices for Low-Voltage Electrical



- a. Line to Neutral: **[1200 V for 480Y/277 V][700 V for 208Y/120 V]**.
 - b. Line to Line: **[2000 V for 480Y/277 V][1200 V for 208Y/120 V]**.
5. Protection modes and UL 1449 VPR for 240/120 V, single-phase, three-wire circuits must not exceed the following:
- a. Line to Neutral: 700 V.
 - b. Line to Line: 1200 V.
6. SCCR: Not less than **[100][200]<Insert value> kA**.
7. In Rating: 20 kA.

E. Options:

- 1. Include integral disconnect switch.
- 2. Include internal thermal protection that disconnects the SPD before damaging internal suppressor components.
- 3. Include indicator light display for protection status.
- 4. Include audible alarm.
- 5. Include NEMA ICS 5, dry Form C contacts rated at **[2 A and 24 V(ac)]<Insert values>** for remote monitoring of protection status.
- 6. Include surge counter.

2.2 TYPE 2 SURGE PROTECTIVE DEVICES (SPDs)

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

- 1. **[ABB, Electrification Business]**
- 2. **[Advanced Protection Technologies Inc. (APT)]**
- 3. **[ALLTEC LLC]**
- 4. **[Citel, Inc.]**
- 5. **[Eaton]**
- 6. **[Intermatic, Inc]**
- 7. **[Leviton Manufacturing Co., Inc.]**
- 8. **[Liebert; Vertiv Holdings Co.]**
- 9. **[Mersen USA]**
- 10. **[Schneider Electric USA, Inc.]**
- 11. **[Siemens Industry, Inc., Energy Management Division]**
- 12. **[SSI, an ILSCO Company]**
- 13. **<Insert manufacturer's name>**

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

- 1. **[ABB, Electrification Business]**
- 2. **[Advanced Protection Technologies Inc. (APT)]**
- 3. **[ALLTEC LLC]**
- 4. **[Citel, Inc.]**
- 5. **[Eaton]**
- 6. **[Intermatic, Inc]**
- 7. **[Leviton Manufacturing Co., Inc.]**

8. [Liebert; Vertiv Holdings Co.]
9. [Mersen USA]
10. [Schneider Electric USA, Inc.]
11. [Siemens Industry, Inc., Energy Management Division]
12. [SSI, an ILSCO Company]
13. <Insert manufacturer's name>

C. Source Limitations: Obtain devices from single source from single manufacturer.

D. General Characteristics:

1. Reference Standards: UL 1449, Type 2[; **UL 1283**].
2. MCOV: Not less than 125 percent of nominal system voltage for 208Y/120 V and 120/240 V power systems, and not less than 115 percent of nominal system voltage for 480Y/277 V power systems.
3. Peak Surge Current Rating: Minimum single-pulse surge current withstand rating per phase must not be less than [100][150]<Insert value> kA. Peak surge current rating must be arithmetic sum of the ratings of individual MOVs in a given mode.
4. Protection modes and UL 1449 VPR for grounded wye circuits with [480Y/277 V][208Y/120 V], three-phase, four-wire circuits must not exceed the following:
 - a. Line to Neutral: [1200 V for 480Y/277 V][700 V for 208Y/120 V].
 - b. Line to Ground: [1200 V for 480Y/277 V][700 V for 208Y/120 V].
 - c. Neutral to Ground: [1200 V for 480Y/277 V][700 V for 208Y/120 V].
 - d. Line to Line: [2000 V for 480Y/277 V][1200 V for 208Y/120 V].
5. Protection modes and UL 1449 VPR for 240/120 V, single-phase, three-wire circuits must not exceed the following:
 - a. Line to Neutral: 700 V.
 - b. Line to Ground: 700 V.
 - c. Neutral to Ground: 700 V.
 - d. Line to Line: 1200 V.
6. SCCR: Equal or exceed [100][200]<Insert value> kA.
7. In Rating: [20][10] kA.

E. Options:

1. Include LED indicator lights for power and protection status.
2. Include internal thermal protection that disconnects the SPD before damaging internal suppressor components.
3. Include NEMA ICS 5, dry Form C contacts rated at [2 A and 24 V(ac)]<Insert values> for remote monitoring of protection status.
4. Include surge counter.

2.3 TYPE 3, TYPE 4, AND TYPE 5 SURGE PROTECTIVE DEVICES (SPDs)

- A. Type 3, Type 4, and Type 5 SPDs are not approved for field installation.[See "Related Requirements" Paragraph in "Summary" Article for products with manufacturer-installed Type 3, Type 4, and Type 5 SPDs.]

2.4 ENCLOSURES

- A. Indoor Enclosures: Type 1.
- B. Outdoor Enclosures: **[Type 3R][Type 4X]**.

2.5 CONDUCTORS AND CABLES

- A. Power Wiring: Same size as SPD leads, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Provide OCPD and disconnect for installation of SPD in accordance with UL 1449 and manufacturer's instructions.
- B. Install leads between disconnects and SPDs short, straight, twisted, and in accordance with manufacturer's instructions. Comply with wiring methods in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
 - 1. Do not splice and extend SPD leads unless specifically permitted by manufacturer.
 - 2. Do not exceed manufacturer's recommended lead length.
 - 3. Do not bond neutral and ground.
- C. Use crimped connectors and splices only. Wire nuts are unacceptable.

3.2 FIELD QUALITY CONTROL

- A. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.
- B. Tests and Inspections:
 - 1. Compare equipment nameplate data for compliance with Drawings and the Specifications.
 - 2. Inspect anchorage, alignment, grounding, and clearances.
 - 3. Verify that electrical wiring installation complies with manufacturer's installation requirements.
- C. Nonconforming Work:
 - 1. SPDs that do not pass tests and inspections will be considered defective.
 - 2. Remove and replace defective units and retest.
- D. Prepare test and inspection reports.
- E. Manufacturer Services:
 - 1. Engage factory-authorized service representative to **[support][supervise]** field tests and

inspections.

3.3 STARTUP SERVICE

- A. Complete startup checks in accordance with manufacturer's instructions.
- B. Do not perform insulation-resistance tests of the distribution wiring equipment with SPDs installed. Disconnect SPDs before conducting insulation-resistance tests; reconnect them immediately after the testing is over.
- C. Energize SPDs after power system has been energized, stabilized, and tested.

END OF SECTION 26 43 13 00



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SECTION 26 50 00 00 - LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Luminaires.
2. Luminaire fittings.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. **[Section 260519 "Low-Voltage Electrical Power Conductors and Cables"]****[and]****[Section 260523 "Control-Voltage Electrical Power Cables"]** specifies wiring connections installed by this Section.
5. Section 260529 "Hangers and Supports for Electrical Systems" specifies channel and angle supports installed by this Section.
6. Section 260546 "Poles for Electrical Systems" specifies lighting standards, utility poles, and accessories referenced by this Section.
7. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs installed by this Section.
8. Section 260923 "Lighting Control Devices" specifies automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors installed by this Section.
9. Section 260936 "Modular Dimming Controls" specifies architectural dimming systems with dimming installed by this Section.
10. Section 260943.16 "Addressable Luminaire Lighting Controls" and Section 260943.23 "Relay-Based Lighting Controls" specify manual or programmable control systems with low-voltage control wiring or data communication circuits installed by this Section.

1.2 DEFINITIONS

- A. BUG Rating: Backlight, uplight, and glare rating for light pollution from exterior luminaires.
- B. Correlated Color Temperature (CCT): The absolute temperature (in kelvins) of a blackbody whose chromaticity (color quality) most nearly resembles that of the light source.
- C. Color Rendering Index (CRI): The measure of the degree of color shift objects undergo when illuminated by the light source as compared with the color of those same objects when illuminated by a reference light source. The lower the CRI of a light source, the more difficult it is to identify colors and stripes on electronic components and wiring.
- D. IDA: International Dark-Sky Association.

E. IES: Illuminating Engineering Society.

F. LPD: Lighting power density.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Luminaires: Include the following additional information:

- a. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing agency, certifying product's compliance with specified listing criteria.
 - 1) If listed manufacturer differs from selling manufacturer, indicate relationship between entities on submittal. Clearly indicate which entity warrants product performance and fitness for purpose.
 - 2) Listing criteria identified in approval letter must match specified listing criteria. Approval of only equipment's enclosure is not considered approval of equipment for intended application.
 - 3) Product identification in approval letter must match product branding and model numbers in submittal. Approval letters for similar products are not acceptable.
- b. Product Certificates: Include product certificates stating compliance with standards listed below, signed by manufacturer or fabricator.
 - 1) Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with current accreditation under National Voluntary Laboratory Accreditation Program (NVLAP) for Energy Efficient Lighting Products.
 - 2) Testing Agency Certified Data: For luminaires indicated on Lighting Fixture Schedule on the Drawings, photometric data certified by qualified independent testing laboratory. Photometric data for remaining luminaires must be certified by manufacturer.
 - 3) Air and Thermal Performance Data: For air-handling luminaires, include data required in **[Section 233713.13 "Air Diffusers."][Section 233713.23 "Registers and Grilles."][Section 233713.43 "Security Registers and Grilles."]**
 - 4) Sound Performance Data: For air-handling luminaires, indicate sound power level and sound transmission class in test reports certified in accordance with standards specified in **[Section 233713.13 "Air Diffusers."][Section 233713.23 "Registers and Grilles."][Section 233713.43 "Security Registers and Grilles."]**
- c. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
- d. Include operating characteristics, electrical characteristics, and furnished accessories.
- e. Include schedule of submitted lighting products. Arrange schedule and accompanying product data in order by luminaire and lamp designations indicated on the Drawings.
- f. Include battery and charger data for emergency lighting units.
- g. Include ballast factor.
- h. Include life, output (lumens, CCT, and CRI), and energy-efficiency data.
- i. Include photometric data and adjustment factors obtained from qualified laboratory tests.
- j. Include manufacturer's sample warranty language.
- k. **<Insert requirements>**.

2. Luminaire Fittings: Include the following additional information:

- a. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing agency, certifying product's compliance with specified listing criteria.
 - 1) If listed manufacturer differs from selling manufacturer, indicate relationship between entities on submittal. Clearly indicate which entity warrants product performance and fitness for purpose.
 - 2) Listing criteria identified in approval letter must match specified listing criteria. Approval of only equipment's enclosure is not considered approval of equipment for intended application.
 - 3) Product identification in approval letter must match product branding and model numbers in submittal. Approval letters for similar products are not acceptable.
- b. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
- c. Include operating characteristics, electrical characteristics, and furnished accessories.
- d. Include schedule of submitted lighting products. Arrange schedule and accompanying product data in order by luminaire and lamp designations indicated on the Drawings.
- e. Include manufacturer's sample warranty language.
- f. **<Insert requirements>**.

B. Samples:

- 1. Luminaires: One for each kind of luminaire with specified rating, size, finish, color, and texture.
- 2. Luminaire Fittings: One for each kind of luminaire fitting with specified rating, size, finish, color, and texture.

C. Shop Drawings: Prepare and submit the following:

- 1. Drawings, Diagrams, and Supporting Documents for Custom Luminaires:
 - a. Include plans, elevations, sections, and mounting and attachment details.
 - b. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - c. Include diagrams for power, signal, and control wiring.

D. Sustainable Design Submittals:

- 1. Product data for sustainable design features for each type of product.
- 2. ASHRAE/IES 90.1 LPD Compliance Documentation: Prepare plans and calculations demonstrating that as-constructed lighting power density complies with mandatory provisions of ASHRAE/IES 90.1 and that as-constructed lighting, including daylighting and controls, improves on baseline energy performance. If included with Project, indicate locations of energy meters for lighting loads.

E. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

A. Manufacturers' published instructions.

B. Field Reports:

- 1. Manufacturer's field reports for field quality-control support.
- 2. Manufacturer's field reports for system startup support.

1.5 CLOSEOUT SUBMITTALS

- A. Warranty documentation.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Spare parts.
- B. Extra stock material.

1.7 MOCKUPS

- A. Provide mockups as indicated on the Drawings to verify selections made under Sample submittals and to set quality standards for materials and execution.
 - 1. Build mockup of luminaires in room or space, complete with power and control connections.
 - 2. Obtain Architect's approval of mockups before starting installation of related Work on the Project.
 - 3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Owner specifically approves such deviations by Change Order.
 - 4. Maintain mockups during construction in undisturbed condition as standard for judging the completed Work.
 - 5. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.8 QUALIFICATIONS

- A. Electrical Power Testing (EPT) Technician III: Possessing active NICET EPT Level III certification. Able to manage switching procedures; conduct tests of complex equipment; analyze test and equipment data; plan a job; and lead a team. Has experience performing NFPA 70B, IEEE, and NETA electrical tests.
- B. Electrical Power Testing (EPT) Technician IV: Possessing active NICET EPT Level IV certification. Able to conduct tests of complex metering and relay systems; evaluate tests, test equipment, test results, and power system performance; recommend actions to maintain or improve system performance; and lead multi-team projects.
- C. Electrical Power Testing and Inspecting Agency: Entities possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
 - 1. On-site electrical testing supervisors must possess active NICET EPT Technician [III][IV] certification.
- D. Luminaire Photometric Testing Laboratory: Entity possessing active qualifications specified in Section 014000 "Quality Requirements" accredited under NIST HB 150-1, and complying with applicable IES testing standards.
- E. Lighting Testing and Inspecting Agency: Entity possessing active qualifications specified in Section 014000 "Quality Requirements" with documented training and experience with testing and inspecting lighting installations in accordance with applicable IES standards.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Protect exposed surface finishes on lighting equipment by applying strippable, temporary protective covering before shipping.

1.10 WARRANTY FOR LUMINAIRES

- A. Special Installer Extended Warranty: Installer warrants that fabricated and installed luminaires perform in accordance with specified requirements and agrees to repair or replace products that fail to perform as specified within extended-warranty period. Warranty must convey to Owner upon acceptance of the Work.
 - 1. Extended-Warranty Period: **[Two]<Insert number>** years from date of Substantial Completion; full coverage for labor, materials, and equipment.
- B. Special Manufacturer Extended Warranty: Manufacturer warrants that luminaires perform in accordance with specified requirements and agrees to provide repair or replacement of products that fail to perform as specified within extended-warranty period.
 - 1. Extended-Warranty Period: **[Five]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for labor, materials, and equipment.

1.11 WARRANTY FOR BATTERIES

- A. Special Manufacturer Extended Warranty for Batteries: Manufacturer warrants that batteries perform in accordance with specified requirements and agrees to provide repair or replacement of batteries that fail to perform as specified within extended-warranty period.
 - 1. Initial Extended-Warranty Period for Li-ion Batteries: **[Three][Four][Five]<Insert number>** years from date of Substantial Completion; full coverage for materials only, free on board **[origin][destination]**, freight prepaid.
 - 2. Follow-On Extended-Warranty Period for Li-ion Batteries: **[10]<Insert number>** years from date of Substantial Completion; prorated coverage for materials only, free on board **[origin][destination]**, freight prepaid.
 - 3. Initial Extended-Warranty Period for Ni-Cd Batteries: **[Five]<Insert number>** years from date of Substantial Completion; full coverage for materials only, free on board **[origin][destination]**, freight prepaid.
 - 4. Follow-On Extended-Warranty Period for Ni-Cd Batteries: **[15]<Insert number>** years from date of Substantial Completion; prorated coverage for materials only, free on board **[origin][destination]**, freight prepaid.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2.2 LUMINAIRES

A. Surface-Mounted Luminaire :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Albeo; brand of GE Current, a Daintree company; American Industrial Partners (AIP)]**
 - b. **[Alera Lighting; brand of GE Current, a Daintree company; American Industrial Partners (AIP)]**
 - c. **[Amerlux]**
 - d. **[Architectural Area Lighting; brand of GE Current, a Daintree company; American Industrial Partners (AIP)]**
 - e. **[Atlas Lighting Products]**
 - f. **[Columbia Lighting; brand of GE Current, a Daintree company; American Industrial Partners (AIP)]**
 - g. **[Cooper Lighting Solutions; Signify North America Corp.]**
 - h. **[Deco Lighting]**
 - i. **[Digital Lumens]**
 - j. **[E-conolight]**
 - k. **[Edison Price Lighting]**
 - l. **[Elite Lighting Corporation]**
 - m. **[Focal Point; Legrand North America, LLC]**
 - n. **[GE Current, a Daintree company; American Industrial Partners (AIP)]**
 - o. **[GE Lighting; a Savant Company]**
 - p. **[H.E. Williams]**
 - q. **[Howard Lighting Products]**
 - r. **[Hubbell Lighting; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - s. **[Kim Lighting; brand of GE Current, a Daintree company; American Industrial Partners (AIP)]**
 - t. **[Lighting Services, Inc.]**
 - u. **[Lightolier; brand of Signify North America Corp.]**
 - v. **[Lithonia Lighting; Acuity Brands Lighting, Inc.]**
 - w. **[LMPG Inc.]**
 - x. **[Luraline Lighting]**
 - y. **[OSRAM SYLVANIA]**
 - z. **[Philips; Signify North America; Signify Holding]**
 - aa. **[Pure Lighting Manufacturing Ltd.]**
 - bb. **[PureEdge Lighting]**
 - cc. **[RAB Lighting]**
 - dd. **[Selux Corporation]**
 - ee. **[Specialty Lighting Industries, Inc.]**
 - ff. **[Visa Lighting]**
 - gg. **[West Durable Lighting]**
 - hh. **[Zumtobel Lighting, Inc.; Zumtobel Group]**
 - ii. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Albeo; brand of GE Current, a Daintree company; American Industrial Partners**

- (AIP)]
 - b. [Alera Lighting; brand of GE Current, a Daintree company; American Industrial Partners (AIP)]
 - c. [Amerlux]
 - d. [Architectural Area Lighting; brand of GE Current, a Daintree company; American Industrial Partners (AIP)]
 - e. [Atlas Lighting Products]
 - f. [Columbia Lighting; brand of GE Current, a Daintree company; American Industrial Partners (AIP)]
 - g. [Cooper Lighting Solutions; Signify North America Corp.]
 - h. [Deco Lighting]
 - i. [Digital Lumens]
 - j. [E-conolight]
 - k. [Edison Price Lighting]
 - l. [Elite Lighting Corporation]
 - m. [Focal Point; Legrand North America, LLC]
 - n. [GE Current, a Daintree company; American Industrial Partners (AIP)]
 - o. [GE Lighting; a Savant Company]
 - p. [H.E. Williams]
 - q. [Howard Lighting Products]
 - r. [Hubbell Lighting; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - s. [Kim Lighting; brand of GE Current, a Daintree company; American Industrial Partners (AIP)]
 - t. [Lighting Services, Inc.]
 - u. [Lightolier; brand of Signify North America Corp.]
 - v. [Lithonia Lighting; Acuity Brands Lighting, Inc.]
 - w. [LMPG Inc.]
 - x. [Luraline Lighting]
 - y. [OSRAM SYLVANIA]
 - z. [Philips; Signify North America; Signify Holding]
 - aa. [Pure Lighting Manufacturing Ltd.]
 - bb. [PureEdge Lighting]
 - cc. [RAB Lighting]
 - dd. [Selux Corporation]
 - ee. [Specialty Lighting Industries, Inc.]
 - ff. [Visa Lighting]
 - gg. [West Durable Lighting]
 - hh. [Zumtobel Lighting, Inc.; Zumtobel Group]
 - ii. <Insert manufacturer's name>
3. Source Limitations: [Obtain products for this luminaire type from single manufacturer][Bin LEDs for this luminaire type within three-step MacAdam Ellipse to ensure consistent chromaticity for all luminaires of this type].
 4. Listing Criteria:
 - a. Incandescent Luminaires: UL CCN IEZR; including UL 1598.
 - b. LED Luminaires: UL CCN IFAM; including UL 1598.
 - c. Outdoor Canopy Luminaires: UL CCN IFAW; including UL 1598.
 - d. Marked in accordance with UL CCN HYXT, including UL 1598, for compatible power supply, installation location, and environmental conditions.
 5. Luminaire Description: <Insert description of desired shape and dimensional limitations>.
 6. Standard Features:
 - a. Openings: Doors, frames, and access panels must operate smoothly, not leak light under operating conditions, and permit relamping without use of tools or parts falling from

- enclosure.
- b. Nominal Operating Voltage: [120 V(ac)][240 V(ac)][277 V(ac)][480 V(ac)][120/60 V(ac)][12 V(dc)][24 V(dc)].
 - c. Nominal Luminaire Operating Power Rating: [Less than 20 W][20 to 60 W][70 to 150 W][150 to 300 W][Greater than 300 W]<Insert basis-of-design product's rated wattage>.
 - d. CRI: [80+][90+].
 - e. Ballast or Driver Location: [Internal][Remote][Self-ballasted lamp].
 - f. Materials:
 - 1) Enclosure: [ASTM B209/B209M extruded-aluminum][ASTM A36/A36M carbon structural steel][ASTM A568/A568M sheet steel][ASTM A240/A240M manufacturer's standard stainless steel][ASTM A653/A653M galvanized-steel] housing and heat sink; free of sharp edges and burrs.
 - 2) Enclosure Ingress Protection Rating: [UL 50E Type 1 or IEC 60529 IP20][UL 50E Type 3R or IEC 60529 IP24][UL 50E Type 4X or IEC 60529 IP65][UL 50E Type 12 or IEC 60529 IP54].
 - 3) Lenses, Diffusers, and Globes:
 - a) [Fixed][Adjustable] lens.
 - b) [Spot][Medium][Wide] light distribution.
 - c) [Tempered Fresnel annealed crystal glass][Prismatic annealed crystal glass][Diffuse annealed crystal glass][Clear annealed crystal glass][Prismatic acrylic][Clear, heat- and UV-stabilized virgin acrylic plastic]<Insert material>.
 - d) Lens Thickness: Not less than **0.125 inch (3 mm)** unless otherwise indicated.
 - e) Distribution: [Type I][Type II][Type III][Type IV][Type V].
 - 4) Visible variations in metal finishes[**outside range of approved Samples**] are unacceptable in adjoining components.
 - g. Incandescent Luminaires (UL CCN IEZR):
 - 1) Lamp Base Size: [Candelabra (E12)][Intermediate (E17)][Medium (E26 or E27)][Mogul (E39)].
 - 2) Lamp Shape and Optics: [Arbitrary Spherical (A)][Bulged (B)][Bulged Reflector (BR)][Candelabra (C)][Candelabra Angular (CA)][Flambeau (F)][Globe (G)][Prismatic Aluminized Reflector (PAR)][Pear Shaped (PS)][Specialty (S)][Reflector (R)][Tube (T)].
 - h. LED Luminaires (UL CCN IFAM):
 - 1) Output Intensity: Not less than [250 lm][575 lm][750 lm][1000 lm][1500 lm][2000 lm][3000 lm][5000 lm][10 000 lm]<Insert lumens>.
 - 2) Efficacy: Not less than [75 lm/W][80 lm/W][85 lm/W]<Insert lm/W>.
 - 3) Rated Life: [35 000][50 000]<Insert number> hours to L70.
 - 4) CCT: [2000 K][2700-2200 K (flame)][Three-step selectable 2700-2500-2200 K][2700 K][3000 K][3500 K][4000 K][5000 K][6500 K][Five-step selectable 3000-6500 K][Three-step selectable 3000-4000-5000 K]<Insert kelvins>.
7. Sustainable Design Features:
- a. Mercury Content: For fluorescent, mercury vapor, metal halide, high-pressure-sodium, neon, and argon lamps, submit data indicating mercury content and lamp life.
 - b. Energy Efficiency of LED Luminaires: Luminaire is certified by ENERGY STAR[and

- Design Lights Consortium].**
- c. Backlight, Uplight, and Glare (BUG) Ratings: Exterior luminaire complies with IES LP-11-recommended BUG ratings at luminaire's intended location.
 - d. IDA/IES Five Principles Ready:
 - 1) Exterior luminaire is adjustable to illuminate only to extent necessary for its intended purpose.
 - 2) Exterior luminaire is aimable.
 - 3) Exterior luminaire is dimmable.
 - 4) Exterior luminaire is controllable to turn on only when needed.
 - 5) Exterior luminaire has warm color temperature.
 - e. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - f. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - g. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - h. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - i. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
8. Other Available Features Required by the Project:
- a. Mounting Hardware: **[Ceiling-mounted][Pendant-mounted][Wall-mounted][Building-mounted][Pole-mounted]<Insert desired mounting hardware>; with [integral mounting provisions][extruded-aluminum][stainless steel]<Insert material>[rectangular arm,][round arm,][11 inch (280 mm) in length][13 inch (330 mm) in length].**
 - b. Mounting Height: **<Insert height of luminaire from finished grade or floor>.**
 - c. Bollard:
 - 1) Shape: **[Round][Square][Hexagonal][Fluted]<Insert shape or feature>.**
 - 2) Height from Finished Grade: **[24 inch (610 mm)][30 inch (762 mm)][36 inch (900 mm)]<Insert value>.**
 - 3) Overall Height: **[30 inch (762 mm)][36 inch (900 mm)]<Insert value>.**
 - 4) Diameter: **[6 inch (150 mm)]<Insert value>.**
 - 5) Bollard Mounting: **[Three-point cast-aluminum base]<Insert mounting provisions>.**
 - d. Decorative Post Top: **[Arm mounted][Tenon mounted][Ring mounted].**
 - e. Roadway Pole: **[Arm mounted][Tenon mounted][Ring mounted].**
 - f. Finishes:
 - 1) Enclosure: **[Clear]<Insert color>[anodized][powder-coat][painted] finish.**
 - 2) Reflector: **[Aluminum]<Insert material finish>.**
 - 3) Reflecting surfaces must have minimum reflectance as follows, unless otherwise indicated:
 - a) White Surfaces: 85 percent.
 - b) Specular Surfaces: 83 percent.
 - c) Diffusing Specular Surfaces: 75 percent.



- g. Factory-Applied Finish for Aluminum Luminaires: Comply with NAAMM/NOMMA AMP 500 for recommendations for applying and designating finishes.
 - 1) Finish designations prefixed by AA comply with system established by Aluminum Association for designating aluminum finishes.
 - 2) Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20 requirements; and seal aluminum surfaces with clear, hard-coat wax.
 - 3) Class I, Clear-Anodic Finish: AA-M32C22A41, complying with AAMA 611.
 - a) Mechanical Finish: Medium satin.
 - b) Chemical Finish: Etched, medium matte.
 - c) Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker.
 - 4) Class I, Color-Anodic Finish: AA-M32C22A42/A44, complying with AAMA 611.
 - a) Mechanical Finish: Medium satin.
 - b) Chemical Finish: Etched, medium matte.
 - c) Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker).
 - 5) Color: **[Light bronze][Medium bronze][Dark bronze][Black]<Insert color>**.
- h. Factory-Applied Finish for Steel Luminaires: Comply with NAAMM/NOMMA AMP 500 for recommendations for applying and designating finishes.
 - 1) Surface Preparation: Clean surfaces to comply with SSPC-SP 1 to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
 - 2) Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.
 - 3) Color: **[As selected from manufacturer's standard catalog of colors][As selected by Architect from manufacturer's full range][Match color sample provided by Architect]**.
- i. Visible variations in metal finishes **[outside range of approved Samples]** are unacceptable in adjoining components.
- j. Dimmable from 100 percent to zero percent of maximum light output.
- k. EMI Filters: Factory installed to suppress conducted EMI in accordance with MIL-STD-461E. Fabricate luminaires with one filter on each ballast or driver requiring filter.
- l. Stainless steel latches.
- m. Integral pressure equalizer.
- n. Photoelectric Switch: Factory-mounted integral to luminaire; listed and labeled in accordance with UL CCN WJFX, including UL 773, or in accordance with UL CCN WJCT, including UL 773A.
 - 1) Contact Relays: Factory mounted, single throw, designed to fail in on position, and factory set to turn light unit on at **1.5 to 3 fc (15 to 30 lx)** and off at **4.5 to 10 fc (45 to 100 lx)** with 15 s minimum time delay. **[Relay must have directional lens in front of photocell to prevent artificial light sources from causing false turn-off.]**
 - a) Relay with locking-type receptacle must comply with NEMA C136.10.
 - b) Adjustable window slide for adjusting on-off set points.

9. Installation Markings:

- a. Relamping Labels: Include recommended lamp type, diameter, shape, size, wattage, and coating on factory-applied label that is visible when luminaire is open for relamping.
- b. All Luminaires (UL CCN HYXT):
 - 1) "DRY LOCATIONS ONLY."
 - 2) "SUITABLE FOR DAMP LOCATIONS."
 - 3) "SUITABLE FOR WET LOCATIONS."
 - 4) "SUITABLE FOR MOUNTING WITHIN 1.2 M (4 FT) OF THE GROUND" or "SUITABLE FOR FLOOR PROXIMITY INSTALLATION."
 - 5) "SUITABLE FOR GROUND-MOUNTED RECESSED."
 - 6) "LIMIT RANGE OF ADJUSTMENT TO <Insert instruction>."
 - 7) "COVERED CEILING MOUNT ONLY."
 - 8) "WALL MOUNT ONLY"
 - 9) "FOR CEILING MOUNTING ONLY."
 - 10) Marked with mounting orientation, such as "THIS END UP."
 - 11) "SUITABLE FOR AIR-HANDLING USE."
 - 12) "VENTILATING OR COOLING AIR ONLY."
 - 13) "ONLY FOR USE IN CEILING PLENUM OF NONCOMBUSTIBLE CONSTRUCTION OR WITH AIR-HANDLING PARTS THAT COVER VENT OPENINGS."
 - 14) "INSTALL ONLY IN ENVIRONMENTAL AIR-HANDLING SPACES WHERE A COMPLETE METAL ENCLOSED WIRING SYSTEM IS PROVIDED."
 - 15) "MIN [75][90][150][200][250] SUPPLY CONDUCTORS."
 - 16) "NOT FOR USE IN DWELLING."
 - 17) "SUITABLE FOR USE AS RACEWAY."
 - 18) "60 Hz" or "AC ONLY."
 - 19) Marked to identify voltage supply or type of branch circuit or both.
- c. Incandescent Luminaires (UL CCN IEZR):
 - 1) "SUITABLE FOR OPERATION IN AMBIENTS NOT EXCEEDING <Insert ambient temperature>°.".
 - 2) "PUSH CONDUCTORS INTO JUNCTION BOX."
 - 3) "SUITABLE FOR UNDER-CABINET MOUNT."
 - 4) "SUITABLE FOR CONTINUOUS ROW MOUNTING."
 - 5) "THIS LUMINAIRE MUST BE MOUNTED OR SUPPORTED INDEPENDENTLY OF AN OUTLET BOX."
- d. LED Luminaires (UL CCN IFAM):
 - 1) "SUITABLE FOR OPERATION IN AMBIENTS NOT EXCEEDING <Insert ambient temperature>°.".
 - 2) "PUSH CONDUCTORS INTO JUNCTION BOX."
 - 3) "WALL MOUNT ONLY."
 - 4) "NONCOMBUSTIBLE SURFACE ONLY."
 - 5) "SUITABLE FOR UNDER-CABINET MOUNT."
 - 6) "SUITABLE FOR CONTINUOUS ROW MOUNTING."
 - 7) "THIS LUMINAIRE MUST BE MOUNTED OR SUPPORTED INDEPENDENTLY OF AN OUTLET BOX."
- e. Outdoor Canopy Luminaires (UL CCN IFAW):
 - 1) "CANOPY LUMINAIRE - NOT THERMALLY PROTECTED."
 - 2) "FOR COVERED CEILING MOUNT ONLY."

3) "OPEN CEILING MOUNT ONLY."

10. Seismic and Wind Performance: Installed product must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:

- a. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events[**and unit must be fully operational after seismic events**]."
- b. Component Importance Factor (Ip): **[1.0][1.5]**.
- c. Component Amplification Factor (ap): **[1.0][2.5]<Insert value>**.
- d. Component Response Modification Factor (Rp): **[1.5][2.5]<Insert value>**.
- e. Component Overstrength Factor (Qo): **[1.5][2.5]<Insert value>**.

B. Recessed Luminaire :

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

- a. **[Albeo; brand of GE Current, a Daintree company; American Industrial Partners (AIP)]**
- b. **[Alera Lighting; brand of GE Current, a Daintree company; American Industrial Partners (AIP)]**
- c. **[Amerlux]**
- d. **[Axis Lighting, Inc.]**
- e. **[Columbia Lighting; brand of GE Current, a Daintree company; American Industrial Partners (AIP)]**
- f. **[Cooper Lighting Solutions; Signify North America Corp.]**
- g. **[Digital Lumens]**
- h. **[Edison Price Lighting]**
- i. **[Elite Lighting Corporation]**
- j. **[Focal Point; Legrand North America, LLC]**
- k. **[GE Current, a Daintree company; American Industrial Partners (AIP)]**
- l. **[GE Lighting; a Savant Company]**
- m. **[Lighting Services, Inc.]**
- n. **[Lightolier; brand of Signify North America Corp.]**
- o. **[Lithonia Lighting; Acuity Brands Lighting, Inc.]**
- p. **[LMPG Inc.]**
- q. **[OSRAM SYLVANIA]**
- r. **[PureEdge Lighting]**
- s. **[RAB Lighting]**
- t. **[Selux Corporation]**
- u. **[Specialty Lighting Industries, Inc.]**
- v. **<Insert manufacturer's name>**

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

- a. **[Albeo; brand of GE Current, a Daintree company; American Industrial Partners (AIP)]**
- b. **[Alera Lighting; brand of GE Current, a Daintree company; American Industrial Partners (AIP)]**
- c. **[Amerlux]**

- d. [Axis Lighting, Inc.]
 - e. [Columbia Lighting; brand of GE Current, a Daintree company; American Industrial Partners (AIP)]
 - f. [Cooper Lighting Solutions; Signify North America Corp.]
 - g. [Digital Lumens]
 - h. [Edison Price Lighting]
 - i. [Elite Lighting Corporation]
 - j. [Focal Point; Legrand North America, LLC]
 - k. [GE Current, a Daintree company; American Industrial Partners (AIP)]
 - l. [GE Lighting; a Savant Company]
 - m. [Lighting Services, Inc.]
 - n. [Lightolier; brand of Signify North America Corp.]
 - o. [Lithonia Lighting; Acuity Brands Lighting, Inc.]
 - p. [LMPG Inc.]
 - q. [OSRAM SYLVANIA]
 - r. [PureEdge Lighting]
 - s. [RAB Lighting]
 - t. [Selux Corporation]
 - u. [Specialty Lighting Industries, Inc.]
 - v. <Insert manufacturer's name>
3. Source Limitations: [Obtain products for this luminaire type from single manufacturer][Bin LEDs for this luminaire type within three-step MacAdam Ellipse to ensure consistent chromaticity for all luminaires of this type].
 4. Listing Criteria:
 - a. Incandescent Luminaires: UL CCN IEZX; including UL 1598[.], and "Chicago Electrical Code."
 - b. LED Luminaires: UL CCN IFAO; including UL 1598[, and "Chicago Electrical Code."]
 - c. Marked in accordance with UL CCN HYXT, including UL 1598, for compatible power supply, installation location, and environmental conditions.
 5. Luminaire Description: <Insert description of desired shape and dimensional limitations>.
 6. Standard Features:
 - a. Ceiling Compatibility: NEMA LE 4.
 - b. Openings: Doors, frames, and access panels must operate smoothly, not leak light under operating conditions, and permit relamping without use of tools or parts falling from enclosure.
 - c. Nominal Operating Voltage: [120 V(ac)][240 V(ac)][277 V(ac)][12 V(dc)][24 V(dc)].
 - d. Nominal Luminaire Operating Power Rating: [Less than 20 W][20 to 60 W]<Insert basis-of-design product's rated wattage>.
 - e. CRI: [80+][90+].
 - f. Ballast or Driver Location: [Internal][Remote][Self-ballasted lamp].
 - g. Materials:
 - 1) Enclosure: [ASTM B209/B209M extruded-aluminum][ASTM A36/A36M carbon structural steel][ASTM A568/A568M sheet steel][ASTM A240/A240M manufacturer's standard stainless steel][ASTM A653/A653M galvanized-steel] housing and heat sink; free of sharp edges and burrs.
 - 2) Enclosure Ingress Protection Rating: [UL 50E Type 1 or IEC 60529 IP20][UL 50E Type 3R or IEC 60529 IP24][UL 50E Type 4X or IEC 60529 IP65][UL 50E Type 12 or IEC 60529 IP54].
 - 3) Lenses, Diffusers, and Globes:
 - a) [Fixed][Adjustable] lens.

- b) **[Spot][Medium][Wide]** light distribution.
 - c) **[Tempered Fresnel annealed crystal glass][Prismatic annealed crystal glass][Diffuse annealed crystal glass][Clear annealed crystal glass][Prismatic acrylic][Clear, heat- and UV-stabilized virgin acrylic plastic]<Insert material>**.
 - d) Lens Thickness: Not less than **0.125 inch (3 mm)** unless otherwise indicated.
 - 4) Visible variations in metal finishes **[outside range of approved Samples]** are unacceptable in adjoining components.
 - h. Incandescent Luminaires (UL CCN IEZX):
 - 1) Lamp Base Size: **[Candelabra (E12)][Intermediate (E17)][Medium (E26 or E27)][Mogul (E39)]**.
 - 2) Lamp Shape and Optics: **[Arbitrary Spherical (A)][Bulged (B)][Bulged Reflector (BR)][Candelabra (C)][Candelabra Angular (CA)][Flambeau (F)][Globe (G)][Prismatic Aluminized Reflector (PAR)][Pear Shaped (PS)][Specialty (S)][Reflector (R)][Tube (T)]**.
 - i. LED Luminaires (UL CCN IFAO):
 - 1) Output Intensity: Not less than **[250 lm][575 lm][750 lm][1000 lm][1500 lm][2000 lm][3000 lm][5000 lm][10 000 lm]<Insert lumens>**.
 - 2) Efficacy: Not less than **[75 lm/W][80 lm/W][85 lm/W]<Insert lm/W>**.
 - 3) Rated Life: **[35 000][50 000]<Insert number>** hours to L70.
 - 4) CCT: **[2000 K][2700-2200 K (flame)][Three-step selectable 2700-2500-2200 K][2700 K][3000 K][3500 K][4000 K][5000 K][6500 K][Five-step selectable 3000-6500 K][Three-step selectable 3000-4000-5000 K]<Insert kelvins>**.
7. Sustainable Design Features:
- a. Mercury Content: For fluorescent, mercury vapor, metal halide, high-pressure-sodium, neon, and argon lamps, submit data indicating mercury content and lamp life.
 - b. Energy Efficiency of LED Luminaires: Luminaire is certified by ENERGY STAR **[and Design Lights Consortium]**.
 - c. Backlight, Uplight, and Glare (BUG) Ratings: Exterior luminaire complies with IES LP-11-recommended BUG ratings at luminaire's intended location.
 - d. IDA/IES Five Principles Ready:
 - 1) Exterior luminaire is adjustable to illuminate only to extent necessary for its intended purpose.
 - 2) Exterior luminaire is aimable.
 - 3) Exterior luminaire is dimmable.
 - 4) Exterior luminaire is controllable to turn on only when needed.
 - 5) Exterior luminaire has warm color temperature.
 - e. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - f. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - g. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - h. Third-Party Certification: Third-party certification, in accordance with multiple attribute

standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.

- i. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.

8. Other Available Features Required by the Project:

- a. Mounting Hardware: **[Ceiling-mounted][Wall-mounted]<Insert desired mounting hardware>**; include universal mounting bracket and integral junction box with conduit fittings.
- b. Finishes:
 - 1) Enclosure: **[Clear]<Insert color>[anodized][powder-coat][painted]** finish.
 - 2) Reflector: **[Aluminum]<Insert material finish>**.
 - 3) Visible variations in metal finishes **[outside range of approved Samples]** are unacceptable in adjoining components.
- c. Dimmable from 100 percent to zero percent of maximum light output.
- d. EMI Filters: Factory installed to suppress conducted EMI in accordance with MIL-STD-461E. Fabricate luminaires with one filter on each ballast or driver requiring filter.
- e. Stainless steel latches.
- f. Integral pressure equalizer.

9. Installation Markings:

- a. Relamping Labels: Include recommended lamp type, diameter, shape, size, wattage, and coating on factory-applied label that is visible when luminaire is open for relamping.
- b. All Luminaires (UL CCN HYXT):
 - 1) "DRY LOCATIONS ONLY."
 - 2) "SUITABLE FOR DAMP LOCATIONS."
 - 3) "SUITABLE FOR WET LOCATIONS."
 - 4) "SUITABLE FOR MOUNTING WITHIN 1.2 M (4 FT) OF THE GROUND" or "SUITABLE FOR FLOOR PROXIMITY INSTALLATION."
 - 5) "SUITABLE FOR GROUND-MOUNTED RECESSED."
 - 6) "LIMIT RANGE OF ADJUSTMENT TO **<Insert instruction>**."
 - 7) "COVERED CEILING MOUNT ONLY."
 - 8) "WALL MOUNT ONLY"
 - 9) "FOR CEILING MOUNTING ONLY."
 - 10) Marked with mounting orientation, such as "THIS END UP."
 - 11) "SUITABLE FOR AIR-HANDLING USE."
 - 12) "VENTILATING OR COOLING AIR ONLY."
 - 13) "ONLY FOR USE IN CEILING PLENUM OF NONCOMBUSTIBLE CONSTRUCTION OR WITH AIR-HANDLING PARTS THAT COVER VENT OPENINGS."
 - 14) "INSTALL ONLY IN ENVIRONMENTAL AIR-HANDLING SPACES WHERE A COMPLETE METAL ENCLOSED WIRING SYSTEM IS PROVIDED."
 - 15) "MIN **[75□][90□][150□][200□][250□]** SUPPLY CONDUCTORS."
 - 16) "NOT FOR USE IN DWELLING."
 - 17) "SUITABLE FOR USE AS RACEWAY."
 - 18) "60 Hz" or "AC ONLY."
 - 19) Marked to identify voltage supply or type of branch circuit, or both.
- c. Incandescent Luminaires (UL CCN IEZX):
 - 1) "TYPE IC LUMINAIRE."

- 2) "TYPE NON-IC LUMINAIRE."
 - 3) "INHERENTLY PROTECTED LUMINAIRE."
 - 4) "INSTALL IN BUILDINGS OF FIRE-RESISTANT CONSTRUCTION."
 - 5) "INSTALL WITH MINIMUM SPACINGS BETWEEN A) CENTER-TO-CENTER OF ADJACENT LUMINAIRES: <Insert distance> INCHES; B) TOP OF LUMINAIRE AND AN OVERHEAD BUILDING MEMBER: <Insert distance> INCHES; AND C) LUMINAIRE CENTER-TO-SIDE OF BUILDING MEMBER: <Insert distance> INCHES."
 - 6) "FOR USE IN CONCRETE ONLY."
 - 7) "SUITABLE FOR USE IN POURED CONCRETE."
 - 8) "SUITABLE FOR SUSPENDED CEILING."
 - 9) "SUITABLE FOR GROUND-MOUNTED RECESSED."
 - 10) "BLINKING LIGHT OF THIS THERMALLY PROTECTED LUMINAIRE MAY INDICATE OVERHEATING."
 - 11) "MAXIMUM OF <Insert size> AWG BRANCH CIRCUIT CONDUCTOR SUITABLE FOR <Insert temperature>° PERMITTED IN BOX."
 - 12) "FOR USE IN ONE- AND TWO-FAMILY DWELLINGS ONLY."
 - 13) "FOR USE IN NON-FIRE-RATED INSTALLATIONS."
 - 14) Provide correlating markings identifying matching housing, trim, rough-in section, and finishing section.
 - 15) "Chicago Electrical Code" or "CCEA."
- d. LED Luminaires (UL CCN IFAO):
- 1) "TYPE IC LUMINAIRE."
 - 2) "TYPE NON-IC LUMINAIRE."
 - 3) "INHERENTLY PROTECTED LUMINAIRE."
 - 4) "INSTALL IN BUILDINGS OF FIRE-RESISTANT CONSTRUCTION."
 - 5) "INSTALL WITH MINIMUM SPACINGS BETWEEN A) CENTER-TO-CENTER OF ADJACENT LUMINAIRES: <Insert distance> INCHES; B) TOP OF LUMINAIRE AND AN OVERHEAD BUILDING MEMBER: <Insert distance> INCHES; AND C) LUMINAIRE CENTER-TO-SIDE OF BUILDING MEMBER: <Insert distance> INCHES."
 - 6) "FOR USE IN CONCRETE ONLY."
 - 7) "SUITABLE FOR USE IN POURED CONCRETE."
 - 8) "SUITABLE FOR SUSPENDED CEILING."
 - 9) "SUITABLE FOR GROUND-MOUNTED RECESSED ONLY."
 - 10) "SUITABLE FOR GROUND-MOUNTED RECESSED."
 - 11) "BLINKING LIGHT OF THIS THERMALLY PROTECTED LUMINAIRE MAY INDICATE OVERHEATING."
 - 12) "MAXIMUM OF <Insert size> AWG BRANCH CIRCUIT CONDUCTOR SUITABLE FOR <Insert temperature>° PERMITTED IN BOX."
 - 13) "ACCESS ABOVE CEILING REQUIRED."
 - 14) "ACCESS BEHIND WALL REQUIRED."
 - 15) "FOR USE IN ONE- AND TWO-FAMILY DWELLINGS ONLY."
 - 16) "FOR USE IN NON-FIRE-RATED INSTALLATIONS."
 - 17) Provide correlating markings identifying matching housing, trim, rough-in section, and finishing section.
 - 18) "Chicago Electrical Code" or "CCEA."
10. Seismic and Wind Performance: Installed product must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:
- a. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events[**and unit must be fully operational**

after seismic events]."

- b. Component Importance Factor (Ip): [1.0][1.5].
- c. Component Amplification Factor (ap): [1.0][2.5]<Insert value>.
- d. Component Response Modification Factor (Rp): [1.5][2.5]<Insert value>.
- e. Component Overstrength Factor (Ωo): [1.5][2.5]<Insert value>.

C. UL IFFR - Track-Lighting Systems :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Alera Lighting; brand of GE Current, a Daintree company; American Industrial Partners (AIP)]
 - b. [Architectural Area Lighting; brand of GE Current, a Daintree company; American Industrial Partners (AIP)]
 - c. [Axis Lighting, Inc.]
 - d. [Columbia Lighting; brand of GE Current, a Daintree company; American Industrial Partners (AIP)]
 - e. [Cooper Lighting Solutions; Signify North America Corp.]
 - f. [Dual-Lite; brand of GE Current, a Daintree company; American Industrial Partners (AIP)]
 - g. [Edison Price Lighting]
 - h. [Elite Lighting Corporation]
 - i. [GE Lighting; a Savant Company]
 - j. [Hubbell Lighting; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - k. [Kim Lighting; brand of GE Current, a Daintree company; American Industrial Partners (AIP)]
 - l. [Lighting Services, Inc.]
 - m. [Lightolier; brand of Signify North America Corp.]
 - n. [Lithonia Lighting; Acuity Brands Lighting, Inc.]
 - o. [Zumtobel Lighting, Inc.; Zumtobel Group]
 - p. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Alera Lighting; brand of GE Current, a Daintree company; American Industrial Partners (AIP)]
 - b. [Architectural Area Lighting; brand of GE Current, a Daintree company; American Industrial Partners (AIP)]
 - c. [Axis Lighting, Inc.]
 - d. [Columbia Lighting; brand of GE Current, a Daintree company; American Industrial Partners (AIP)]
 - e. [Cooper Lighting Solutions; Signify North America Corp.]
 - f. [Dual-Lite; brand of GE Current, a Daintree company; American Industrial Partners (AIP)]
 - g. [Edison Price Lighting]
 - h. [Elite Lighting Corporation]
 - i. [GE Lighting; a Savant Company]
 - j. [Hubbell Lighting; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - k. [Kim Lighting; brand of GE Current, a Daintree company; American Industrial Partners (AIP)]
 - l. [Lighting Services, Inc.]



- m. [Lightolier; brand of Signify North America Corp.]
 - n. [Lithonia Lighting; Acuity Brands Lighting, Inc.]
 - o. [Zumtobel Lighting, Inc.; Zumtobel Group]
 - p. <Insert manufacturer's name>
3. Source Limitations: [Obtain products for this luminaire type from single manufacturer][Bin LEDs for this luminaire type within three-step MacAdam Ellipse to ensure consistent chromaticity for all luminaires of this type].
4. Listing Criteria:
- a. Track Lighting: UL CCN IFFR; including UL 1574.
 - b. Marked in accordance with UL CCN HYXT, including UL 1598, for compatible power supply, installation location, and environmental conditions.
5. Product Description: <Insert description of desired shape and dimensional limitations>.
6. Standard Features:
- a. Openings: Doors, frames, and access panels must operate smoothly, not leak light under operating conditions, and permit relamping without use of tools or parts falling from enclosure.
 - b. Nominal Luminaire Operating Voltage: [120 V(ac)][240 V(ac)][277 V(ac)][12 V(dc)][24 V(dc)].
 - c. Nominal Luminaire Operating Power Rating: [Less than 20 W][20 to 60 W][70 to 150 W][150 to 300 W][Greater than 300 W]<Insert basis-of-design product's rated wattage>.
 - d. CRI: [80+][90+].
 - e. Ballast or Driver Location: [Internal][Remote][Self-ballasted lamp].
 - f. Materials:
 - 1) Enclosure: [ASTM B209/B209M extruded-aluminum][ASTM A36/A36M carbon structural steel][ASTM A568/A568M sheet steel][ASTM A240/A240M manufacturer's standard stainless steel][ASTM A653/A653M galvanized-steel] housing and heat sink; free of sharp edges and burrs.
 - 2) Enclosure Ingress Protection Rating: UL 50E Type 1 or IEC 60529 IP20.
 - 3) Lenses, Diffusers, and Globes:
 - a) [Fixed][Adjustable] lens.
 - b) [Spot][Medium][Wide] light distribution.
 - c) [Tempered Fresnel annealed crystal glass][Prismatic annealed crystal glass][Diffuse annealed crystal glass][Clear annealed crystal glass][Prismatic acrylic][Clear, heat- and UV-stabilized virgin acrylic plastic]<Insert material>.
 - d) Lens Thickness: Not less than 0.125 inch (3 mm) unless otherwise indicated.
 - 4) Visible variations in metal finishes[outside range of approved Samples] are unacceptable in adjoining components.
 - g. Incandescent Lamp Track-Lighting Luminaire:
 - 1) Lamp Base Size: [Candelabra (E12)][Intermediate (E17)][Medium (E26 or E27)].
 - 2) Lamp Shape and Optics: [Arbitrary Spherical (A)][Bulged (B)][Bulged Reflector (BR)][Candelabra (C)][Candelabra Angular (CA)][Flambeau (F)][Globe (G)][Prismatic Aluminized Reflector (PAR)][Pear Shaped (PS)][Specialty (S)][Reflector (R)][Tube (T)].

- h. LED Track-Lighting Luminaires:
 - 1) Output Intensity: Not less than [250 lm][575 lm][750 lm][1000 lm][1500 lm][2000 lm][3000 lm][5000 lm][10 000 lm]<Insert lumens>.
 - 2) Efficacy: Not less than [75 lm/W][80 lm/W][85 lm/W]<Insert lm/W>.
 - 3) Rated Life: [35 000][50 000]<Insert number> hours to L70.
 - 4) CCT: [2000 K][2700-2200 K (flame)][Three-step selectable 2700-2500-2200 K][2700 K][3000 K][3500 K][4000 K][5000 K][6500 K][Five-step selectable 3000-6500 K][Three-step selectable 3000-4000-5000 K]<Insert kelvins>.
- 7. Sustainable Design Features:
 - a. Mercury Content: For fluorescent, mercury vapor, metal halide, high-pressure-sodium, neon, and argon lamps, submit data indicating mercury content and lamp life.
 - b. Energy Efficiency of LED Luminaires: Luminaire is certified by ENERGY STAR[and Design Lights Consortium].
 - c. Corporate Sustainability Report: Provide [third-party-verified]corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - d. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - e. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - f. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - g. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
- 8. Other Available Features Required by the Project:
 - a. Mounting Hardware: [Ceiling-mounted][Pendant-mounted][Wall-mounted]<Insert desired mounting hardware>; with integral mounting provisions.
 - b. Mounting Height: <Insert height of luminaire from finished grade or floor>.
 - c. Finishes:
 - 1) Enclosure: [Clear]<Insert color>[anodized][powder-coat][painted] finish.
 - 2) Reflector: [Aluminum]<Insert material finish>.
 - 3) Visible variations in metal finishes[outside range of approved Samples] are unacceptable in adjoining components.
 - d. Dimmable from 100 percent to zero percent of maximum light output.
- 9. Installation Markings:
 - a. Relamping Labels: Include recommended lamp type, diameter, shape, size, wattage, and coating on factory-applied label that is visible when luminaire is open for relamping.
 - b. All Luminaires (UL CCN HYXT):
 - 1) "DRY LOCATIONS ONLY."
 - 2) "SUITABLE FOR DAMP LOCATIONS."
 - 3) "LIMIT RANGE OF ADJUSTMENT TO <Insert instruction>."
 - 4) "MIN [75□][90□][150□][200□][250□] SUPPLY CONDUCTORS."
 - 5) "60 Hz" or "AC ONLY."
 - 6) Marked to identify voltage supply or type of branch circuit, or both.



- c. Track Systems (UL CCN IFFR):
 - 1) "FOR CLIP MOUNTING ONLY."
 - 2) "DO NOT PENDANT MOUNT THIS TRACK SUCH AS BY STEMS OR WIRES."
 - 3) "FOR USE IN <Insert ceiling grid manufacturer and product>."
- 10. Seismic and Wind Performance: Installed product must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:
 - a. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events[**and unit must be fully operational after seismic events**]."
 - b. Component Importance Factor (Ip): [1.0][1.5].
 - c. Component Amplification Factor (ap): [1.0][2.5]<Insert value>.
 - d. Component Response Modification Factor (Rp): [1.5][2.5]<Insert value>.
 - e. Component Overstrength Factor (Ωo): [1.5][2.5]<Insert value>.
- D. UL FTBR or FTBV - Emergency Lighting and Power Equipment :
 - 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Amerlux]
 - b. [Cooper Lighting Solutions; Signify North America Corp.]
 - c. [Dual-Lite; brand of GE Current, a Daintree company; American Industrial Partners (AIP)]
 - d. [Evenlite, Inc.]
 - e. [GE Current, a Daintree company; American Industrial Partners (AIP)]
 - f. [Hubbell Lighting; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - g. [Lithonia Lighting; Acuity Brands Lighting, Inc.]
 - h. [Philips; Signify North America; Signify Holding]
 - i. <Insert manufacturer's name>
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Amerlux]
 - b. [Cooper Lighting Solutions; Signify North America Corp.]
 - c. [Dual-Lite; brand of GE Current, a Daintree company; American Industrial Partners (AIP)]
 - d. [Evenlite, Inc.]
 - e. [GE Current, a Daintree company; American Industrial Partners (AIP)]
 - f. [Hubbell Lighting; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - g. [Lithonia Lighting; Acuity Brands Lighting, Inc.]
 - h. [Philips; Signify North America; Signify Holding]
 - i. <Insert manufacturer's name>
 - 3. Source Limitations: Obtain products from single manufacturer.
 - 4. Listing Criteria:
 - a. Emergency Lighting and Power: UL CCN FTBR or UL CCN FTBV; including UL 924, NFPA 101, and ICC IBC.

- b. Marked in accordance with UL CCN HYXT, including UL 1598, for compatible power supply, installation location, and environmental conditions.
5. Product Description: **<Insert description of desired shape and dimensional limitations>.**
6. Standard Features:
- a. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.
- b. Status and Test Indication: Visible and accessible without opening luminaire or entering ceiling space.
- 1) Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
- 2) Test Push-Button: Push-to-test button in unit housing simulates loss of normal power and demonstrates unit operability.
- c. Nominal Operating Voltage: **[120 V(ac)][277 V(ac)][6 V(dc)][9.6 V(dc)][12 V(dc)][24 V(dc)].**
- d. Mounting: **[Ceiling][Wall]** with universal junction box adaptor.
- e. Enclosure: UV stable thermoplastic housing rated for **[damp][wet]** locations.
- f. Flame Rating: UL 94 **[5VA][5VB][V-0][V-1][V-2][HB].**
- g. Light Source: **[One][Two][halogen lamp(s)][krypton lamp(s)][LED head(s)].**
7. Sustainable Design Features:
- a. Mercury Content: For fluorescent, mercury vapor, metal halide, high-pressure-sodium, neon, and argon lamps, submit data indicating mercury content and lamp life.
- b. Energy Efficiency of LED Luminaires: Luminaire is certified by ENERGY STAR[**and Design Lights Consortium**].
- c. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
- d. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
- e. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
- f. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
- g. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
8. Other Available Features Required by the Project:
- a. Mounting Height: **<Insert height of luminaire from finished floor>.**
- b. Internal-Type Emergency Power Unit: Self-contained, modular, battery-inverter unit, factory mounted within luminaire body[**and compatible with ballast or driver**].
- 1) Emergency Connection: Operate **[one]<Insert number>** lamp(s) continuously at an output of **[1100]<Insert value>** lumens each upon loss of normal power. Connect unswitched circuit to battery-inverter unit and switched circuit to luminaire ballast or driver.
- 2) Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically

-
- recharged and floated on charger.
 - 3) Nightlight Connection: Operate lamp continuously at **[40]<Insert number>** percent of rated light output.
 - 4) Test Push-Button and Indicator Light: Visible and accessible without opening luminaire or entering ceiling space.
 - a) Push-Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
 - b) Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
 - 5) Battery Type: **[Ni-Cd][Li-ion]**.
 - 6) Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.
 - 7) Remote Test: Switch in handheld remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
 - 8) Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.
- c. External-Type Emergency Power Unit: Self-contained, modular, battery-inverter unit, suitable for powering one or more lamps, remote mounted from luminaire.
- 1) Emergency Connection: Operate **[one]<Insert number>[incandescent][LED]** lamp continuously. Connect unswitched circuit to battery-inverter unit and switched circuit to luminaire **[ballast or driver]**.
 - 2) Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
 - 3) Nightlight Connection: Operate lamp in a remote luminaire continuously.
 - 4) Battery Type: **[Ni-Cd][Li-ion]**.
 - 5) Charger: Fully automatic, solid-state, constant-current type.
 - 6) Housing: Type 1 enclosure listed for installation inside, on top of, or remote from luminaire. Remote assembly must be located no less than half of distance recommended by **[ballast or driver][emergency power unit]** manufacturer, whichever is less.
 - 7) Test Push-Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
 - 8) LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
 - 9) Remote Test: Switch in handheld remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
 - 10) Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.
9. Installation Markings:
- a. Relamping Labels: Include recommended lamp type, diameter, shape, size, wattage, and

- coating on factory-applied label that is visible when luminaire is open for relamping.
- b. All Luminaires (UL CCN HYXT):
 - 1) "SUITABLE FOR DAMP LOCATIONS."
 - 2) "SUITABLE FOR WET LOCATIONS."
 - 3) "SUITABLE FOR MOUNTING WITHIN 1.2 M (4 FT) OF THE GROUND" or "SUITABLE FOR FLOOR PROXIMITY INSTALLATION."
 - 4) Marked to identify voltage supply or type of branch circuit or both.
- c. Emergency Lighting and Power Equipment (UL CCN FTBR):
 - 1) "SUITABLE FOR OPERATION IN AMBIENTS NOT EXCEEDING <Insert ambient temperature>°."
 - 2) "HAS CLASS 2 OUTPUTS."
- 10. Seismic and Wind Performance: Installed product must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:
 - a. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events[**and unit must be fully operational after seismic events**]."
 - b. Component Importance Factor (Ip): [1.0][1.5].
 - c. Component Amplification Factor (ap): [1.0][2.5]<Insert value>.
 - d. Component Response Modification Factor (Rp): [1.5][2.5]<Insert value>.
 - e. Component Overstrength Factor (Qo): [1.5][2.5]<Insert value>.

E. UL FWBO - Exit Fixture :

- 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Amerlux]
 - b. [Cooper Lighting Solutions; Signify North America Corp.]
 - c. [Evenlite, Inc.]
 - d. [Hubbell Lighting; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - e. [Lithonia Lighting; Acuity Brands Lighting, Inc.]
 - f. [Philips; Signify North America; Signify Holding]
 - g. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Amerlux]
 - b. [Cooper Lighting Solutions; Signify North America Corp.]
 - c. [Evenlite, Inc.]
 - d. [Hubbell Lighting; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - e. [Lithonia Lighting; Acuity Brands Lighting, Inc.]
 - f. [Philips; Signify North America; Signify Holding]
 - g. <Insert manufacturer's name>
- 3. Source Limitations: Obtain products from single manufacturer.
- 4. Listing Criteria:



- a. Exit Fixtures: UL CCN FWBO; including UL 924, NFPA 101[, **NFPA 5000**], and ICC IBC.
 - b. Marked in accordance with UL CCN HYXT, including UL 1598, for compatible power supply, installation location, and environmental conditions.
5. Product Description: **<Insert description of desired shape and dimensional limitations>**.
6. Standard Features:
 - a. Nominal Operating Voltage: [**120 V(ac)**][**277 V(ac)**][**6 V(dc)**][**9.6 V(dc)**][**12 V(dc)**][**24 V(dc)**].
 - b. Light Source: LED; 50,000 hours minimum rated life.
 - c. Legend Color: [**Red**][**Green**].
 - d. Internal emergency power unit.
 - e. Battery Type: [**Ni-Cd**][**Li-ion**].
 - f. Master/Remote Sign Configurations:
 - 1) Master Unit: Comply with requirements above for self-powered exit signs, and provide additional capacity in [**LED power supply**][**battery**] for power connection to remote unit.
 - 2) Remote Unit: Comply with requirements above for self-powered exit signs, except omit power supply, battery, and test features. Arrange to receive full power requirements from master unit. Connect for testing concurrently with master unit as a unified system.
7. Sustainable Design Features:
 - a. Mercury Content: For fluorescent, mercury vapor, metal halide, high-pressure-sodium, neon, and argon lamps, submit data indicating mercury content and lamp life.
 - b. Energy Efficiency of LED Luminaires: Luminaire is certified by ENERGY STAR[**and Design Lights Consortium**].
 - c. Corporate Sustainability Report: Provide [**third-party-verified**]corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - d. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - e. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - f. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - g. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
8. Other Available Features Required by the Project:
 - a. Mounting Height: **<Insert height of luminaire from finished floor>**.
9. Installation Markings:
 - a. All Luminaires (UL CCN HYXT):
 - 1) "SUITABLE FOR DAMP LOCATIONS."
 - 2) "SUITABLE FOR WET LOCATIONS."
 - 3) "SUITABLE FOR MOUNTING WITHIN 1.2 M (4 FT) OF THE GROUND" or "SUITABLE FOR FLOOR PROXIMITY INSTALLATION."
 - 4) Marked to identify voltage supply or type of branch circuit or both.

- b. Exit Fixtures (UL CCN FWBO):
 - 1) "SUITABLE FOR OPERATION IN AMBIENTS NOT EXCEEDING <Insert ambient temperature>°F."
10. Seismic and Wind Performance: Installed product must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:
 - a. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events[**and unit must be fully operational after seismic events**]."
 - b. Component Importance Factor (Ip): [1.0][1.5].
 - c. Component Amplification Factor (ap): [1.0][2.5]<Insert value>.
 - d. Component Response Modification Factor (Rp): [1.5][2.5]<Insert value>.
 - e. Component Overstrength Factor (Ωo): [1.5][2.5]<Insert value>.
- F. UL FWBX - Self-Luminous or Photoluminescent Exit Sign :
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Cooper Lighting Solutions; Signify North America Corp.]
 - b. [Dual-Lite; brand of GE Current, a Daintree company; American Industrial Partners (AIP)]
 - c. [Evenlite, Inc.]
 - d. [Isolite Corporation]
 - e. [Lithonia Lighting; Acuity Brands Lighting, Inc.]
 - f. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Cooper Lighting Solutions; Signify North America Corp.]
 - b. [Dual-Lite; brand of GE Current, a Daintree company; American Industrial Partners (AIP)]
 - c. [Evenlite, Inc.]
 - d. [Isolite Corporation]
 - e. [Lithonia Lighting; Acuity Brands Lighting, Inc.]
 - f. <Insert manufacturer's name>
 3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: UL CCN FWBX; including UL 924, NFPA 101[, **NFPA 5000**], and ICC IBC.
 5. Exit Sign Description: <Insert description of desired shape and dimensional limitations>.
 6. Standard Features:
 - a. Powered by tritium gas, with universal bracket for flush-ceiling, wall, or end mounting. Signs must be guaranteed by manufacturer to maintain minimum brightness requirements in UL 924 for [10][15][20] years.
 - b. Use strontium oxide aluminate compound to store ambient light and release stored energy when light is removed. Include universal bracket for flush-ceiling, wall, or end mounting.
 7. Sustainable Design Features:

- a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
8. Installation Markings:
- a. All Luminaires (UL CCN HYXT):
 - 1) "SUITABLE FOR DAMP LOCATIONS."
 - 2) "SUITABLE FOR WET LOCATIONS."
 - 3) "SUITABLE FOR MOUNTING WITHIN 1.2 M (4 FT) OF THE GROUND" or "SUITABLE FOR FLOOR PROXIMITY INSTALLATION."
 - b. Self-Luminous and Photoluminescent Exit Signs (UL CCN FWBX):
 - 1) "SUITABLE FOR OPERATION IN AMBIENTS NOT EXCEEDING **<Insert ambient temperature>°.**"
 - 2) Mark with minimum illumination level of necessary lighting type to achieve required visibility.
9. Seismic and Wind Performance: Installed product must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:
- a. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events[**and unit must be fully operational after seismic events**]."
 - b. Component Importance Factor (Ip): **[1.0][1.5]**.
 - c. Component Amplification Factor (ap): **[1.0][2.5]<Insert value>**.
 - d. Component Response Modification Factor (Rp): **[1.5][2.5]<Insert value>**.
 - e. Component Overstrength Factor (Qo): **[1.5][2.5]<Insert value>**.

2.3 LUMINAIRE FITTINGS

A. Luminaire Support Accessories:

1. Standard Features:
 - a. Sized and rated for luminaire weight.
 - b. Capable of maintaining luminaire position after cleaning and relamping.
 - c. Capable of supporting luminaire without causing deflection of ceiling or wall.
 - d. Capable of supporting horizontal force equal to 100 percent of luminaire weight and vertical force equal to 400 percent of luminaire weight.
2. Sustainable Design Features:

- a. Corporate Sustainability Report: Provide **[third-party-verified]** corporate sustainability report that is publicly available from manufacturer and that includes environmental impacts of extraction operations and activities associated with product and its supply chain.
 - b. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles (160 km)** of Project site.
 - c. Regional Materials (IgCC/ASHRAE 189.1): Provide documentation if product is sourced (extracted, harvested, recovered, or manufactured) within **500 miles (800 km)** of Project site. Identify percentage of product's travel that is by rail or water.
 - d. Third-Party Certification: Third-party certification, in accordance with multiple attribute standard(s) developed by consensus-based process from an approved standard development organization, is publicly available for product.
 - e. Third-Party-Verified Product Life-Cycle Assessment: Assessment covering cradle-to-gate scope, in accordance with ISO 14040 and ISO 14044, is publicly available for product.
3. Other Available Features Required by the Project:
- a. Hook Hangers: Integrated assembly matched to luminaire, supply voltage, and equipment with threaded attachment, cord, and locking-type plug.
 - b. Wires: ASTM A641/A641M, Class 3, soft temper, zinc-coated steel, **[12 gage (2.68 mm)]<Insert size>** wire supports **[adjustable to][10 ft (3 m)]<Insert value>** in length.
 - c. Aircraft Cables: **[5/32 inch (4 mm)]<Insert value>** diameter aircraft cable supports **[adjustable to][10 ft (3 m)]<Insert value>** in length.
 - d. Single-Stem Hangers: **1/2 inch (13 mm)** nominal diameter steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.
 - e. Rod Hangers: **3/16 inch (5 mm)** nominal diameter, cadmium-plated, threaded steel rod.

2.4 MAINTENANCE MATERIAL ITEMS

- A. Spare Parts: Furnish to Owner spare parts, for repairing lighting equipment, that are packaged with protective covering for storage on-site and identified with labels describing contents. **[Include the following:]**
 1. Diffusers and Lenses: **[One for every 100]<Insert quantity>** of each type and rating installed. Furnish at least one of each type.
 2. Globes and Guards: **[One for every 20]<Insert quantity>** of each type and rating installed. Furnish at least one of each type.
- B. Extra Stock Material: Furnish to Owner extra materials[, **from same production run,**] that match products installed and that are packaged with protective covering for storage and identified with labels describing contents. **[Include the following:]**
 1. Incandescent Lamps: **[10 for every 100]<Insert quantity>** of each type and rating installed. Furnish at least one of each type.
 2. Luminaire-Mounted Emergency Battery Packs: **[One for every 20][One for every 50]<Insert quantity>** of each type and rating installed. Furnish at least one of each type.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

- B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Temporary Lighting: If approved by Architect, specified luminaires for the Project may be installed for temporary lighting. Install and energize minimum quantity of luminaires necessary to meet needs of construction activities. When construction is sufficiently complete, remove, disassemble, clean, and relamp luminaires used for temporary lighting before reinstalling for the Project's delivery.

3.3 SELECTION OF LUMINAIRES

- A. Finished Spaces:
 - 1. Location: **<Insert list of product types>**.
- B. Unfinished Spaces:
 - 1. Location: **<Insert list of product types>**.

3.4 INSTALLATION OF LIGHTING

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in Contract Documents or manufacturers' published instructions, comply with the following:
 - 1. Electrical Construction: ICC IBC, ICC IFB, NFPA 1, NFPA 70, and NECA NEIS 1.
 - 2. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
 - 3. Work in Confined Spaces: NFPA 350.
 - 4. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
 - 5. Installation of Indoor Lighting Systems: NECA NEIS 500.
 - 6. Installation of Exterior Lighting Systems: NECA NEIS 501.
 - 7. Installation of Industrial Lighting Systems: NECA NEIS 502.
 - 8. Installation of Luminaires, Lampholders, and Lamps: Article 410 of NFPA 70.
 - 9. Installation of Extra-Low-Voltage Lighting: Article 411 of NFPA 70.
 - 10. Installation of Lighting for Sensitive Electronic Equipment: Article 647 of NFPA 70.
 - 11. Installation of Emergency Lighting and Exit Signs: ICC IBC, NFPA 101, and Parts IV and V in Article 700 of NFPA 70.
 - 12. Consult Architect for resolution of conflicting requirements.
- C. Special Installation Techniques:
 - 1. Install luminaires level, plumb, and square with finished floor or grade unless otherwise indicated.
 - 2. Install luminaires at height and aiming angle as indicated on the Drawings.
 - 3. Coordinate layout and installation of luminaires with other construction.
 - 4. Adjust luminaires that require field adjustment or aiming. **[Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources, favoring a north orientation.]**

5. Exterior Bollard Luminaires:
 - a. Align units for optimum directional alignment of light distribution.
 - b. Install on concrete base with top **[4 inch (100 mm)]<Insert dimension>** above finished grade or surface at luminaire location. Cast conduit into base, and shape base to match shape of bollard base. Finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Section 033000 "Cast-in-Place Concrete."
6. Exterior In-Ground Luminaires:
 - a. Install on concrete base with top **[4 inch (100 mm)]<Insert dimension>** above finished grade or surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Section 033000 "Cast-in-Place Concrete."
7. Exterior Corrosion Prevention:
 - a. Do not use aluminum in contact with earth or concrete. When in direct contact with dissimilar metals, protect aluminum with insulating fittings or treatment.
 - b. When embedding steel conduits in concrete, wrap conduit with **10 mil (0.254 mm)** thick, pipe-wrapping plastic tape applied with a 50 percent overlap.
8. Flush-Mounted Luminaire Support:
 - a. Secured to outlet box.
 - b. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
 - c. Trim ring flush with finished surface.
9. Wall-Mounted Luminaire Support: **[Attached to structural members in walls][Attached to a minimum 1/8 inch (3 mm) backing plate attached to wall structural members][Attached using through bolts and backing plates on either side of wall]<Insert means of attachment>**.
 - a. Do not attach luminaires directly to gypsum board.
10. Suspended Luminaire Support:
 - a. Ceiling Mount:
 - 1) Hook hangers.
 - 2) **[Two]<Insert number>** wires.
 - 3) **[Two][Four]<Insert number>** aircraft cables.
 - b. Pendants and Rods: Where longer than **48 inch (1220 mm)**, brace to limit swinging.
 - c. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
 - d. Continuous Rows of Luminaires: Provide tubing or stem for wiring at one point and **[tubing or rod][wire support]** for suspension for each unit length of luminaire chassis, including one at each end.
 - e. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.
11. Ceiling-Grid-Mounted Luminaire Support:

- a. Install ceiling support system rods or wires[, **independent of the ceiling suspension devices,**] for each luminaire. Locate not more than **6 inch (150 mm)** from luminaire corners.
 - b. Support Clips: Fasten to luminaires and to ceiling grid members at or near each luminaire corner with clips that are UL listed for application.
 - c. Luminaires of Sizes Smaller than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support luminaires independently with no fewer than two **3/4 inch (20 mm)** metal channels spanning and secured to ceiling tees.
 - d. Seismic Restraint: Install at least one independent support rod or wire from structure to tab on luminaire. Wire or rod must have breaking strength for luminaire weight with safety factor of 3.0.
12. Remote Mounting of Ballasts or Drivers: Do not exceed distance between ballast or driver and luminaire recommended by ballast or driver manufacturer.
 13. Emergency Power Units: Secure with approved fasteners in four or more locations, spaced near corners of unit.
 14. Install wiring connections for luminaires.
 15. Identification: Provide labels for luminaires and associated electrical equipment.
 - a. Identify field-installed conductors, interconnecting wiring, and components.
 - b. Provide warning signs.
 - c. Label each enclosure with engraved metal or laminated-plastic nameplate.
 16. **<Insert more stringent installation requirements that supplement or supersede listed standards and manufacturers' published instructions>.**

D. Interfaces with Other Work:

1. Coordinate installation of new products for **<Insert system or product family/category>** with existing conditions.
 - a. **<Insert requirements for transition between new and existing>.**
2. Coordinate with **<Insert Section number and title>** for **<Insert description of interfacing related Work>.**
 - a. **<Insert requirements for transition between this Section and related Work>.**

- E. Systems Integration: Integrate lighting control devices and equipment with electrical power connections for operation of luminaires as specified.

3.5 FIELD QUALITY CONTROL OF LIGHTING

A. Administrant for Electrical Power Tests and Inspections:

1. **[Owner][Tenant]** will engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
2. Engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].

B. Administrant for Field Tests and Inspections of Lighting Installations:

1. **[Owner][Tenant]** will engage qualified lighting testing and inspecting agency to administer and perform tests and inspections.
2. Engage qualified lighting testing and inspecting agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].

C. Acceptance Testing Preparation:

1. **<Insert requirements>**.

D. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.

E. Tests and Inspections:

1. Perform manufacturer's recommended tests and inspections.
2. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
3. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.
4. Verify operation of photoelectric controls.
5. Exterior Illumination Tests:
 - a. Measure light intensities at night. Use photometers with calibration referenced to NIST standards.

F. Nonconforming Work:

1. Luminaire will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

G. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

H. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.

1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project's site.

3.6 SYSTEM STARTUP

A. Perform startup service.

1. Complete installation and startup checks in accordance with manufacturer's published instructions.
2. Burn-in lamps that require specific aging period to operate properly, prior to occupancy by Owner.
3. Charge **[emergency power units][and][batteries]** minimum of one hour and depress switch to conduct short-duration test.
4. Charge **[emergency power units][and][batteries]** minimum of 24 hours and conduct one-hour

discharge test.

5. **<Insert startup steps if any>.**

- B. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** system startup.

1. Manufacturer's Field Reports for System Startup Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project's site.

3.7 ADJUSTING

- A. Luminaire Aiming Adjustments: When requested within **[12]<Insert number>** months of date of Substantial Completion, provide on-site assistance in adjusting aiming direction of luminaires to suit occupied conditions. Make up to **[two]<Insert number>** visits to the Project's site during other-than-normal hours for this purpose. Some of the Work may be required during hours of darkness.

1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
2. Parts and supplies must be manufacturer's authorized replacement parts and supplies.
3. Adjust aim of luminaires in presence of Architect.

3.8 CLOSEOUT ACTIVITIES

- A. Training:

1. **[With assistance from factory-authorized service representatives, train][Train]** Owner's maintenance personnel on the following topics:
 - a. How to adjust, operate, and maintain luminaires**[and photoelectric controls]**.
2. **[Provide video recordings of training sessions to Owner.][Allow Owner to record training sessions.]**

3.9 PROTECTION

- A. After installation, protect lighting equipment from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 26 50 00 00



Task	Specification	Specification Description
26 51 00 00	26 50 00 00	Lighting
26 51 13 00	26 50 00 00	Lighting
26 51 16 00	26 50 00 00	Lighting
26 51 19 00	26 50 00 00	Lighting
26 51 23 00	26 50 00 00	Lighting
26 51 33 00	02 84 16 00	Handling of Lighting Ballasts and Lamps Containing PCBs and Mercury
26 51 33 00	26 50 00 00	Lighting
26 52 00 00	26 50 00 00	Lighting
26 52 13 00	26 50 00 00	Lighting
26 52 13 13	26 50 00 00	Lighting
26 52 13 16	26 50 00 00	Lighting
26 54 00 00	26 50 00 00	Lighting
26 54 19 00	26 50 00 00	Lighting
26 55 00 00	26 50 00 00	Lighting
26 55 13 00	26 50 00 00	Lighting
26 55 16 00	26 50 00 00	Lighting
26 55 29 00	26 50 00 00	Lighting
26 55 39 00	26 50 00 00	Lighting
26 55 53 00	26 50 00 00	Lighting
26 55 53 11	26 50 00 00	Lighting
26 55 53 12	26 50 00 00	Lighting
26 55 53 13	26 50 00 00	Lighting



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SECTION 26 55 61 00 - THEATRICAL LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Luminaires and accessories.
2. Distribution components.
3. Lighting control system.
4. Desktop operator workstation.
5. Rigging components.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. Section 284600 "Fire Detection and Alarm" specifies fire-alarm control panels and cabling referenced by this Section.

1.2 DEFINITIONS

- A. Channel: An individual control output on a control console, accessed and regulated by a slider, switch, or button; or in some cases, accessed by a discretely assigned address and regulated by a data input apparatus.
- B. Control Voltage: As defined in NFPA 70, term for circuits and equipment operating at less than 50 V or for remote-control, signaling, and power-limited circuits.
- C. Fade Time: The time it takes all zones to fade from one lighting scene to another, with all zones arriving at the next scene at the same time.
- D. Scene: The lighting effect created by adjusting several zones of lighting to the desired intensity.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For theatrical lighting.
1. Include plans, elevations, sections, and [mounting][attachment] details.
 2. Detail fabrication and installation for dimmer racks and arrangements, characteristics, and circuit assignments of various modules and rack-mounted accessories.
 3. Elevation views of front, rear, and side panels indicating devices and controls, including

- illustrations and dimensioned outline drawings.
- 4. Include diagrams for power, signal, and control wiring. Show connections, circuits, and channel assignments.
- 5. Equipment legend showing a unified system of designations for lighting instruments, panels, dimmers, circuits, and equipment.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans, reflected ceiling plan(s), and other details drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Required working clearances for operation, maintenance, and environmental conditions.
 - 2. Areas above and around dimming equipment where piping and ducts are prohibited.
 - 3. Rack layout and relationships between components and adjacent structural and mechanical elements.
- B. Qualification Data: For Installer.
- C. Seismic Qualification Data: Certificates, for lighting equipment, distribution equipment, and rigging components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For luminaires, distribution components, software operating manuals, and controls to include in emergency, operation, and maintenance manuals.
 - 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Instructional DVD: Professionally produced informational presentation to provide comprehensive instructions for equipment installation, connectivity, programing, and functional use. Information provided shall be specific to equipment provided for Project and shall include ancillary equipment and its integration into the theatrical lighting control system.
 - b. Control-Console Introduction:
 - 1) Descriptions of controls and features.
 - 2) Software instruction manuals.
 - 3) Setup requirements for unit and related equipment.
 - 4) Default settings.
 - 5) Maintenance procedures and schedules.
 - c. Control-Console Operation:

- 1) Elementary on-off operation.
- 2) How to set cues manually.
- 3) How to patch dimmer to channels electronically.
- 4) How to operate presets manually.
- 5) How to operate fundamental memory.
- 6) How to set and record simple cues.
- 7) How to recall, play back, and revise cues and scenes.
- 8) How to use submasters, groups, focus points, fader channels; and how to split cues, store and recall programs, set up special effects, and print out cues.
- 9) How to set up and run system for a typical event or performance.
- 10) How to get help.

d. Dimming Racks:

- 1) Descriptions of features, functions, and safety and security precautions.
- 2) Descriptions of dimming module features, software-driven functions, non-dim functions, and associated racking systems.
- 3) How to compare connected loads against dimmer capacity ratings.
- 4) How to terminate basic power-in and power-out connections.
- 5) Basic maintenance requirements, including need for qualified electrician for internal maintenance; basic maintenance schedule; techniques for keeping terminals properly tightened, filter screens clean, and overheat sensors checked; and techniques for performing other required servicing.
- 6) How to adjust dimmer-control module.
- 7) How to get help.
- 8) Description of warranty.

- e. System Troubleshooting: Procedures for handling problems with common software, programming, control console, dimmer rack, and distribution system; include information on how to get help.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On USB drive or compact disk, complete with data files.
3. Device address list if applicable.
4. Printout of software application and graphic screens.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Dimmer Modules: **[One]<Insert number>** of each type and rating installed.
2. Fuses: Three of each kind.
3. Lamps: **[One]<Insert number>** for every **[10]<Insert number>** of each type and rating installed. Furnish at least one of each type.
4. Glass Roundels: **[One]<Insert number>** for every **[three]<Insert number>** of each type and color installed. Furnish at least one of each type.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

1.8 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of the complete dimming control system and luminaires that fail in materials or workmanship within specified warranty period.
 - 1. Lamps are not included as part of the special warranty.
 - 2. Warranty Period: Cost to repair or replace parts for **[two]<Insert number>** years from date of Substantial Completion.
 - 3. Extended Warranty Period: Cost of replacement parts (materials only, f.o.b. the nearest shipping point to Project site), for **[eight]<Insert number>** years.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Dimmer racks shall withstand the effects of earthquake motions determined according to **[ASCE/SEI 7]<Insert requirement>**.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with NFPA 70.

2.2 PLUG CONNECTORS

- A. Pin Type: ANSI E1.24, two pole, three wire, 20 A.
- B. Twist-Locking Type: NEMA WD 6, two pole, three wire, 20 A.

2.3 LUMINAIRES AND ACCESSORIES

- A. General:
 - 1. Comply with UL 1573 and listed and labeled by an NRTL.
 - 2. Luminaires: Equipped with pigtail, yoke with pipe clamp, safety cable for batten mounting, and filter holder.
 - 3. Metal Parts: Free of burrs, sharp corners, and edges.
 - 4. Sheet Metal Components: Steel unless otherwise indicated. Form and support to prevent warping and sagging.
 - 5. Luminaire Doors and Their Internal Access: Smooth operating, free of light leakage under operating conditions, and arranged to permit relamping without use of tools. Doors, lenses, diffusers, and other pieces arranged to prevent accidental falling during relamping and when secured in operating position.
 - 6. Pigtail: Factory wired, **36-inch- (900-mm-)** long, three-wire cord and plug connector assembly with cord encased in woven fiberglass or silicone tubing.
 - 7. Lamp Sockets: Relampable without disturbing alignment or focus adjustment.

8. Luminaire Ventilation Openings: Baffled against light leaks.
 9. Luminaire Operating Controls and Handles: Thermally insulated.
 10. Lenses: Borosilicate glass in silicone mountings.
 11. Framing Shutters: Stainless steel, four way; with each blade in a separate plane under adjustable tension mounting. Blades adjust plus or minus 30 degrees of rotation in gate for 120-degree-minimum total angular rotation between adjacent blades.
 12. Color Filter Frame Holder: Attached to front of luminaire.
 13. Luminaire Yoke: Rigid metal, arranged for vertical aiming of unit and equipped with T-bolt or hand screw to lock alignment.
- B. Ellipsoidal Spotlights: Luminaires with an elliptical reflector mounted in a fixed relationship to the lamp. Light shall be projected through a gate where the beam is shaped by using shutters, a gobo, or an iris. The shaped beam shall then be focused by a system of lenses.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Altman Lighting Co. Inc.]**
 - b. **[Electronic Theatre Controls, Inc]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Lighting & Electronics, Inc.]**
 - e. **[Philips; Signify North America; Signify Holding]**
 - f. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Altman Lighting Co. Inc.]**
 - b. **[Electronic Theatre Controls, Inc]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Lighting & Electronics, Inc.]**
 - e. **[Philips; Signify North America; Signify Holding]**
 - f. **<Insert manufacturer's name>**
 3. Tag ES-1 :
 - a. Lamp: **[1000 W Q1000/4CL, ANSI FEL][750 W ANSI HPL]<Insert description>**.
 - b. Pattern Holders: Three for each luminaire, with framing shutters.
 - c. Color Frame: Black, metal.
 - d. Minimum Cosine Illumination Performance Ratings When Operated with ANSI 1.9, FEL Lamp:
 - 1) 171,000-beam candlepower at 20-degree field angle.
 - 2) 48,000-beam candlepower at 40-degree field angle.
 - e. Minimum Cosine Illumination Performance Ratings When Operated with ANSI 1.9 Series, HPL Lamp:
 - 1) 124,300-beam candlepower at 20-degree field angle.
 - 2) 51,500-beam candlepower at 40-degree field angle.
- C. Zoom Ellipsoidal Spotlights: Luminaires with an elliptical reflector mounted in an adjustable relationship to the lamp. Light shall be projected through a gate where the beam is shaped by using shutters, a

gobo, or an iris. The shaped beam shall then be focused by a system of lenses.

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Altman Lighting Co. Inc.]**
 - b. **[Electronic Theatre Controls, Inc]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Lighting & Electronics, Inc.]**
 - e. **[Philips; Signify North America; Signify Holding]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Altman Lighting Co. Inc.]**
 - b. **[Electronic Theatre Controls, Inc]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Lighting & Electronics, Inc.]**
 - e. **[Philips; Signify North America; Signify Holding]**
 - f. **<Insert manufacturer's name>**
3. Tag ZES-1 :
 - a. Lamp: **[1000 W Q1000/4CL, ANSI FEL][750 W ANSI HPL]<Insert description>**.
 - b. Pattern Holders: Three for each luminaire, with framing shutters.
 - c. Operator adjustable from **[15- to 35][25- to 50]**-degree field angle.
 - d. Field-angle adjustment scale label on instrument housing for field reference.
 - e. Minimum Cosine Illumination Performance Rating When Operated with ANSI 1.9, FEL Lamp: 82,000-beam candlepower at 35-degree field angle.
 - f. Minimum Cosine Illumination Performance Rating When Operated with ANSI 1.9, HPL Lamp: 95,330-beam candlepower at 35-degree field angle.

D. Fresnel Lens Spotlights:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Altman Lighting Co. Inc.]**
 - b. **[Electronic Theatre Controls, Inc]**
 - c. **[Lighting & Electronics, Inc.]**
 - d. **[Philips; Signify North America; Signify Holding]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Altman Lighting Co. Inc.]**
 - b. **[Electronic Theatre Controls, Inc]**

- c. **[Lighting & Electronics, Inc.]**
 - d. **[Philips; Signify North America; Signify Holding]**
 - e. **<Insert manufacturer's name>**
3. Die-cast extruded-aluminum housing, with hinged front for relamping.
4. Tag FLS-1 :
 - a. Lamp: **[1000 W Q1000T7/4CL, ANSI EGT][750 W ANSI HPL]<Insert description>**.
 - b. Lens: **6 inches (152 mm)**.
 - c. Illumination Performance Rating When Operated with ANSI 1.9, EGT Lamp:
 - 1) 175,000-beam candlepower at 12.5-degree field angle in spot focus.
 - 2) 12,000-beam candlepower at 74.6-degree field angle in flood focus.
 - d. Illumination Performance Rating When Operated with ANSI 1.9, HPL Lamp:
 - 1) 124,300-beam candlepower at 20-degree field angle in spot focus.
 - 2) 17,600-beam candlepower at 65-degree field angle in flood focus.
 - e. Barn Doors: Two four-leaf rotatable metal flaps for every three luminaires.
- E. Follow Spotlights:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Altman Lighting Co. Inc.]**
 - b. **[Lycian Stage Lighting]**
 - c. **[Strong International]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Altman Lighting Co. Inc.]**
 - b. **[Lycian Stage Lighting]**
 - c. **[Strong International]**
 - d. **<Insert manufacturer's name>**
 3. Tag FS-1 :
 - a. Lamp:
 - 1) **[Metal halide; G22 medium bi-post; CRI: 90; color: 6000 K; life: 750 hours; HMI 575 W/GS 95 V]<Insert description>**.
 - 2) Quartz-projector type, **<Insert number>** W, for **<Insert number>**-V supply.
 - b. Adjustable lenses in metal housing.
 - c. Adjustable, underslung base stand mounted on **3-inch (75-mm)**, locking-type, rubber-tired, ball-bearing casters.
 - d. Adjustable lamp holder and socket assembly with precision tuning adjustment; allows user to replace lamp without tools.
 - e. Three-leaf, full-range mechanical dimmer.



- f. Adjustable iris and framing shutters.
- g. Automatic color boom.
- h. Removable power cable, **25 feet (8 m)** long.
- i. Iris-Open, Spot-Focus Performance: **[800,000]<Insert value>** -beam candlepower at **[7.2]<Insert number>**-degree field angle.
- j. Iris-Open, Flood-Focus Performance: **[330,000]<Insert value>** -beam candlepower at **[12.2]<Insert number>**-degree field angle.

F. PAR Lamp Holders:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Altman Lighting Co. Inc.]**
 - b. **[James Thomas Engineering, Inc.]**
 - c. **[Lighting & Electronics, Inc.]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Altman Lighting Co. Inc.]**
 - b. **[James Thomas Engineering, Inc.]**
 - c. **[Lighting & Electronics, Inc.]**
 - d. **<Insert manufacturer's name>**
3. Tag PLH-1 :
 - a. Lamp: **[300 W PAR 38]<Insert description>**.
 - b. Housing: Steel or aluminum, **[flat black color,]** with porcelain-plated shell socket.
 - c. Barn Doors: Two four-leaf rotatable metal flaps for every three luminaires.
4. Tag PLH-2 :
 - a. Lamp: **[575 W tungsten halogen; 90 GLA 575 W; 120 V; color: 3050 K, ANSI GKV]<Insert description>**.
 - b. Housing: Steel or aluminum, with porcelain-plated shell socket **[and color frame]**.
 - c. Barn Doors: Two four-leaf rotatable metal flaps for every three luminaires.
 - d. With Lens Holder and Replaceable Lenses:
 - 1) - Very narrow spot.
 - 2) - Narrow spot.
 - 3) - Medium flood.
 - 4) - Wide flood.
 - 5) - Very wide flood.
 - e. **[Motorized][Manual]** color wheel.

- G. Borderlight Units: Compartmented, three-circuit striplight with nine **[120-W, PAR 38/SP][120-W, PAR 38/FL][250-W, PAR 38/SP]** lamps in porcelain sockets and steel sheet housing, **90 inches (2286 mm)** long. Compartments shall be in line and wired on **[two][three][four]** alternate circuits, each producing a different color.

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Altman Lighting Co. Inc.]**
 - b. **[Lighting & Electronics, Inc.]**
 - c. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Altman Lighting Co. Inc.]**
 - b. **[Lighting & Electronics, Inc.]**
 - c. **<Insert manufacturer's name>**
 3. Front Door: Spring loaded; designed to hold either filter frames or color roundels.
 4. Color Roundels: One for each lamp; **[alternating red, blue, and clear]<Insert colors>**.
 - a. Additional Roundels: **<Insert number>** amber and **<Insert number>** green.
 5. Hanger: Adjustable, steel-strap type equipped at each end with pipe clamp and safety cable for suspension from a batten.
 6. Housing shall be constructed of **0.036-inch (0.9-mm)** steel with louvers for heat dissipation and baffles for control of light leaks within luminaire.
- H. Cyclorama Lights: Suitable for lighting cycloramas from above.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Altman Lighting Co. Inc.]**
 - b. **[James Thomas Engineering, Inc.]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Lighting & Electronics, Inc.]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Altman Lighting Co. Inc.]**
 - b. **[James Thomas Engineering, Inc.]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Lighting & Electronics, Inc.]**
 - e. **<Insert manufacturer's name>**
 3. Tag CL-1 :
 - a. Lamp: **[1000 W Q1000T3/1CL, ANSI FFT]<Insert description>**.
 - b. Housing: Aluminum**[or steel][, flat black color][, with color frame]**.
- I. Black Lights: Portable, producing a wash of UV light for special effects.

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Altman Lighting Co. Inc.]**
 - b. **[Lighting & Electronics, Inc.]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Altman Lighting Co. Inc.]**
 - b. **[Lighting & Electronics, Inc.]**
 - c. **<Insert manufacturer's name>**
3. Tag BL-1 :
 - a. Lamp: **[250-W blacklight flood, H37KB-250, with integral filter to eliminate far-UV effect while maximizing the near-UV effect]<Insert description>**.
 - b. Housing: Steel[or aluminum][, flat black color], with carry handle.
 - c. C-clamp for using on light pipe.

J. Moving Lights:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[High End Systems, Inc]**
 - b. **[Martin Professional, Inc]**
 - c. **[Vari-Lite; Signify North America; Signify Holding]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[High End Systems, Inc]**
 - b. **[Martin Professional, Inc]**
 - c. **[Vari-Lite; Signify North America; Signify Holding]**
 - d. **<Insert manufacturer's name>**
3. Tag ML-1 :
 - a. General: 700-W, 120-V, metal halide, motorized remote-controlled lighting instrument; NRTL listed.
 - b. Lamp: Short-arc metal halide, 14,500 lumens; color temperature of 5600 K, CRI of 80.
 - c. Color System: Three-filter CYM (cyan, yellow, magenta) cross-fading mechanism, and 11 standard colors on a fixed wheel.
 - d. Optics: Zoom optics with continuously variable field angle from 18.5 to 42 degrees, programmable over a timed range of 2 seconds to 20 minutes; with a mechanical iris for beam-size control. Variable beam focus to soften the edges of gobos and light beams.

- Zoom combined with iris can project a beam with a field angle of 8 degrees.
- e. Dimming: Coated glass dimmer wheel, with controls to provide smooth timed fades.
- f. Strobe for strobe lighting effects.
- g. Gobo: One rotating wheel with five rotatable wheel positions and one open position. One fixed gobo wheel with 11 pattern positions and one open position.
- h. Beam Orientation Control: Smooth pan and tilt using a three-phase stepper motor system. Pan, 540 degrees; tilt, 270 degrees at 0.3-degree repeatability on either axis.
- i. Control: ANSI E1.11 (USITT DMX512-A) protocol using five pin connectors.

2.4 DISTRIBUTION COMPONENTS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Electronic Theatre Controls, Inc]**
 2. **[ESL Power Systems, Inc.]**
 3. **[Performance Electric]**
 4. **[SSRC]**
 5. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Electronic Theatre Controls, Inc]**
 2. **[ESL Power Systems, Inc.]**
 3. **[Performance Electric]**
 4. **[SSRC]**
 5. **<Insert manufacturer's name>**
- C. Connector Strip: Listed and labeled by an NRTL; factory-wired wireway and receptacle assembly.
1. Wireway: Steel or extruded aluminum, with removable cover and nominal cross-section dimensions of **3 by 4-1/2 inches (75 by 115 mm)**.
 2. Accessories: Cable clamps, support cradles, and cable strain relief grips for each cable.
 3. Receptacles:
 - a. Pigtail mounted, **18 inches (450 mm)** long, with strain relief at wireway wall penetration.
 - b. Flush mounted in wireway cover.
 4. Receptacle Wiring: For connecting to terminal blocks; with 125 deg C, crosslinked, PE-insulated, identification-labeled wire.
 5. Terminal Blocks: Molded-barrier type with screw lugs to suit supply conductors.
 6. Mounting Hardware: Furnished with each unit; permits surface, single-pipe-bracket, or double-pipe-bracket mounting.
 7. Finish: Semigloss or matte black.
- D. Plug-in Boxes: Listed and labeled by an NRTL; factory-wired wireway and receptacle assembly, **24 inches (600 mm)** long unless otherwise indicated; with the following features:
1. Wireway: Steel or extruded aluminum, with removable cover and nominal cross-section dimensions of **3 by 4-1/2 inches (75 by 115 mm)**.
 2. Accessories: Cable clamps, support cradles, and cable strain relief grips for each cable.
 3. Receptacles:



- a. Pigtail mounted, **18 inches (450 mm)** long, with strain relief at wireway wall penetration.
 - b. Flush mounted in wireway cover.
 4. Receptacle Wiring: For connecting to terminal blocks; with 125 deg C, crosslinked, PE-insulated, identification-labeled wire.
 5. Terminal Blocks: Molded-barrier type with screw lugs to suit supply conductors.
 6. Surface or Grid Mounting: With accessories for surface mounting or with pipe-mounting accessory bracket.
 7. Recessed Mounting: With flanged cover suitable for recessed mounting in wall.
 8. Finish: Semigloss or matte black.
- E. Gridiron Junction Boxes: Listed and labeled by an NRTL; factory wired with terminal strips and concentric knockouts on all sides.
1. Terminal Blocks: Molded-barrier type with screw lugs to suit supply conductors.
 2. Accessories: Cable clamps, support cradles, and cable strain relief grips for each cable; and brackets for surface or pipe mounting.
 3. Finish: Semigloss or matte black.
- F. Floor Pockets: Listed and labeled by an NRTL; flush-mounted, receptacle outlet assembly.
1. Box: **0.0598-inch (1.5-mm)** steel sheet, **10 inches (250 mm)** deep.
 2. Cover Plate: Steel, cast iron, or cast aluminum with nonskid safety tread surface and self-closing, hinged door with cable notches.
 3. Barrier for allowing installation of control-voltage control receptacle for console input or handheld remotes.
- G. Company Switch: Listed and labeled by an NRTL as complying with UL 891.
1. Enclosure: NEMA 250 **[Type 3R][Type 4X]** with interlocked, full-height doors.
 2. Breakers:
 - a. General Requirements: Comply with UL 489 and NEMA AB 3, with interrupting capacity to comply with available fault currents.
 - b. Features and Accessories:
 - 1) Main molded case circuit breaker with safety interlock to doors.
 - 2) Standard frame sizes, trip ratings, and number of poles.
 - 3) Lugs: **[Mechanical][Compression]** type, suitable for number, size, trip ratings, and conductor material.
 - 4) Application Listing: Appropriate for application; Type HID for feeding lighting circuits.
 - 5) Ground-Fault Protection: Comply with UL 1053; **[integrally mounted, self-powered][remote-mounted and powered]** type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
 3. Receptacles:
 - a. **[Locking][Locking, cam style]** color coded, wired to main circuit breaker.
 - b. Cable entry at **[side][bottom]** of enclosure.
 - c. Rated for **[200][400]** amps at 600-V ac.
 - d. Integral safety interlock allowing access only if main circuit breaker is in "OFF" position.
 4. Integral ground lug for facility ground conductor.

2.5 WIRE AND CABLE

- A. Building Wire in Raceways: Comply with requirements specified in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Portable Power Cable: Listed and labeled by an NRTL; flexible stage and lighting power cable; Type SC, SCE, or SCT; 600 V; multiconductor; 60 deg C temperature rating.
- C. Ethernet Cabling: Comply with requirements specified in Section 260523 "Control-Voltage Electrical Power Cables."
 - 1. For 10/100BaseT, comply with provisions for UTP cable and hardware.
 - 2. For 10Base-FL, comply with provisions for **[50/125][62.5/125]**-micrometer, multimode, optical-fiber cable and hardware.
- D. ANSI E1.11 (USITT DMX512-A) Control Cabling: Comply with requirements specified in Section 260523 "Control-Voltage Electrical Power Cables."
 - 1. Standard Cable, NFPA 70 **[Type CM][or][Type CMG]**:
 - a. Paired, low-capacitance computer cable for ANSI E1.11 (USITT DMX512-A) applications. Two pairs, twisted, **[No. 22 AWG][No. 24 AWG]**, stranded, tinned-copper conductors.
 - b. Inner Shield: 100 percent coverage, aluminum foil-polyester tape.
 - c. Outer Shield: 90 percent coverage, tinned-copper braid.
 - d. Outer Shield Drain Wire: Stranded, tinned copper.
 - e. Listed and labeled in accordance with UL 444.
 - 2. Plenum-Rated Cable, NFPA 70 Type CMP:
 - a. Paired, low-capacitance computer cable for ANSI E1.11 (USITT DMX512-A) applications. Two pairs, twisted, **[No. 22 AWG][No. 24 AWG]**, stranded, tinned-copper conductors.
 - b. Inner Shield: 100 percent coverage, aluminum foil-polyester tape.
 - c. Outer Shield: 90 percent coverage, tinned-copper braid.
 - d. Outer Shield Drain Wire: Stranded, tinned copper.
 - e. Listed and labeled in accordance with UL 444.
 - f. Investigate insulation and jacket materials in accordance with UL 2257.
- E. Control-Voltage Control Cabling:
 - 1. Control-Cable Conductors:
 - a. Class 1 Control Circuits:
 - 1) Conductor: Stranded copper, **[Type THHN-THWN, single-conductor wire complying with UL 83][Type XHHW, single-conductor wire complying with UL 44][Type XHHW, multi-conductor cable complying with UL 44]**.
 - 2) Method: **[In raceway][Concealed in building finishes][In cable tray]**.
 - b. Class 2 Control Circuits:
 - 1) Conductor: Stranded copper, **[Type THHN-THWN, single-conductor wire complying with UL 83][Type XHHW, single-conductor wire complying with UL 44][Type XHHW, multi-conductor cable complying with UL 44]**.
 - 2) Method: **[In raceway][Concealed in building finishes][In cable tray]**.
 - c. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type TW complying with UL

83.

2. Standard Cable, NFPA 70 Type CMG:
 - a. One pair, twisted, **[No. 16 AWG, stranded][or][No. 18 AWG, stranded (19x30)]**, tinned-copper conductors.
 - b. Unshielded.
 - c. Listed and labeled in accordance with UL 444.
3. Plenum-Rated Cable, NFPA 70 Type CMP:
 - a. One pair, twisted, **[No. 16 AWG, stranded (19x29)][or][No. 18 AWG, stranded (19x30)]**, tinned-copper conductors.
 - b. Unshielded.
 - c. Listed and labeled in accordance with UL 444.
 - d. Investigate insulation and jacket materials in accordance with UL 2257.

2.6 LIGHTING CONTROL SYSTEM

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 1. **[Electronic Theatre Controls, Inc]**
 2. **[Entertainment Technology]**
 3. **[Leviton Manufacturing Co., Inc.]**
 4. **[Philips; Signify North America; Signify Holding]**
 5. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 1. **[Electronic Theatre Controls, Inc]**
 2. **[Entertainment Technology]**
 3. **[Leviton Manufacturing Co., Inc.]**
 4. **[Philips; Signify North America; Signify Holding]**
 5. **<Insert manufacturer's name>**
- C. Description: Microprocessor-based modular system consisting of dimmer and control modules operated from remote-control stations and a control console.
 1. Comply with UL 508.
 2. Comply with ANSI E1.11 (USITT DMX512-A) **[RDM][and][or][ACN]** for data transmission.
- D. Dimmer Racks: Listed and labeled by an NRTL; dead-front, front-access, **[wall-mounted][freestanding]** rack for mounting modular dimmers; formed-steel or extruded-aluminum structural members; completely enclosed with steel or aluminum panels. Painted with manufacturer's standard corrosion-resistant primer and finish coats, and having the following features:
 1. Primary Circuit Breaker: Fault-current withstand rating of the rack; not less than **[10,000 A][50,000 A]<Insert number>**, symmetrical.
 2. Hinged, locking front door, with openings to allow air intake across the face of all dimmer modules.
 3. Individual rack sections shall not exceed **84 inches high by 25 inches deep by 30 inches wide**

- (2134 mm high by 635 mm deep by 762 mm wide). Multisection racks shall be interconnected with busbars.
4. For each module position, provide support rails and control-pin configurations, constructed for precise alignment of dimmer modules into power and signal connector sockets, with keyed connections for power capacity restrictions.
 5. Forced-air cooling of each rack for maintaining operating temperature at each dimmer, assuming full load, in ambient temperature not to exceed 40 deg C. Exhaust rates shall be variable, using temperature sensors and fan-speed control electronics. Individual control of multiple fans is acceptable in lieu of fan-speed control. Fan(s) shall start and stop automatically. Fan noise at full load shall be less than 3.1 sones.
 6. Each rack shall have an automatic air-temperature sensor to shut off all dimmers in the rack, should the internal temperature rise above maximum safe operating limits. In an overheat condition, the fan shall continue operating. When a safe operating temperature is restored, the system shall automatically reset to allow normal user control.
 7. Fabricate and test dimmer racks to withstand seismic forces defined in Section 260548 "Vibration and Seismic Controls for Electrical Systems."
- E. Dimmers: Modular solid-state units that operate smoothly over their operating ranges without audible lamp noise or radio-frequency interference at any setting. Modules shall be dead-front, draw-out type with floating line, load, and control sockets for smooth insertion and withdrawal; with load-side thermal-magnetic circuit breaker, speed-controlled cooling fan, and overtemperature sensor.
1. Non-Dim Units: On-off relay control only. Capable of serving inductive loads, such as motors or HID luminaires.
 2. Surge Protection: Modules shall withstand power-line surges of 6000 V/3000 A according to IEEE C62.41.1 and IEEE C62.41.2.
 3. Filter each dimmed circuit to provide a minimum 350-mic.sec., current-rise time at a 90-degree conduction angle at 50 percent of rated dimmer capacity. At any load within rating, rate of current rise shall not exceed 30 mA/mic.sec., measured from 10 to 90 percent of load current waveform.
- F. Control System: Microprocessor-based control system, ANSI E1.11 (USITT DMX512-A) **[RDM][and][or][ACN]** protocol, with a nonvolatile system memory to adjust dimmer channel settings for different scenes, to patch dimmers to channels, and to manually or automatically change dimmer settings from one preset scene to another.
1. Control shall support Ethernet-based LAN at devices.
 2. Provide means to create and monitor show data on a PC using software by console manufacturer. Software shall be capable of the following:
 - a. Creating show and providing for use of show files.
 - b. Playing back show in a console-simulation mode.
 - c. Accessing all remote-control stations associated with the console and control system.
 - d. Providing standard Ethernet connection between the console control system and the lighting system components.
 3. Display the following system status information on a color, **[17-inch (430-mm) LCD]<Insert size and type>** monitor associated with the control console:
 - a. Current channel intensities.
 - b. Cue information.
 - c. Monitor.
 4. Moving Lights: Include a standard control library, a program patch specific to luminaire(s) provided, and selective programming with ANSI E1.11 (USITT DMX512-A) **[RDM][and][or][ACN]** addressing of fade, focus points, beam, image, color, **<Insert attributes>** and position.

- G. Control Console: Tabletop unit with manual and computer-based programming controls, memory units, indicating devices, and the following features:
1. Grand-master level control.
 2. Blackout switch.
 3. Multiple submaster level controls with overlapping pile-on performance.
 4. Bump buttons for momentary control of channels or submasters, one for each submaster level control.
 5. Two cross-fade controls for split dipless fade between scenes, each with its own fade progress indicator.
 6. One set of scene level controls for each scene when used in two-scene preset mode. Second set of scene level controls to allow setting levels into memory for expanded single scenes when used in multiple single-channel scene mode. Each set shall have same quantity of scene level controls as is used for submaster level controls.
 7. Multibutton keypad for programming in multiscene memory mode.
 8. Fade time control for assigning fade time to cues, with individual cue adjustment from one second to five minutes, minimum.
 9. Digital display, for operating menus and memory readout.
 10. Controls for setting levels into memory.
 11. Cord and connector for connecting console to outlets for console power and control.
- H. System Operation: Selectable between multichannel two-scene preset and four-channel single-scene memory. Console features include electronic patching of control signals for up to 512 dimmers and off-line data storage using USB drive port. Operational capability includes the following:
1. Live and blind programming.
 2. Special effects programmability for automatic operation of lights in pulsating, sequential dimming and brightening, and other special operating modes. Special effects menu displays operator guidance for programming and individual step levels.
 3. Signal from fire-alarm control panel that automatically brings selected circuits to fully on or fully bright condition, overriding normal dimming and on-off controls.
 4. Inserting cues between designated cues without renumbering.
 5. Out-of-sequence playback of cues.
 6. Controlling houselights and stage lights from console by assigning their dimmers or non-dim on-off controls to a channel.
 7. Retaining programmed cues in memory for minimum of one year after power outage.
 8. Automatic sequential execution of programmed cues.
 9. Printing cues using parallel or serial printer port, cable, and printer. Cable and printer are not included with this system.
- I. Console Power and Control Outlets: Multiple receptacles matched to connector on console connector cord.
- J. House Lighting Control Station: Architectural-type, multichannel, remote-dimmer-control station with the following features:
1. System controls designated houselights, stage lights, and other lights.
 2. Stage lighting controls compatible with dimming and control system.
 3. Flush mounting.
 4. **[Four][Eight][Sixteen]** channels, each with slider potentiometer control.
 5. Master-slider potentiometer that controls lights on all channels proportionally from completely dimmed to degree of brightness that corresponds to individual slider positions.
 6. Fully on switch that turns all channels on at full brightness regardless of slider position.
 7. Take-control/off switch that places station in control of channels and sets lighting to levels dictated by channel and master-slider controls.

8. Legend on face of wall plate that identifies items as "House Lighting Control Station" and identifies functions of each slider and switch position, with slider positions individually graduated from zero to maximum.
 9. Illuminated push buttons for activating preset scenes of house lighting and labeled ["Entry."]["Panic."]["Entry" and "Panic."]
 10. Flush wall mounted unless otherwise indicated.
- K. Entry Station: Push button activates or deactivates indicating light and presets scene of house lighting control system.
1. LED indicating light illuminates when preset command is executed.
 2. Labeled "Entry."
 3. Flush wall mounted unless otherwise indicated.
- L. Key-Entry Station: Key-operated switch controls station to activate or deactivate indicating light and presets scene of lighting control system.
1. LED indicating light illuminates when preset command is executed.
 2. Labeled "Entry."
 3. Flush wall mounted unless otherwise indicated.
- M. Emergency Lighting Control Station: **[Key-operated]** push button activates indicating light and brings selected dimmers to fully bright condition (i.e., the "Panic" preset). Operating push button a second time returns dimmers to previous setting.
1. Emergency mode indicating light.
 2. Labeled "Emergency Lights."
- N. Flush wall mounted unless otherwise indicated.

2.7 DESKTOP OPERATOR WORKSTATION

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Dell Technologies Inc.]**
 2. **[HP Inc.]**
 3. **[Lenovo Holding Co., Inc.; Lenovo Group Ltd.]**
 4. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Dell Technologies Inc.]**
 2. **[HP Inc.]**
 3. **[Lenovo Holding Co., Inc.; Lenovo Group Ltd.]**
 4. **<Insert manufacturer's name>**
- C. Performance Requirements:
1. Performance requirements may dictate equipment exceeding minimum requirements indicated.
 2. Capable of running **[Microsoft Windows]<Insert operating system name>**.
 3. ENERGY STAR compliant.

D. Personal Computer:

1. Minimum Processor Speed: <Insert gigahertz>.
2. RAM:
 - a. Capacity: [2][4][8]<Insert value>[GB].
 - b. Speed and Type: [1333]<Insert value> MHz, <Insert type>.
3. Hard Drive:
 - a. Number of Hard Drives: [One][Two]<Insert number>.
 - b. Capacity: <Insert number and measurement unit>.
 - c. Minimum Average Seek Time: <Insert number and measurement unit>.
 - d. Cache Buffer Size: <Insert number and measurement unit>.
 - e. <Insert requirements>.
4. Second Hard Drive:
 - a. Capacity: <Insert number and measurement unit>.
 - b. Minimum Average Seek Time: <Insert number and measurement unit>.
 - c. Cache Buffer Size: <Insert number and measurement unit>.
 - d. <Insert requirements>.
5. Optical Drive:
 - a. Type: <Insert type>.
 - b. Minimum Average Access Time: <Insert number> ms.
 - c. Data Transfer Speed: <Insert number>[MB][TB]/s.
 - d. Reading Formats: Data, audio, recordable, <Insert other> and rewritable.
6. Optical Read and Write Drive:
 - a. Include with at least 2 MB of data buffer.
 - b. Type: <Insert type>.
 - c. Minimum Data Buffer Capacity: <Insert number and measurement unit>.
 - d. Minimum Average Access Time: <Insert number> ms.
 - e. Nominal Data Transfer Rates:
 - 1) Reading: <Insert number>[MB][TB]/s.
 - 2) Writing: <Insert number>[MB][TB]/s.
 - f. Average access time of 150 ms or less.
 - g. MTBF of at least 100,000 power-on hours.
7. Expansion Slots: Minimum of 4, [32][64]<Insert number> bit.
8. Video Card:
 - a. Capable of supporting [one][two][three][four] monitor(s.)
 - b. Resolution: [1920 by 1200]<Insert values> pixels minimum for each monitor.
 - c. RAM: <Insert number>[MB][GB][TB].
 - d. Controller Speed: <Insert number>[MHz][GHz].
 - e. On-Board Memory Speed: <Insert number>[MHz][GHz].
 - f. On-Board Memory Data Width: <Insert number> bit.
9. Sound Card:

- a. At least 128 voice wavetable synthesis.
 - b. Capable of delivering three-dimensional sound effects.
 - c. High-resolution 16-bit stereo digital audio recording and playback with user-selectable sample rates up to 48,000 Hz.
 10. Network Interface Card: Include card with connection, as applicable.
 - a. 10-100-1000 base TX Ethernet with RJ45 connector port.
 - b. 100 base FX Ethernet with SC or ST port.
 11. Wireless Ethernet, 802.11 a/b/g/n.
 12. Optical Modem: Full duplex link for connection to fiber-optic cable provided.
 13. I/O Ports:
 - a. Two USB 3.0 ports on front panel, six on back panel, and three internal on motherboard.
 - b. One serial port.
 - c. One parallel port.
 - d. Two PS/2 ports.
 - e. One RJ-45.
 - f. One stereo line-in and line-out on back panel.
 - g. One microphone and headphone connector on front panel.
 - h. One IEEE 1394 on front and back panel with PCI-e card.
 - i. One ESATA port on back panel.
 14. Battery: Life of at least three years to maintain system clock/calendar and ROM, as a minimum.
- E. Keyboard:
1. 101 enhanced keyboard.
 2. Full upper- and lowercase ASCII keyset, numeric keypad, dedicated cursor control keypad, and 12 programmable function keys.
 3. Wireless operation within up to **72 inches (1800 mm)** in front of workstation.
- F. Pointing Device:
1. Either a two- or three-button mouse.
 2. Wireless operation within up to **72 inches (1800 mm)** in front of workstation.
- G. Flat Panel Display Monitor:
1. Number of Displays: **[One][Two]<Insert number>**.
 - a. Display Support: **[Individual tilt adjustable base][Desk mounted, adjustable bracket capable of supporting number of monitors specified above with integral power and display cable organization][Wall mounted, adjustable bracket capable of supporting number of monitors specified above with integral power and display cable organization]<Insert description>**.
 2. Color display with **<Insert inches (mm)>** diagonal viewable area.
 3. Aspect Ratio: **[16 to 9]<Insert value>**.
 4. Resolution: **[1920 by 1080]<Insert value>** pixels at 60 Hz with pixel size of **[0.277]<Insert number>** mm or smaller.
 5. **[Digital][or][analog]** input signal.
 6. Response Time: **<Insert number>** ms.
 7. Dynamic Contrast Ratio: **[50000 to 1]<Insert ratio>**.
 8. Brightness: **[250 cd/sq. m]<Insert value>**.

9. ENERGY STAR compliant.
10. Antiglare display.

H. Speakers:

1. Two, with individual controls for volume, bass, and treble.
2. Signal to Noise Ratio: At least 65 dB.
3. Power: At least 4 W per speaker/channel.
4. Magnetic shielding to prevent distortion on the video monitor.

I. I/O Cabling: Include applicable cabling to connect I/O devices.

J. Software:

1. Factory-installed operating system.

K. Uninterruptable power supply (UPS) unit for the workstation.

1. Provide continuous, regulated output power without using their batteries during brown-out, surge, and spike conditions.
 - a. Load served shall not exceed 75 percent of UPS rated capacity, including power factor of connected loads, but excluding the printer. UPS shall provide [15]<Insert number> minutes of battery power.
2. Performance:
 - a. Input Voltage: Single phase, 120-V ac, compatible with field power source.
 - b. Load Power Factor Range (Crest Factor): 0.65 to 1.0.
 - c. Output Voltage: 101- to 132-V ac, while input voltage varies between 89- and 152-V ac.
 - d. On-Battery Output Voltage: Sine wave.
 - e. Inverter overload capacity shall be minimum 150 percent for 30 seconds.
 - f. Recharge time shall be a maximum of six hours to 90 percent capacity after full discharge to cutoff.
 - g. Transfer Time: 6 ms.
3. UPS shall be automatic during fault or overload conditions.
4. Unit with integral line-interactive, power condition topology to eliminate all power contaminants.
5. Include front panel with power switch and visual indication of power, battery, fault, and temperature.
6. Unit shall include an audible alarm of faults and front panel silence feature.
7. Unit with four 120-V, 15-A receptacles.
8. UPS shall include dry contacts (digital output points) for low battery condition and battery-on (primary utility power failure)[**and connect the points to the monitoring and control system**].
9. Batteries shall be sealed lead-acid type and be maintenance free. Battery replacement shall be front accessible by user without dropping load.
10. Include tower models installed in ventilated cabinets at the particular installation location.

2.8 RIGGING COMPONENTS

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

1. [Altman Lighting Co. Inc.]
 2. [James Thomas Engineering, Inc.]
 3. [SSRC]
 4. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [Altman Lighting Co. Inc.]
 2. [James Thomas Engineering, Inc.]
 3. [SSRC]
 4. <Insert manufacturer's name>
- C. Pipe Clamps: Malleable iron, suitable for clamping luminaires or items to pipe from **3/4 to 2 inches (20 to 51 mm)** in OD. Arranged for horizontal rotation of yoke for aiming; equipped with T-bolt to lock alignment.
- D. Safety Cables: Heavy-duty, flexible steel; **30-inch (762-mm)** nominal length, with spring clip at one end and steel ring at the other end.
- E. Cable Grips: [**Stainless**][**Galvanized**] steel; basket-weave type for supporting stage cables.
- F. <Insert accessories>.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA NEIS 1.
- B. Set permanently mounted items level, plumb, and square with ceilings and walls.
- C. Indicated mounting heights are to bottom of unit for suspended items and to center of unit for wall-mounted items.
- D. Mount and connect luminaires, and install and connect distribution devices.
 1. If arrangement is not indicated, install so each luminaire, dimmer, house lighting circuit, control channel, and outlet circuit can be operated, and complete system demonstrated, in all operating modes.
 2. Install safety cables secured to stage rigging or gridiron for all pipe-mounted electrical luminaires and equipment.
- E. Dimmer Rack Mounting: Install and anchor dimmer racks level on **4-inch- (100-mm-)** high concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."
 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch (450-mm)** centers around full perimeter of base.
 2. For dimmer racks, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

4. Install anchor bolts to elevations required for proper attachment to dimmer racks.

- F. Comply with mounting and anchoring requirements specified in Section 260529 "Hangers and Supports for Electrical Systems" and Section 260548 "Vibration and Seismic Controls for Electrical Systems."

3.2 WIRING

A. Power Wiring:

1. Install wiring as specified in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for hardwired connections. Install wiring in raceways except cable and plug connections. Install cable strain relief device on power and control cable drops.
2. Install power wiring with a separate neutral for each output circuit from main dimmer and for each house and stage lighting circuit.

B. Signaling, Remote-Control, and Power-Limited Circuits:

1. Comply with requirements specified in Section 260523 "Control-Voltage Electrical Power Cables" for installation of wiring. **[Install wiring in raceways except cable and plug connections]<Insert wiring method>**.
2. Comply with the following unless otherwise indicated:
 - a. Size conductors according to lighting control device manufacturer's written instructions.
 - b. Select cable insulation, shielding, drain wire, and jacket complying with lighting control device manufacturer's written instructions.
 - c. Install circuits to eliminate RFI and electromagnetic interference.
3. Remote-control circuits associated with emergency lighting control shall be installed complying with Class 1 circuit standards in NFPA 70.

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points.

D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes and in terminal cabinets and equipment enclosures.

E. Remove wall plates and protect devices and assemblies during painting.

F. Support luminaires, distribution components, and accessories as specified in Section 260529 "Hangers and Supports for Electrical Systems." Equip all pipe-mounted equipment with safety cables that are secured to supporting pipe.

G. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

3.3 IDENTIFICATION

A. Identify components and power and control wiring according to Section 260553 "Identification for Electrical Systems."

B. Label each luminaire, lighting outlet, distribution device, and dimmer module with unique designation. Labels on elevated components shall be readable from the floor.

3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test, inspect, and adjust components, assemblies, and equipment installations, including connections.
- B. Tests and Inspections:
 - 1. Schedule visual and mechanical inspections and electrical tests with at least seven days' advance notice.
 - 2. Visual and Mechanical Tests and Inspections:
 - a. Inspect each luminaire, outlet, module, control, and device for defects, finish failure, corrosion, physical damage, labeling by an NRTL, and nameplate.
 - b. Exercise and perform operational tests on mechanical parts and operable devices according to manufacturer's written instructions.
 - c. Check tightness of electrical connections with torque wrench.
 - d. Verify proper protective device settings, fuse types, and ratings.
 - e. Record results of tests and inspections.
 - 3. Electrical Tests: Perform tests according to manufacturer's written instructions.
 - a. Continuity tests of circuits.
 - b. Operational Tests: Connect each outlet to a luminaire and a dimmer output circuit, so each dimmer module, dimmer-control and output circuit, outlet, and luminaire in a typical operating mode will be sequentially tested. Set and operate controls to demonstrate luminaires, outlets, dimmers, and controls in a sequence that cues and reproduces actual operating functions for a typical system of the size and scope installed. Include operation and control of houselights and stage lights from each control location and station, including optional plug-in, control-console outlet locations. Record luminaire and outlet assignments, control settings, operations, cues, and observations of performance.
- C. Stage lighting will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.
 - 1. Prepare a schedule of lighting outlets by number; indicate circuits, dimmers, connected luminaires, and control-channel assignments. Prepare a schedule of control settings and circuit assignments for house control channels. Prepare written reports of tests and observations. Report defective materials, workmanship, and unsatisfactory test results. Include records of repairs and adjustments made.

3.5 ADJUSTING

- A. Occupancy Adjustments: When requested within [12]<Insert number> months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to [two]<Insert number> visits to Project during other-than-normal occupancy hours for this purpose.
- B. Modify the software programming as required to comply with the Contract Documents.

3.6 SOFTWARE SERVICE AGREEMENT

- A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for [two]<Insert number> years.



B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within **[two]<Insert number>** years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least **[30]<Insert number>** days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.7 DEMONSTRATION

A. **[Engage a factory-authorized service representative to train][Train]** Owner's staff to adjust, operate, and maintain stage lighting equipment.

1. Training shall be **[one][two]** four-hour **[session][sessions]**.
2. Include costs associated with the training with the equipment installation.
3. Provide a 14-day notice to Owner prior to scheduling training period.

END OF SECTION 26 55 61 00



Task	Specification	Specification Description
26 55 61 00	26 50 00 00	Lighting



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SECTION 26 55 68 00 - ATHLETIC FIELD LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Athletic field luminaires and lamps.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies temperature, humidity, acoustical, and other field conditions applicable to the Work specified in this Section.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies seismic hazard, wind hazard, other structural load design conditions applicable to the Work specified in this Section.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional coordination, scheduling, sequencing, submittal, and installation requirements applicable to the Work for electrical, communications, and electronic safety and security systems on the Project, including wiring methods.
4. **[Section 013100 "Project Management and Coordination"]<Insert Section number and title>** for preinstallation conference procedures.
5. Section 055000 "Metal Fabrications" specifies pipe bollards installed by this Section.
6. Section 260519 "Low-Voltage Electrical Power Conductors and Cables" specifies cables installed by this Section.
7. Section 260533.13 "Conduits for Electrical Systems" specifies raceways installed by this Section.
8. Section 260533.16 "Boxes and Covers for Electrical Systems" specifies boxes and covers installed by this Section.
9. Section 260553 "Identification for Electrical Systems" specifies identification products installed by this Section.
10. **[Section 260923 "Lighting Control Devices"]****[Section 260943.16 "Addressable Luminaire Lighting Controls"]****[Section 260943.23 "Relay-Based Lighting Controls"]****[and]****[Section 265561 "Theatrical Lighting"]** specifies lighting control equipment and cabling connections to luminaires installed by this Section.
11. Section 262716 "Electrical Cabinets and Enclosures" specifies enclosures installed by this Section.
12. Section 264313 "Surge Protective Devices for Low-Voltage Electrical Power Circuits" specifies surge protective devices installed by this Section.
13. Section 260546 "Poles for Electrical Systems" specifies poles installed by this Section.

1.2 DEFINITIONS

- A. ACN: Architecture for Control Networks.
- B. CCT: Correlated color temperature; a measure of the chromaticity (yellowness or blueness) of a white light source, expressed as the absolute temperature in kelvins of a blackbody radiator having similar chromaticity.
- C. CRI: Color rendering index; a unitless estimation of how accurately a white light source displays the colors of reflected surfaces.
- D. CV: Coefficient of variation.

- E. DMX512: Digital multiplex with 512 pieces of information.
- F. LLF: Light-loss factor.
- G. RGBA: Red, green, blue, and amber.
- H. RGBW: Red, green, blue, and white.
- I. SPD: Surge protective device.
- J. UG: Uniformity gradient.
- K. UGR: Unified glare rating.

1.3 DELEGATED DESIGN SERVICES

- A. Delegated Design Professionals:
 - 1. Engage qualified lighting design professional to design athletic field lighting equipment.
 - 2. Engage qualified electrical professional engineer to design power distribution for athletic field lighting equipment.
 - 3. Engage qualified structural professional engineer to design poles, hangers, and supports for athletic field lighting equipment.

1.4 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at **[Project site]<Insert location>**.
- B. Preinstallation Coordination Meeting(s): For athletic field lighting. Conduct meeting(s) **[as videoconference][or][at Project site]<Insert location> before <Insert construction activity>**.
 - 1. Attendees: Installers, fabricators, representatives of manufacturers, and administrators for field tests and inspections. Notify Architect[, **Construction Manager**][, and **Owner's Commissioning Authority**] of scheduled meeting dates.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Arrange in order of luminaire designation.
 - 2. Complete ordering information for luminaire, lamps, and accessories.
 - 3. Data on features, accessories, and finishes.
 - 4. Physical description and dimensions of luminaires.
 - 5. Ballast, including UL listing and recognition, ANSI certification, and Energy Independence and Security Act of 2007 compliance.
 - 6. Lamps, including life, output (lumens, CCT, and CRI), and energy-efficiency data.
 - 7. Photometric data and adjustment factors based on laboratory tests by, or under supervision of, qualified luminaire photometric testing laboratory, for each lighting luminaire type. Adjustment factors must be for lamps, ballasts, and accessories identical to those indicated for the luminaire as applied in this Project.
 - 8. Photoelectric relays.

9. Means of attaching luminaires to supports and indication that attachment is suitable for components involved.
10. Include sample warranty language.
11. Product Certificates:
 - a. For each type of bilevel and dimmer-controlled luminaire ballast, signed by product manufacturer.
 - b. For support structures, including brackets, arms, appurtenances, bases, anchorages, and foundations, signed by product manufacturer.

B. Shop Drawings: Prepare and submit the following:

1. Drawings, Diagrams, and Supporting Documents for Nonstandard or Custom Luminaire:
 - a. Include plans, elevations, sections, and mounting and attachment details.
 - b. Details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - c. Diagrams for power, signal, and control wiring.
 - d. **<Insert additional requirements for drawing content or format>.**

C. Delegated Design Submittals: Include analysis data signed by delegated design professional(s) responsible for their preparation.

1. Drawings and specifications for construction of lighting system.
2. Manufacturer's determination of LLF used in design calculations.
3. Lighting system design calculations for the following:
 - a. Target illuminance.
 - b. Point calculations of horizontal and vertical illuminance, CV, and UG at minimum grid size and area.
 - c. Point calculations of horizontal and vertical illuminance in indicated areas of concern for spill light.
 - d. Calculations of source intensity of luminaires observed at eye level from indicated properties near the playing fields.
4. Luminaire layout and aiming diagrams.
5. Electrical system design calculations for the following:
 - a. Short-circuit current calculations for rating of panelboards.
 - b. Total connected and estimated peak-demand electrical load, in kilowatts, of lighting system.
 - c. Capacity of **[feeder][service]** required to supply lighting system.
6. Electrical wiring diagrams, including required conductors, cables, and wiring methods.
7. Electrical riser diagrams.
8. Structural analysis data and calculations used for the following:
 - a. Pole selection.
 - b. Luminaire mounting arrangement.

D. Field quality-control reports.

1.6 INFORMATIONAL SUBMITTALS

- A. Manufacturers' published instructions.

B. Field Reports:

1. Manufacturer's field reports for field quality-control support.
2. Manufacturer's field reports for system startup support.

1.7 CLOSEOUT SUBMITTALS

- A. Warranty documentation.
- B. Maintenance service agreement.

1.8 MAINTENANCE MATERIAL SUBMITTALS

- A. Spare parts.
- B. Consumable items.

1.9 QUALIFICATIONS

- A. Electrical Power Testing (EPT) Technician III: Possessing active NICET EPT Level III certification. Able to manage switching procedures; conduct tests of complex equipment; analyze test and equipment data; plan a job; and lead a team. Has experience performing NFPA 70B, IEEE, and NETA electrical tests.
- B. Electrical Power Testing (EPT) Technician IV: Possessing active NICET EPT Level IV certification. Able to conduct tests of complex metering and relay systems; evaluate tests, test equipment, test results, and power system performance; recommend actions to maintain or improve system performance; and lead multi-team projects.
- C. Electrical Power Testing and Inspecting Agency: Entities possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
 1. On-site electrical testing supervisors must possess active NICET EPT Technician [III][IV] certification.
- D. Electrical Professional Engineer: Professional engineer possessing active qualifications specified in Section 014000 "Quality Requirements," with expertise in electrical engineering, including electrical power system modeling and analysis of electrical safety in accordance with NFPA 70E.
- E. Structural Professional Engineer: Professional engineer possessing active qualifications specified in Section 014000 "Quality Requirements," with expertise in structural engineering, including design of seismic-load and wind-load controls, utility poles, equipment hangers and supports, and concrete foundations.
- F. Lighting Design Professional: Design professional possessing active qualifications in accordance with Section 014000 "Quality Requirements" and the following:
 1. Expertise in lighting design.
 2. Lighting Certified (LC) Professional by the National Council on Qualifications for the Lighting Professions (NCQLP).

- G. Exterior Athletic Lighting Installers: Installer possessing active qualifications specified in Section 014000 "Quality Requirements," and able to present unexpired certified Installer credentials issued by exterior athletic lighting manufacturer prior to starting installation.
- H. Outdoor Pole Testing and Inspecting Agency: Entity possessing active qualifications specified in Section 014000 "Quality Requirements" with documented training and experience in accordance with ASTM C1093 for foundation testing and inspections.
- I. Lighting Testing and Inspecting Agency: Entity possessing active qualifications specified in Section 014000 "Quality Requirements" with documented training and experience with testing and inspecting lighting installations in accordance with applicable IES standards.

1.10 DELIVERY, STORAGE, AND HANDLING

- A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.11 WARRANTY FOR ATHLETIC FIELD LIGHTING

- A. Special Installer Extended Warranty: Installer warrants that fabricated and installed athletic field lighting and associated electrical equipment perform in accordance with specified requirements and agrees to repair or replace components or products that fail to perform as specified within extended-warranty period. Warranty must convey to Owner upon acceptance of the Work.
 - 1. Extended-Warranty Period: **[Two][Three][Four][20]<Insert number>** years from date of Substantial Completion; full coverage for labor, materials, and equipment.
 - 2. Alignment Extended-Warranty Period: **[Five]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for labor, materials, and equipment.
 - a. Accuracy of alignment of luminaires must remain within specified illuminance uniformity ratios.
 - b. Realign luminaires that become misaligned during the warranty period.
 - c. Replace alignment products that fail within the warranty period.
 - d. Verify successful realignment of luminaires by retesting as specified in "Field Quality Control of Athletic Field Lighting" Article.
- B. Special Manufacturer Extended Warranty: Manufacturer warrants that athletic field lighting and associated electrical equipment perform in accordance with specified requirements and agrees to provide repair or replacement of components or products that fail to perform as specified within extended-warranty period. Warranty must convey to Owner upon acceptance of the Work.
 - 1. Luminaire Extended-Warranty Period: **[Five]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for materials **[that failed because of transient voltage surges]** only free on board **[origin][destination]**, freight prepaid.
 - 2. Lamps and Fuses Extended-Warranty Period: **[Two]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for materials only, free on board **[origin][destination]**, freight prepaid.



PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Description: **<Insert brief description of desired athletic field lighting system>.**
- B. Performance Criteria:
 - 1. Regulatory Requirements:
 - a. Components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - b. **<Insert requirements>.**
 - 2. General Characteristics:
 - a. Facility Type: **[Professional][College][Semiprofessional][Sports club][Amateur league][High school][Training facility][Elementary school][Recreational or social facility].**
 - b. Glare Control: Design illumination for each playing area to minimize direct glare in adjacent and nearby areas.
 - 1) Design source intensity of luminaires that may be observed at an elevation of **60 inch (1524 mm)** above finished grade from nearby properties to be less than **[12 000 cd][20 000 cd][30 000 cd]<Insert candela>** when so observed.
 - 2) Design source intensity of luminaires that may be observed at an elevation of **60 inch (1524 mm)** above finished grade from designated "spill-light critical" areas to be less than **[12 000 cd][20 000 cd][30 000 cd]<Insert candela>** when so observed.
 - c. Egress Lighting: In case of power failure, provide not less than **[1.0 fc (10.8 lx)]<Indicate value>** average illumination, within 30 seconds, measured at grade in spectator and spectator egress areas.
 - 1) Duration of emergency illumination must be not less than **[15 min]<Insert time>.**
 - 2) Momentary Power Interruptions: Provide emergency illumination immediately following restoration of power to the lighting circuits. Emergency illumination must automatically extinguish after **[15 min]<Insert time>.**
 - d. Lighting Control: Manual, low voltage, or digital; providing the following functions, integrated into a single control station, with multiple subcontrol stations as indicated:
 - 1) Control Station: Key-operated master switch, manual push-button controls, and system status indicator lights. **[Test switch of egress lighting system.]**
 - 2) Light Levels: Two levels of control - **[100/50 percent]<Insert two percentages>** of minimum target illumination.
 - 3) **<Insert Project-specific control requirements>.**
 - e. Electric Power Distribution Requirements:
 - 1) Electric Power: **[208 V][240 V][480 V];** three phase.

- a) Include roughing-in of service indicated for nonsports improvements on the Project site.
 - b) Balance load between phases. Install wiring to balance three phases at each support structure.
 - c) Include required overcurrent protective devices and individual lighting control for each sports field or venue.
 - d) Include indicated feeder capacity and panelboard provisions for future lighted sports field construction.
 - 2) Maximum Total Load: **<Insert number> A.**
 - 3) Maximum Total Voltage Drop from Source to Load: **[5 percent]<Insert percentage>**, including voltage drops in branch circuit, subfeeder, and feeder.
3. Illumination Criteria: Calculate by computer-analyzed point method complying with IES RP-6 to optimize selection, location, and aiming of luminaires.
- a. Minimum average target illuminance level for each lighted area for each sports venue and for the indicated class of play in accordance with IES RP-6.
 - b. CV and maximum-to-minimum uniformity ratios for each lighted area equal to or less than those listed in IES RP-6 for the indicated class of play.
 - c. UG levels within each lighted area equal to or less than those listed in IES RP-6 for the indicated speed of sport.
 - d. Minimum Average Target Illumination: **<Insert fc or lx>**.
 - e. CV: **<Insert value>**.
 - f. Maximum-to-Minimum Uniformity Ratio: **<Insert value>**.
 - g. UG Level: **<Insert value>**.
 - h. Grid Pattern Dimensions: For playing areas of each sport and areas of concern for spill-light control, correlate and reference calculated parameters to the grid areas. Each grid point represents the center of the grid area defined by the length and width of the grid spacing.
 - i. Spill-Light Control: Minimize spill light for each playing area on adjacent and nearby areas.
 - 1) Prevent light trespass on properties near the Project as defined by **<Insert name(s) of authorities having jurisdiction>**.
 - 2) For areas indicated on the Drawings as "spill-light critical," limit the level of illuminance directed into the area from any luminaire or group of luminaires, and measured **36 inch (914 mm)** above grade to the following:
 - a) Maximum Horizontal Illuminance: **[0.25 fc (2.7 lx)][0.5 fc (5.4 lx)][0.75 fc (8.1 lx)]**.
 - b) Maximum Vertical Illuminance from the Direction of the Greatest Contribution of Light: **[1.0 fc (10.8 lx)][2.0 fc (21.5 lx)][3.0 fc (32.3 lx)]**.
 - 3) Calculate the horizontal and vertical illuminance due to spill light for points spaced **[20 ft (6 m)]<Insert dimension>** apart in areas indicated on the Drawings as "spill-light critical," to ensure that design complies with the above limits.
 - j. Determine LLF in accordance with IES RP-6 and manufacturer's test data.
 - 1) Use LLF at **[100 percent]<Insert percentage>** of rated lamp life. LLF must be applied to initial illumination to ensure that target illumination is achieved at 100 percent of lamp life and must include consideration of field factor.
 - 2) LLF must not be higher than 70 percent and may be lower when determined by manufacturer after application of the ballast output and optical system output, in accordance with IES RP-6.



- k. Luminaire-Mounting Height: Comply with IES RP-6[, **with consideration for requirements to minimize spill light and glare**].
- l. Luminaire Placement: Luminaire clusters must be outside the glare zones defined by IES RP-6.
- m. Baseball Fields:
 - 1) IES RP-6, Classes of Play: **[Class I][Class II][Class III][Class IV]**.
 - 2) Speed of Sport: **[Fast][Moderate][Slow]**.
 - 3) Grid Pattern Dimensions: **30 by 30 ft (9 by 9 m)**.
- n. Softball Fields:
 - 1) IES RP-6, Classes of Play: **[Class I][Class II][Class III][Class IV]**.
 - 2) Speed of Sport: **[Fast][Moderate][Slow]**.
 - 3) Grid Pattern Dimensions: **20 by 20 ft (6 by 6 m)**.
- o. Football Fields:
 - 1) IES RP-6, Classes of Play: **[Class I][Class II][Class III][Class IV]**.
 - 2) Speed of Sport: **[Fast][Moderate][Slow]**.
 - 3) Grid Pattern Dimensions: **30 by 30 ft (9 by 9 m)**.
- p. Soccer Fields:
 - 1) IES RP-6, Classes of Play: **[Class I][Class II][Class III][Class IV]**.
 - 2) Speed of Sport: **[Fast][Moderate][Slow]**.
 - 3) Grid Pattern Dimensions: **30 by 30 ft (9 by 9 m)**.
- q. Outdoor Tennis Courts:
 - 1) IES RP-6, Classes of Play: **[Class I][Class II][Class III][Class IV]**.
 - 2) Speed of Sport: **[Fast][Moderate][Slow]**.
 - 3) Grid Pattern Dimensions: **10 by 10 ft (3 by 3 m)**.
- r. Insert Sport:
 - 1) IES RP-6, Classes of Play: **[Class I][Class II][Class III][Class IV]**.
 - 2) Speed of Sport: **[Fast][Moderate][Slow]**.
 - 3) Grid Pattern Dimensions: **<Insert dimensions>**.
- 4. Life-Cycle Cost Criteria:
 - a. Estimated life-cycle cost of lighting system for period of **<Insert number>** years based on the parameters below:
 - 1) Energy Cost: **<Insert dollars>**.
 - 2) Lamp Replacement Cost: **<Insert dollars>**.
 - 3) General Maintenance Cost: **<Insert dollars>**.
 - b. **<Insert life-cycle cost criteria>**.

2.2 ATHLETIC FIELD LUMINAIRES AND LAMPS

A. UL IFAM - LED Surface-Mounted Athletic Field Luminaire :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[CHM Lighting]**
 - b. **[Ephesus Sports Lighting; a brand of Cooper Lighting Solutions; Signify N.V.]**
 - c. **[Musco Lighting]**
 - d. **[Sportsbeams]**
 - e. **[Sportsliter Solutions; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[CHM Lighting]**
 - b. **[Ephesus Sports Lighting; a brand of Cooper Lighting Solutions; Signify N.V.]**
 - c. **[Musco Lighting]**
 - d. **[Sportsbeams]**
 - e. **[Sportsliter Solutions; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - f. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria:
 - a. LED Surface-Mounted Luminaires: UL CCN IFAM; including UL 1598.
 - b. LED Drivers: UL CCN FKSZ or UL CCN FKSZ2; including UL 8750.
5. Standard Features:
 - a. Doors, Frames, and Other Internal Access: Smooth operating, free from light leakage under operating conditions, and arranged to permit servicing without using tools. Arrange doors, frames, lenses, diffusers, and other pieces to prevent their accidental falling during servicing and when secured in operating position. Doors must be removable for cleaning or replacing lens. Designed to disconnect driver when door opens.
 - b. Finishes:
 - 1) Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
 - 2) Appearance of Finished Work: Noticeable variations in same piece are unacceptable. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and can be and are assembled or installed to minimize contrast.
 - c. Exposed Hardware: Corrosion-resistant metal latches, fasteners, and hinges.
 - d. Markings: "Suitable for Wet Locations."
 - e. Luminaire Mounting: Bracket mounted.
 - f. Driver Mounting: **[Remote; grouped in cabinets][Bracket mounted][Integral to luminaire; field changeable]**.
 - g. Driver Performance:

- 1) Nominal Input Voltage: [120 V][208 V][240 V][277 V][480 V], 60 Hz.
 - 2) Nominal Input Power: [80 W][100 W][150 W][300 W][500 W][1000 W][1200 W][1500 W]<Insert wattage>.
 - 3) Power Factor: Not less than [0.90]<Insert power factor requirement> lagging.
 - 4) Total Harmonic Distortion: Not greater than [16 percent][20 percent]<Insert percentage>.
- h. Beam Spread Pattern: [NEMA Type 1 (very narrow)][NEMA Type 2 (narrow)][NEMA Type 3 (medium narrow)][NEMA Type 4 (medium)][NEMA Type 5 (medium wide)][NEMA Type 6 (wide)][NEMA Type 7 (very wide)][Narrow spot (2 deg H by 2 deg V)][Narrow flood (4 deg H by 4 deg V)][Horizontal flood (5 deg H by 3 deg V)][Vertical flood (3 deg H by 5 deg V)][Medium flood (5 deg H by 5 deg V)][Wide flood (6 deg H by 6 deg V)]<Insert _ deg H by _ deg V beam angles>.
- i. Light Color: [White only][Tunable RGBW][Tunable RGBA]<Insert color requirement>[designed for 4K/HDTV broadcasting].
- 1) White Correlated Color Temperature: [2700 to 3000 K][4000 K][5000 K][5700 to 6000 K][3000/4000/5000 K selectable]<Insert CCT kelvins>.
 - 2) White Color Rendering Index: [70+][80+][90+]<Insert CRI>.
- j. Energy Efficiency: [Premium][DLC listed][and][ENERGY STAR listed].
6. Other Available Features Required by the Project:
- a. Spill-Light Control Devices: Internal louvers and external baffles furnished by manufacturer and designed for secure attachment to specific luminaire.
 - b. Dimming: [0-10 V dimmable]<Insert dimming requirement>.
 - c. Dimming Range (Light Output): [0-100 percent][10-100 percent or better][20-100 percent or better]<Insert dimming range requirement>.
 - d. Dim to off.
 - e. Surge Protection: Provide integral Type 2 SPDs; nonmodular, with digital indicator lights[and one set of dry contacts].
- 1) Maximum SPD Discharge Current Rating: [10 kA][20 kA]<Insert kA> per phase.
- f. Unified Glare Rating: [Less than 22][Less than 19]<Insert UGR requirement>.
 - g. Field-changeable lenses.
 - h. Luminaire Lighting Control Interface: [TIA-485 jack for ESTA E1.11 DMX512 cable][Termination box for ESTA E1.11 DMX512 cable][8P8C jack for ESTA E1.31 ACN Ethernet cable][DALI driver][Wireless] Open Lighting Alliance compliant interface.
 - i. Pre-terminated wiring pigtail.
 - j. 12 V secondary output power for external sensors, controls, or accessories.

2.3 MAINTENANCE MATERIAL ITEMS

- A. Spare Parts: Furnish to Owner spare parts, for repairing sports lighting, that are packaged with protective covering for storage on-site and identified with labels describing contents.[Include the following:]
1. Glass, Acrylic, and Plastic Lenses, Covers, and Other Optical Parts: [One percent]<Insert percentage> of each type and rating installed. Furnish at least one of each type.
 2. Ballasts: [One percent]<Insert percentage> of each type and rating installed. Furnish at least one of each type.
 3. Fuses: [10 percent]<Insert percentage> of each type and rating installed. Furnish at least one of

each type.

- B. Consumable Items: Furnish to Owner extra consumable items for storage on-site, identified with labels describing contents.[**Include the following:**]
 - 1. Lamps: [**10 percent**]**<Insert percentage>** of each type and rating installed. Furnish at least one of each type.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for luminaire electrical and communications conduit to verify actual locations of connections before pole or luminaire installation.
- C. Examine foundations for suitable conditions where luminaires will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF ATHLETIC FIELD LIGHTING

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in Contract Documents or manufacturers' published instructions, comply with the following:
 - 1. Electrical Construction: ICC IBC, ICC IFB, NFPA 1, NFPA 70, and NFPA 70E.
 - 2. Electrical Safety: NFPA 70E.
 - 3. Grounding and Bonding: NFPA 70E 250 and Article 250 of NFPA 70.
 - 4. Life Safety and Means of Egress Work: NFPA 101.
 - 5. Emergency and Standby Power Work: NFPA 110, NFPA 111, and NFPA 70E 416.
 - 6. Luminaires and Supports: Article 410 of NFPA 70.
 - 7. Consult Architect for resolution of conflicting requirements.
- C. Special Installation Techniques:
 - 1. Athletic Field Luminaires, Lamps, and Ballasts:
 - a. Install luminaires at height and aiming angle as indicated on Drawings.
 - b. Install controls and ballast housings in cabinets mounted on support structure at least **10 ft (3 m)** above finished grade.
 - 2. Structural Supports:
 - a. Provide [**steel**]**[aluminum]****[concrete]** poles and other support structures, brackets, arms, appurtenances, bases, anchorages, and foundations for athletic field lighting.
 - b. Use web fabric slings (not chain or cable) to raise and set structural members. Protect equipment during installation to prevent corrosion.
 - c. Install poles and other structural units level, plumb, and square.



- d. Except for embedded structural members, grout void between pole base and foundation. Use nonshrinking or expanding concrete grout firmly packed in entire void space. Use a short piece of **1/2 inch (13 mm)** diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole. Nonshrink grout is specified in Section 055000 "Metal Fabrications."
 - e. Extend cast-in-place bolted base foundations **36 inch (914 mm)** above grade, minimum.
 - f. Install protective pipe bollards on **[two][three]<Insert number>** sides of each embedded pole installed in paved areas.
3. Surge Protection: Install Type 2 surge protective devices; nonmodular, with digital indicator lights[**and one set of dry contacts**].
 - a. Peak Single-Impulse Surge Current Rating: **<Insert number>** kA per phase.
 4. Wiring Methods:
 - a. Install cables in raceways, except when cables are installed within boxes and poles. Conceal raceways and cables.
 - b. Feeders, Subfeeders, Branch Circuits, and Control Wiring: Underground nonmetallic raceway; 10 AWG minimum conductor size for power wiring.
 - c. Overhead-, pole-, or structure-supported wiring and transformers are[**not**] permitted.
 - d. Electrical Enclosures Exposed to Weather: UL 50E, Type 3R enclosure constructed from **[stainless steel][corrosion-resistant material]**, with hinged doors fitted with padlock hasps or lockable latches.
 - e. Install lighting control equipment and cabling connections to luminaires.
 5. Identification: Provide labels for athletic field lighting and associated electrical equipment.
 - a. Identify system components and terminals.
 - b. Identify field-installed conductors, interconnecting wiring, and components.
 - c. Provide warning signs.
 - d. Label each enclosure with engraved metal or laminated-plastic nameplate.
 6. **<Insert more stringent installation requirements that supplement or supersede listed standards and manufacturers' published instructions>.**
- D. Interfaces with Other Work:
1. Coordinate installation of new products for **<Insert system or product family/category>** with existing conditions.
 - a. **<Insert requirements for transition between new and existing>.**
 2. Coordinate with Section 260573 "Power System Studies" for mitigating available fault current and arc-flash hazard in electrical equipment installed for athletic field lighting.
 3. Coordinate with **<Insert Section number and title>** for **<Insert description of interfacing related Work>.**
 - a. **<Insert requirements for transition between this Section and related Work>.**
- E. Systems Integration: Integrate athletic field lighting controls with facility lighting controls.

3.3 FIELD QUALITY CONTROL OF ATHLETIC FIELD LIGHTING

- A. Administrant for Electrical Power Tests and Inspections:
1. **[Owner][Tenant]** will engage qualified medium-voltage electrical testing and inspecting agency to administer and perform tests and inspections.
 2. Engage qualified medium-voltage electrical testing and inspecting agency to administer and perform tests and inspections.
 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
 4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].
- B. Administrant for Field Tests and Inspections of Lighting Installations:
1. **[Owner][Tenant]** will engage qualified lighting testing and inspecting agency to administer and perform tests and inspections.
 2. Engage qualified lighting testing and inspecting agency to administer and perform tests and inspections.
 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
 4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].
- C. Acceptance Testing Preparation:
1. **<Insert requirements>**.
- D. Field tests and inspections must be witnessed by **[Architect][authorities having jurisdiction]<Insert names or titles of witnesses>**.
- E. Tests and Inspections:
1. After installing sports lighting system and after electrical circuits have been energized, perform proof-of-performance field measurements and analysis for compliance with requirements.
 2. Playing and Other Designated Areas: Make field measurements at intersections of grids, dimensioned and located as specified in "Performance Requirements" Article and as described below:
 - a. Baseball Fields: Measure at least **[25]<Insert number>** points of the infield and **[87]<Insert number>** points of the outfield. Extend the grid **15 ft (5 m)** outside the foul lines, extending to outfield boundary or fence.
 - b. Softball Fields: Measure at least **[16]<Insert number>** points of the infield and **[48]<Insert number>** points of the outfield. Extend the grid **15 ft (5 m)** outside the foul lines, extending to outfield boundary.
 - c. Football Fields: Lighted area is **[180 by 360 ft (55 by 110 m)]<Insert dimensions>**. Measure at least **[91]<Insert number>** points.
 - d. Soccer Fields: Lighted area is **[210 by 370 ft (64 by 113 m)]<Insert dimensions>**. Measure at least **[91]<Insert number>** points.
 - e. Outdoor Tennis Courts: Measure at least **[30]<Insert number>** points for a double court.
 - f. **<Insert sports venue>**: Measure at least **<Insert number>** points.
 3. Make field measurements at established test points in areas of concern for spill light and glare.
 4. Perform analysis to demonstrate correlation of field measurements with specified illumination quality and quantity values and corresponding computer-generated values that were submitted with engineered design documents. Submit a report of the analysis. For computer-generated

- values, use manufacturer's lamp lumens that are adjusted to lamp age at time of field testing.
5. Report results in writing.

F. Nonconforming Work:

1. Sports lighting will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.
3. Correction of Illumination Deficiencies for Playing Areas: Make corrections to illumination quality or quantity, measured in field quality-control tests, that varies from specified illumination criteria by plus or minus 10 percent.
 - a. Add or replace luminaires; change mounting height and aiming; or install louvers, shields, or baffles.
 - b. If luminaires are added or mounting height is changed, revise aiming and recalculate and modify or replace support structures if indicated.
 - c. Do not replace luminaires with units of higher or lower wattage without Architect's approval.
 - d. Retest as specified above after repairs, adjustments, or replacements are made.
 - e. Report results in writing.

G. Correction of Excessive Illumination in Spill-Light-Critical Areas: If measurements indicate that specified limits for spill light are exceeded, make corrections to illumination quantity, measured in field quality-control tests, that reduce levels to within specified maximum values.

1. Replace luminaires; change mounting heights and revise aiming; or install louvers, shields, or baffles.
2. Obtain Architect's approval to replace luminaires with units of higher or lower wattage.
3. If mounting height is changed, revise aiming and recalculate and modify or replace support structures if indicated.
4. Retest as specified above after repairs, adjustments, or replacements are made.

H. Assemble and submit test and inspection reports.

I. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.

1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at Project site.

3.4 SYSTEM STARTUP

A. Perform startup service.

1. Complete installation and startup checks in accordance with manufacturer's published instructions.
2. **<Insert startup steps if any>.**

B. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** system startup.

1. Manufacturer's Field Reports for System Startup Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at Project site.

3.5 ADJUSTING

- A. Adjust luminaires and supports to maintain orientation and aiming as recommended by manufacturer.
- B. Luminaire Aiming Adjustments: When requested within [12]<Insert number> months of date of Substantial Completion, provide on-site assistance in adjusting aiming direction of luminaires to suit occupied conditions. Make up to [two]<Insert number> visits to the Project site during other-than-normal hours for this purpose. Some of the Work may be required during hours of darkness.
 - 1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
 - 2. Parts and supplies must be manufacturer's authorized replacement parts and supplies.
 - 3. Adjust aim of luminaires in presence of Architect.

3.6 CLOSEOUT ACTIVITIES

- A. Training:
 - 1. **[With assistance from factory-authorized service representatives, train][Train]** Owner's maintenance personnel on the following topics:
 - a. How to adjust, operate, and maintain luminaires[**and lighting controls**].

3.7 PROTECTION

- A. After installation, protect athletic field lighting and associated electrical equipment from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

3.8 MAINTENANCE

- A. Maintenance Service Agreement: Beginning at Substantial Completion, verify that maintenance service agreement includes [three][six][nine][12] months' full maintenance by **[skilled employees of athletic field lighting installer][manufacturer's authorized service representative]**. Include **[semiannual][annual]** preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper athletic field lighting operation. Verify that parts and supplies are manufacturer's authorized replacement parts and supplies.

END OF SECTION 26 55 68 00



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Task	Specification	Specification Description
26 55 68 00	26 50 00 00	Lighting
26 55 70 00	26 50 00 00	Lighting
26 56 00 00	26 50 00 00	Lighting
26 56 13 00	02 41 19 00	Selective Demolition
26 56 13 00	26 50 00 00	Lighting
26 56 18 00	26 50 00 00	Lighting
26 56 19 00	26 50 00 00	Lighting
26 56 21 00	26 50 00 00	Lighting



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SECTION 27 11 00 00 - COMMUNICATIONS EQUIPMENT ROOM FITTINGS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Communications-circuit accessories.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. **[Section 013100 "Project Management and Coordination"]<Insert Section number and title>** for preinstallation conference procedures.
5. Section 061000 "Rough Carpentry" furnishes equipment backing panels installed by this Section.
6. Section 260526 "Grounding and Bonding for Electrical Systems" specifies the following installed by this Section:
 - a. Grounding and bonding conductors.
 - b. Grounding and bonding clamps.
 - c. Grounding and bonding bushings.
 - d. Grounding and bonding hubs.
 - e. Grounding and bonding connectors.
 - f. Intersystem bonding bridge grounding connector.
 - g. Grounding and bonding busbars.
 - h. Signal reference grids.
7. Section 260529 "Hangers and Supports for Electrical Systems" specifies hangers, supports, and concrete bases for communications equipment installed by this Section.
8. Section 260533.16 "Boxes and Covers for Electrical Systems" furnishes the following installed by this Section:
 - a. Metallic outlet boxes, device boxes, rings, and covers.
 - b. Junction boxes and pull boxes.
 - c. Cover plates for device boxes.
9. Section 260548 "Vibration and Seismic Controls for Electrical Systems" specifies vibration isolation and seismic-control devices referenced by this Section.
10. Section 260553 "Identification for Electrical Systems" specifies labels and warning signs for communications pathways installed by this Section.
11. Section 262716 "Electrical Cabinets and Enclosures" specifies the following installed by this Section:
 - a. Cabinets and cutout boxes.
 - b. Termination boxes.
 - c. Miscellaneous enclosures.

- d. Rack or frame systems.
- e. Enclosure-mounted relocatable power taps.

12. Section 262719 "Multi-Outlet Assemblies" specifies the following installed by this Section:

- a. Wall-mounted, surface metal raceway multi-outlet assemblies.
- b. Indoor service poles.

- 13. Section 262726.33 "General-Grade Duplex Straight-Blade Receptacles" specifies duplex receptacles installed by this Section.
- 14. Section 262726.39 "Locking Receptacles" specifies locking receptacles installed by this Section.
- 15. Section 262726.51 "Connectors, Cords, and Plugs" specifies pendant flexible cords and connectors installed by this Section.
- 16. Section 270528 "Pathways for Communications Systems" specifies cable pathways serving communications equipment room fittings installed under this Section.

1.2 DEFINITIONS

A. Abbreviations for Communications Spaces:

- 1. EF: Entrance facility; generally serves campus or building. EF may include an ER.
- 2. ER: Equipment room; generally serves campus or building.
- 3. TE: Telecommunications enclosure; generally serves a single tenant or floor.
- 4. TR: Telecommunications room; generally serves a single tenant or floor.

B. Abbreviations for Communications Facilities:

- 1. HC: Horizontal cross-connect; also called "floor distributor" (FD).
- 2. IC: Intermediate cross-connect; also called "building distributor" (BD).
- 3. MC: Main cross-connect; also called "campus distributor" (CD).

C. Abbreviations for Grounding and Bonding:

- 1. BBC: Backbone bonding conductor, for connecting multiple TBBs serving the same floor.
- 2. PBB: Primary bonding busbar; located in main distribution frame room, ideally near electrical service entrance.
- 3. RBB: Rack bonding busbar; located in equipment cabinets and racks.
- 4. SBB: Secondary bonding busbar; located in intermediate distribution frame rooms.
- 5. TBB: Telecommunications bonding backbone, for connecting SBBs to PBB.
- 6. TBC: Telecommunications bonding conductor, for connecting PBB to intersystem bonding termination device or busbar at electrical service entrance.
- 7. TEBC: Telecommunications equipment bonding conductor, for connecting RBBs to SBBs or PBB.
- 8. UBC: Unit bonding conductor, for connecting individual communications equipment to RBBs or SBBs.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at **[Project site]<Insert location>**.
- B. Preinstallation Coordination Meeting(s): For communications equipment room planning. Conduct meeting(s) **[as videoconference][or][at Project site]<Insert location>** before **<Insert construction activity>**.

1. Attendees: Representative of Owner's information and communications technology staff[**that will be installing electronic equipment**][**and cables**], installers, fabricators, representatives of manufacturers, and administrators for field tests and inspections. Notify Architect[, **Construction Manager**][, **and Owner's Commissioning Authority**] of scheduled meeting dates.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing laboratory, certifying that model number corresponding to specified product complies with specified listing criteria.

B. Shop Drawings: Prepare and submit the following:

1. Communications Equipment Room Drawings, Diagrams, and Supporting Documents:

- a. Include plans, elevations, sections, details, and attachments to other work.
- b. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
- c. Equipment Racks and Cabinets: Indicate workspace requirements and access for cable connections.
- d. Switchboards, Panelboards, and Safety Switches: Indicate workspace requirements and access for cable connections.
- e. Grounding and Bonding: Indicate location of busbars and their mounting details showing standoff insulators and wall mounting brackets.
- f. Cable Trays, Large Raceways, Ducts, and Piping: Indicate elevation and route of vertical and horizontal cable trays, raceways or ducts larger than **2 inch (50 mm)** wide, and fire-suppression piping located inside communications equipment room.
- g. Luminaires: Indicate elevation, orientation, and size of luminaires inside the communications equipment room for coordination with cable trays, equipment racks, cabinets, and other equipment.
- h. Access Panels: Indicate locations, dimensions, and clearances required to open access panels in ducts, walls, or ceilings inside communications equipment room.
- i. Controls: Indicate locations of sensors, switches, and push-buttons for HVAC, fire suppression, fire alarm, and standby power.
- j. Adjust configurations and locations of distribution frames, cross-connects, and patch panels in equipment rooms to accommodate and optimize configurations and space requirements of communications equipment.
- k. Adjust configurations and locations of equipment with distribution frames, cross-connects, and patch panels of cabling systems of other communications, electronic safety and security, and related systems that share space in equipment room.
- l. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.

1.5 INFORMATIONAL SUBMITTALS

A. Manufacturers' published instructions.

1.6 QUALIFICATIONS

- ##### A. Electrical Power Testing (EPT) Technician I: Possessing active NICET EPT Level I certification. Able to work safely around electrical power equipment and cabling under supervision.



- B. Electrical Power Testing (EPT) Technician II: Possessing active NICET EPT Level II certification. Able to isolate and ground electrical power equipment, to connect test equipment, and to conduct and document standard tests of basic equipment.
- C. Electrical Power Testing (EPT) Technician III: Possessing active NICET EPT Level III certification. Able to manage switching procedures, to conduct tests of complex equipment, to analyze test and equipment data, to plan a job, and to lead a team. Has experience performing NFPA 70B, IEEE, and NETA electrical tests.
- D. Electrical Power Testing (EPT) Technician IV: Possessing active NICET EPT Level IV certification. Able to conduct tests of complex metering and relay systems; to evaluate tests, test equipment, test results, and power system performance; to recommend actions to maintain or improve system performance; and to lead multi-team projects.
- E. Electrical Power Testing and Inspecting Agency: Entities possessing active credentials from qualified electrical testing laboratory recognized by authorities having jurisdiction.
 - 1. On-site electrical testing supervisors must possess active NICET EPT Technician [III][IV] certification.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- B. Seismic and Wind Performance: Installed assembly must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:
 - 1. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events[, and unit must be fully operational after seismic events].
 - 2. Component Importance Factor (Ip): [1.0][1.5].
 - 3. Component Amplification Factor (ap): [1.0][2.5]<Insert value>.
 - 4. Component Response Modification Factor (Rp): [1.5][2.0][2.5][6.0]<Insert value>.
 - 5. Component Overstrength Factor (Ωo): [1.5][2.5]<Insert value>.

2.2 COMMUNICATIONS-CIRCUIT ACCESSORIES

- A. Description: This category covers devices intended for connecting communications circuits in accordance with Article 800 of NFPA 70.
- B. UL DUXR - 66-Style or 110-Style Cross-Connect Frame :
 - 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [Belden Canada ULC]
 - b. [CommScope, Inc]
 - c. [Optical Cable Corporation (OCC)]
 - d. [Ortronics, Inc.]
 - e. [Panduit Corp]
 - f. [Siemon Co. (The)]
 - g. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Belden Canada ULC]
 - b. [CommScope, Inc]
 - c. [Optical Cable Corporation (OCC)]
 - d. [Ortronics, Inc.]
 - e. [Panduit Corp]
 - f. [Siemon Co. (The)]
 - g. <Insert manufacturer's name>
 3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: Investigated, labeled, and marked by [UL Solutions][or][FM Approvals][, CSA Group (with "US" marking)][, Intertek ETL][, TÜV Rheinland][, or other qualified electrical testing laboratory recognized by authorities having jurisdiction] in accordance with one or more of the following guide information and corresponding standards:
 - a. For Communications Circuits: UL CCN DUXR; including UL 1863 and UL 467.
 - b. For Audio/Video, Data, and Signaling Circuits: UL CCN DUXR; including UL 1977 and UL 467.
 5. Standard Features: This product type includes the frame only. Block inserts and related termination equipment are specified in communications cabling Sections.
- C. UL DUXR - Patch Panel :
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [CommScope, Inc]
 - b. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Legrand AV Inc.; Legrand North America, LLC]
 - d. [Leviton Manufacturing Co., Inc.]
 - e. [Ortronics, Inc.]
 - f. [Panduit Corp]
 - g. [Pass & Seymour; Legrand North America, LLC]
 - h. [Siemon Co. (The)]
 - i. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [CommScope, Inc]



- b. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Legrand AV Inc.; Legrand North America, LLC]
 - d. [Leviton Manufacturing Co., Inc.]
 - e. [Ortronics, Inc.]
 - f. [Panduit Corp]
 - g. [Pass & Seymour; Legrand North America, LLC]
 - h. [Siemon Co. (The)]
 - i. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by [UL Solutions][or][FM Approvals][, CSA Group (with "US" marking)][, Intertek ETL][, TÜV Rheinland][, or other qualified electrical testing laboratory recognized by authorities having jurisdiction] in accordance with one or more of the following guide information and corresponding standards:
- a. For Communications Circuits: UL CCN DUXR; including UL 1863 and UL 467.
 - b. For Audio/Video, Data, and Signaling Circuits: UL CCN DUXR; including UL 1977 and UL 467.
5. Standard Features:
- a. Mounting: [Equipment rack][Wall].
 - b. Style: [Modular][Prepopulated 110 punch down].
 - c. EMI Compatibility: [Shielded][Unshielded].
 - d. Configuration: [Standard][High density]; [flat][angled].
 - e. Include provisions for labeling ports.
 - f. Distribution Port Quantity: [12][24][48][72][144]<Insert quantity>.
 - g. Cable Type: [Cat. 5e][Cat. 6][Cat. 6a][Optical fiber]<Insert cable type>.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Contact telecommunications service provider and arrange for installation of demarcation point, protected entrance terminals, and a housing when so directed by service provider.

3.2 SELECTION OF GROUNDING AND BONDING PRODUCTS FOR COMMUNICATIONS

- A. Grounding and Bonding Conductors:

- 1. Communications Busbar Connections:
 - a. TBC: Not smaller than [1/0 AWG][3/0 AWG]<Insert wire size> and no smaller than largest TBB.
 - b. TBB: Not smaller than 2 kcmil per linear ft of conductor length, but not larger than 750 kcmil, unless otherwise indicated on Drawings.
 - c. BBC: Not smaller than largest TBB to which it is connected unless otherwise indicated on Drawings.
 - d. TEBC: Not smaller than [2 AWG]<Insert wire size> unless otherwise indicated on Drawings. Provide bolted connectors.
 - e. UBC: Not smaller than [6 AWG]<Insert wire size> unless otherwise indicated on

- f. Bonding Conductors to Structural Steel: Not smaller than **[6 AWG]<Insert wire size>** unless otherwise indicated on Drawings. Provide bolted clamp connectors.
 2. Cable Tray Connections:
 - a. Cable Tray Equipment Grounding Conductor: **[8 AWG][6 AWG][4 AWG]**.
 - b. Cable Tray Bonding Jumper: If not supplied by cable manufacturer, provide bonding jumper not smaller than **[10 AWG][6 AWG]** and not longer than **12 inch (300 mm)**. If jumper is wire, it must be terminated with lug having **[one hole and standard barrel for one crimp][two holes and long barrel for two crimps]**. If jumper is flexible braid, it must be terminated with **[one- or two-hole ferrule][one-hole ferrule]**. Attach with bonding screw or connector provided by cable tray manufacturer.
 3. Underground Connections: Not smaller than **[2 AWG]<Insert wire size>**. Provide welded connectors, except bolted connectors may be used in handholes or manholes and as otherwise indicated on Drawings.
- B. Grounding and Bonding Busbars:
1. PBB:
 - a. Dimensions: **[1/4 inch thick by 4 inch high (6.3 mm thick by 100 mm high)]<Insert dimensions>**.
 - b. Stand-Off Distance: **[2 inch (50 mm)][4 inch (100 mm)]<Insert dimension>**.
 2. SBB:
 - a. Dimensions: **[1/4 inch thick by 4 inch high (6.3 mm thick by 100 mm high)]<Insert dimensions>**.
 - b. Stand-Off Distance: **[2 inch (50 mm)][4 inch (100 mm)]<Insert dimension>**.
- C. Access Floor Signal Reference Grid:
1. Provide low-impedance path between telecommunications cabinets, equipment racks, and reference grid, by installing **[6 AWG]<Insert wire size>** bonding conductors in a grid pattern under the floor.
 - a. Install grid bonding conductors on **4 ft (1200 mm)** centers, so as to permit bonding of one structural pedestal for each access floor tile. Connect grid conductors together where they cross each other.
 - b. Bond SBBs in room to two or more bonding conductors of reference grid with TEBCs.
 - c. Bond equipment to nearest SBB and to reference grid with TEBCs.
 - d. Bond conduits and piping entering equipment room with TEBCs to nearest SBB and to grid conductor nearest entry into room.
- D. Signal Reference Grid Wire Mesh:
1. Provide low-impedance path between telecommunications cabinets, equipment racks, and reference grid, by installing wire mesh **[in concrete floor slab][above ceiling]** with the following features:
 - a. Wire mesh, 10 AWG solid copper, **2 inch (50 mm)** spacing.
 - b. Wire mesh, 10 AWG solid copper, **3 inch (75 mm)** spacing.
 - c. Wire mesh, 10 AWG solid copper, **4 inch (100 mm)** spacing.
 - d. Wire mesh, 10 AWG solid copper, **6 inch (150 mm)** spacing.

- e. Wire mesh, 10 AWG solid copper, **12 inch (300 mm)** spacing.
- f. Wire mesh, 8 AWG solid copper, **4 inch (100 mm)** spacing.
- g. Wire mesh, 8 AWG solid copper, **6 inch (150 mm)** spacing.
- h. Wire mesh, 8 AWG solid copper, **8 inch (200 mm)** spacing.
- i. Wire mesh, 8 AWG solid copper, **12 inch (300 mm)** spacing.
- j. Wire mesh, 6 AWG solid copper, **4 inch (100 mm)** spacing.
- k. Wire mesh, 6 AWG solid copper, **6 inch (150 mm)** spacing.
- l. Wire mesh, 6 AWG solid copper, **8 inch (200 mm)** spacing.
- m. Wire mesh, 6 AWG solid copper, **12 inch (300 mm)** spacing.
- n. Wire mesh, 6 AWG solid copper, **24 inch (610 mm)** spacing.
- o. Wire mesh, 4 AWG solid copper, **4 inch (100 mm)** spacing.
- p. Wire mesh, 4 AWG solid copper, **6 inch (150 mm)** spacing.
- q. Wire mesh, 4 AWG solid copper, **12 inch (300 mm)** spacing.
- r. Wire mesh, 2 AWG solid copper, **4 inch (100 mm)** spacing.
- s. Wire mesh, 2 AWG solid copper, **6 inch (150 mm)** spacing.
- t. Wire mesh, 2 AWG solid copper, **12 inch (300 mm)** spacing.
- u. Wire mesh, 2 AWG solid copper, **24 inch (610 mm)** spacing.

E. Signal Reference Grid Tape Mesh:

- 1. Provide low-impedance path between telecommunications cabinets, equipment racks, and reference grid, by installing tape mesh under floor finish with the following features:
 - a. Wire mesh, **2 inch (50 mm)** by **16 mil (0.4 mm)** solid copper, **12 inch (300 mm)** spacing.
 - b. Wire mesh, **2 inch (50 mm)** by **16 mil (0.4 mm)** solid copper, **24 inch (610 mm)** spacing.

3.3 SELECTION OF COLORS AND IDENTIFICATION MARKINGS

- A. Comply with 29 CFR 1910.144 for color identification of hazards, and the following:
 - 1. Fire-protection[**and fire-alarm**] equipment[, **including raceways**,] must be finished, painted, or suitably marked safety red.
 - 2. Ceiling-mounted hangers, supports, cable trays, and raceways must be finished, painted, or suitably marked safety yellow where less than [7.7 ft (2.3 m)]<Insert height> above finished floor.
- B. Pipe and Conduit Labeling: Comply with ASME A13.1[**and IEEE C2**].
- C. Color Coding Scheme for Communications Cable and Terminations: Comply with BICSI N1 and TIA-598.
- D. Accessible Fittings for Raceways: Identify cover of junction and pull box of the following systems with wiring system legend and system voltage. System legends must be as follows:
 - 1. "COMMUNICATIONS."
 - 2. "FIRE ALARM."
 - 3. "SECURITY."
 - 4. <Insert name>.
- E. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. Identify by system and circuit designation.
- F. Locations of Underground Lines: Underground-line warning tape for communication, control wiring, and optical-fiber cable.

- G. Communications Vaults, Manholes, Handholes, and Pull and Junction Boxes: For conductors in vaults, pull and junction boxes, manholes, and handholes, use **[vinyl wraparound labels][self-adhesive wraparound labels][snap-around labels][snap-around color-coding bands][self-adhesive vinyl tape]** to identify phase.
 - 1. Locate identification at changes in direction, at penetrations of walls and floors, at **50 ft (15 m)** maximum intervals in straight runs, and at **25 ft (7.6 m)** maximum intervals in congested areas.
- H. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use **[write-on tags][self-adhesive labels]** with conductor or cable designation, origin, and destination.
- I. Control-Circuit Conductor Termination Identification: For identification at terminations, provide **[heat-shrink preprinted tubes][self-adhesive labels]** with conductor designation.
- J. Conductors to Be Extended in Future: Attach **[write-on tags][marker tape]** to conductors[**and list source**].
- K. Auxiliary Electrical Systems Conductor Identification: **[Marker tape][Self-adhesive vinyl tape]** that is uniform and consistent with system used by manufacturer for factory-installed connections.
- L. Equipment and Cabling Identification for Administrative Records and Labeling: Comply with TIA-606 requirements for **[Class 1][Class 2][Class 3][Class 4]** network administration.
- M. Equipment Identification Labels:
 - 1. Black letters on white field.
 - 2. Indoor Equipment: **[Self-adhesive label][Baked-enamel signs][Metal-backed butyrate signs][Laminated acrylic or melamine plastic sign]**.
 - 3. Outdoor Equipment: **[Laminated acrylic or melamine sign][Stenciled legend 4 inch (100 mm) high]**.
 - 4. Equipment to Be Labeled:
 - a. Racks, Frames, and Enclosures: Identify front and rear of each enclosure with self-adhesive labels[**containing equipment designation**].
 - b. Patch Panels: **[Label individual rows in each rack, starting at top and working down, with self-adhesive labels.][Label individual rows and outlets, starting at to left and working down, with self-adhesive labels.]**
 - c. Communications cabinets.
 - d. Access doors and panels for concealed communications items.
 - e. Emergency system boxes and enclosures.
 - f. Contactors.
 - g. Remote-controlled switches, dimmer modules, and control devices.
 - h. Monitoring and control equipment.
 - i. Fire-alarm equipment.
 - j. Security equipment.
 - k. Life-safety communications equipment.
 - l. **<Insert equipment>**.
- N. Backbone Cables: Label each cable with a **[vinyl-wraparound label][snap-around label][self-adhesive wraparound label]** indicating the location of the far or other end of the backbone cable. Patch panel or punch down block where cable is terminated should be labeled identically.
- O. Horizontal Cables: Label each cable with a **[vinyl-wraparound label][snap-around label][self-adhesive wraparound label]**.



P. Cover Plates: Label individual cover plates with self-adhesive labels. Place label at top of cover plate. Identify cover plate in accordance with TIA-606.

Q. Cable Ties: General purpose, for attaching tags, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

3.4 SELECTION OF SIGNS AND HAZARD MARKINGS

A. Comply with 29 CFR 1910.145 for danger, caution, warning, and safety instruction signs.

B. Signs, labels, and tags required for personnel safety must comply with the following standards:

1. Safety Colors: NEMA Z535.1.
2. Facility Safety Signs: NEMA Z535.2.
3. Safety Symbols: NEMA Z535.3.
4. Product Safety Signs and Labels: NEMA Z535.4.
5. Safety Tags and Barricade Tapes for Temporary Hazards: NEMA Z535.5.

C. Electrical Hazard Warnings:

1. Multiple Power Sources Warning Legend: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT/RACK HAS MULTIPLE POWER SOURCES."
2. <Insert names and wording of warning signs or labels>.

D. Operating Instruction Signs: **[Self-adhesive labels][Baked-enamel warning signs][Metal-backed, butyrate warning signs][Laminated acrylic or melamine plastic signs]**.

E. Emergency Operating Instruction Signs: **[Self-adhesive labels][Baked-enamel warning signs][Metal-backed, butyrate warning signs][Laminated acrylic or melamine plastic signs]** with white legend on red background with minimum **3/8 inch (10 mm)** high letters for emergency instructions at equipment used for **<Insert emergency operations>**.

F. Label TBC, TBBs, and BBCs at attachment points with legend: "WARNING! COMMUNICATIONS BONDING CONDUCTOR. DO NOT REMOVE OR DISCONNECT!"

3.5 INSTALLATION OF FITTINGS FOR ENTRANCE FACILITY

A. Reference Standards for Installation: Unless more stringent installation requirements are specified in Contract Documents or manufacturers' published instructions, comply with the following:

1. Designated Critical Operations Areas: Comply with Article 708 of NFPA 70.
2. Communications Systems: Comply with Ch. 8 of NFPA 70 and with BICSI N1.
3. Grounding and Bonding: Comply with Article 250 of NFPA 70 and with BICSI N3.
4. Consult Architect for resolution of conflicting requirements.

B. Provide the following specified products in entrance facility room or space as indicated on Drawings:

1. Equipment backing panel .
 - a. Install from **6 inch (150 mm)** to **8 ft, 6 inch (2588 mm)** above finished floor. If plywood is

fire treated, ensure that fire-treatment stamp is visible after installation.

2. PBB .
3. NEMA 5-20R [isolated ground,][extra-heavy-duty,]<Insert description> duplex straight-blade receptacle, outlet box, and cover plate .
4. [NEMA L5-20R][NEMA L6-20R][NEMA L14-20R][, isolated ground,]<Insert description> locking receptacle, outlet box, and cover plate .
5. [NEMA L5-20R][NEMA L6-20R][NEMA L14-20R][, isolated ground,]<Insert description> pendant, extra-hard-usage, jacketed, flexible cord and connector .
6. Surface-mounted multi-outlet assembly .
7. Indoor service pole .
8. [19 inch open][19 inch enclosed][23 inch open][23 inch enclosed] equipment rack with RBB and enclosure-mounted relocatable power tap .
9. 66-style or 110-style cross-connect frame .
10. Patch panel .

3.6 INSTALLATION OF FITTINGS FOR EQUIPMENT ROOM

- A. Reference Standards for Installation: Unless more stringent installation requirements are specified in Contract Documents or manufacturers' published instructions, comply with the following:
 1. Designated Critical Operations Areas: Comply with Article 708 of NFPA 70.
 2. Communications Systems: Comply with Ch. 8 of NFPA 70 and with BICSI N1.
 3. Grounding and Bonding: Comply with Article 250 of NFPA 70 and with BICSI N3.
 4. Consult Architect for resolution of conflicting requirements.
- B. Provide the following specified products in entrance facility room or space as indicated on Drawings:
 1. Equipment backing panel .
 - a. Install from **6 inch (150 mm)** to **8 ft, 6 inch (2588 mm)** above finished floor. If plywood is fire treated, ensure that fire-treatment stamp is visible after installation.
 2. PBB .
 3. NEMA 5-20R [isolated ground,][extra-heavy-duty,]<Insert description> duplex straight-blade receptacle, outlet box, and cover plate .
 4. [NEMA L5-20R][NEMA L6-20R][NEMA L14-20R][, isolated ground,]<Insert description> locking receptacle, outlet box, and cover plate .
 5. [NEMA L5-20R][NEMA L6-20R][NEMA L14-20R][, isolated ground,]<Insert description> pendant, extra-hard-usage, jacketed, flexible cord and connector .
 6. Surface-mounted multi-outlet assembly .
 7. Indoor service pole .
 8. [19 inch open][19 inch enclosed][23 inch open][23 inch enclosed] equipment rack with RBB and enclosure-mounted relocatable power tap .
 9. 110-style cross-connect frame .
 10. Patch panel .

3.7 INSTALLATION OF FITTINGS FOR TELECOMMUNICATIONS ROOMS

- A. Reference Standards for Installation: Unless more stringent installation requirements are specified in Contract Documents or manufacturers' published instructions, comply with the following:
 1. Designated Critical Operations Areas: Comply with Article 708 of NFPA 70.
 2. Communications Systems: Comply with Ch. 8 of NFPA 70 and with BICSI N1.

3. Grounding and Bonding: Comply with Article 250 of NFPA 70 and with BICSI N3.
4. Consult Architect for resolution of conflicting requirements.

B. Provide the following specified products in intermediate distribution frame room or space as indicated on Drawings:

1. Equipment backing panel .
 - a. Install from **6 inch (150 mm)** to **8 ft, 6 inch (2588 mm)** above finished floor. If plywood is fire treated, ensure that fire-treatment stamp is visible after installation.
2. SBB .
3. NEMA 5-20R [**isolated ground,**][**extra-heavy-duty,**]**<Insert description>** duplex straight-blade receptacle, outlet box, and cover plate .
4. [**NEMA L5-20R**][**NEMA L6-20R**][**NEMA L14-20R**][**, isolated ground,**]**<Insert description>** locking receptacle, outlet box, and cover plate .
5. [**NEMA L5-20R**][**NEMA L6-20R**][**NEMA L14-20R**][**, isolated ground,**]**<Insert description>** pendant, extra-hard-usage, jacketed, flexible cord and connector .
6. Surface-mounted multi-outlet assembly .
7. Indoor service pole .
8. [**19 inch open**][**19 inch enclosed**][**23 inch open**][**23 inch enclosed**] equipment rack with RBB and enclosure-mounted relocatable power tap .
9. 110-style cross-connect frame .
10. Patch panel .

3.8 INSTALLATION OF BONDING FOR COMMUNICATIONS

A. Grounding of Communications: Bond PBB and SBBs to grounding electrode conductors at electrical power service entrance, and at electrical power derived systems serving communications equipment, using intersystem bonding termination device.

1. Structural Steel: Where structural steel of steel frame building is readily accessible within room or space, bond each SBB and PBB to vertical steel of building frame.

B. Comply with manufacturer's published instructions.

C. Reference Standards:

1. Bonding of Communications: Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with BICSI N3.
2. Consult Architect for resolution of conflicting requirements.

D. Special Techniques:

1. Bonding of Busbars:
 - a. Indicate locations of grounding busbars on Drawings. Install busbars horizontally, on insulated spacers **12 inch (300 mm)** above finished floor unless otherwise indicated.
 - b. Where busbars are indicated on both sides of doorways, route bonding conductor up to top of door frame, across top of doorway, and down; connect to continuation of horizontal busbar.
2. Bonding Conductors:

- a. Stacking of conductors under a single bolt is not permitted when connecting to busbars.
 - b. Assemble wire connector to conductor, complying with manufacturer's published instructions and as follows:
 - 1) Use crimping tool and die specific to connector.
 - 2) Pretwist conductor.
 - 3) Apply antioxidant compound to bolted and compression connections.
 - c. Install in straightest and shortest route between origination and termination point, and no longer than required. Bend radius must not be smaller than 10 times diameter of conductor. No single bend may exceed 90 degrees.
 - d. Install without splices.
 - e. Support conductors at not more than **36 inch (900 mm)** intervals.
 - f. Outside telecommunications rooms, install conductors in metric designator 21 (trade size 3/4) PVC-80 conduit until conduit enters telecommunications room. Install bonding conductors in EMT-A or EMT-SS when routed through plenum. Do not install bonding conductors in EMT-S unless otherwise indicated on Drawings.
 - 1) If bonding conductor must be installed in EMT-S or other ferrous metallic raceway, bond conductor to raceway using grounding bushing and bond both ends of raceway to SBB.
3. Provide TBC and terminate ends to PBB and intersystem bonding **[termination device][busbar]** at electrical service entrance in accordance with Section 250.94, "Bonding for Communication Systems," of NFPA 70.
 4. Busbar Interconnections: Bond SBBs to PBB with TBBs. If more than one TBB is installed, bond TBBs together with BBCs where required by TIA-607.
 5. Communications Enclosures: Bond metallic enclosures of telecommunications equipment with UBCs to nearest SBB or PBB.
 6. Equipment Racks: Bond metallic components of enclosures to RBB using UBCs. Provide **[top-mounted][vertically mounted]** RBB if not provided by enclosure or rack manufacturer. Bond RBB to SBB with TEBC. Power connection must comply with NFPA 70; equipment grounding conductor in power cord of cord- and plug-connected equipment must be considered supplemental to bonding requirements in this Section.
 7. Shielded Cable: Bond shield of shielded cable to SBB in communications rooms and spaces. Comply with TIA-568.1 and TIA-568.2 when grounding shielded balanced twisted-pair cables.
 8. Primary Protector: Bond to PBB with insulated bonding conductor.
 9. Electrical Power Panelboards: Where electrical panelboards for communications equipment are located in same room or space, bond each ground bar of panelboard to SBB.
 10. Cable Trays: Provide continuous electrical path by installing bonding clips and jumpers. Bond each end to nearest SBB.
 11. Ladder Racks: Provide continuous electrical path by installing bonding clips and jumpers. Bond each end to nearest SBB.
 12. Access Floors: Bond metal parts of access floors to SBB.
 13. **<Insert connections for other equipment>**.

3.9 FIELD QUALITY CONTROL FOR BONDING OF COMMUNICATIONS

A. Administrant for Grounding and Bonding Tests and Inspections:

1. **[Owner][Tenant]** will engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
2. Engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections

- on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].

B. Acceptance Testing Preparation:

1. **<Insert requirements>**.

C. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.

D. Tests and Inspections:

1. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with calibrated torque wrench in accordance with manufacturer's published instructions.
2. Test bonding connections of system using AC earth ground-resistance tester, taking two-point bonding measurements in each telecommunications equipment room containing PBB or SBB, using process recommended by BICSI N1. Conduct tests with facility in operation.
 - a. Measure resistance between PBB and electrical service intersystem termination point. Maximum acceptable value is 100 mΩ.
 - 1) If measured resistance from electrical service equipment to ground exceeds **[5 Ω<Insert resistance>**, notify Architect and include recommendations to reduce resistance to ground.
 - b. Measure resistance between SBBs and PBB. Maximum acceptable value is 100 mΩ.
3. Test for ground loop currents using digital clamp-on ammeter, with full scale not more than 10 A, displaying current in increments of 0.01 A at accuracy of plus or minus 2.0 percent.
 - a. With grounding infrastructure completed and communications system electronics operating, measure current in bonding conductors connected to PBB[**and to SBBs**]. Maximum acceptable AC current level is 1 A.

E. Nonconforming Work:

1. Communications bonding will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

F. Collect, assemble, and submit test and inspection reports.

3.10 PROTECTION

- A. After installation, protect communications equipment room fittings from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 27 11 00 00



Task	Specification	Specification Description
27 11 16 00	27 11 00 00	Communications Equipment Room Fittings
27 11 19 00	27 11 00 00	Communications Equipment Room Fittings
27 11 19 00	27 13 23 00	Communications Optical Fiber Backbone Cabling
27 11 23 00	26 05 00 00	Sleeves and Sleeve Seals for Electrical Raceways and Cabling
27 11 23 00	27 11 00 00	Communications Equipment Room Fittings



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SECTION 27 13 13 00 - COMMUNICATIONS COPPER BACKBONE CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Backbone communications cables.
2. Communications-, audio/video-, data-, and other signaling-circuit accessories.

B. Products Furnished, but Not Installed, under This Section:

1. **<Insert products furnished, but not installed>.**

C. Products Installed, but Not Furnished, under This Section:

1. See Section 270553 "Identification for Communications Systems" for communications equipment labels.
2. See Section 271513 "Communications Copper Horizontal Cabling" for Type CM, CMG, and CMX cabling.

D. Related Requirements:

1. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
2. Section 270010 "Supplemental Requirements for Communications" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.

1.2 UNIT PRICES

- A. See Section 012200 "Unit Prices" for description of unit prices affecting items specified in this Section.**

1.3 ALTERNATES

- A. See Section 012300 "Alternates" for description of alternates affecting items specified in this Section.**

1.4 DEFINITIONS

A. Cable Types:

1. FTP: Foil shielded twisted pair.
2. F/FTP: Bundle of FTP cables with overall foil shield.
3. F/UTP: Bundle of UTP cables with overall foil shield.
4. S/FTP: Bundle of FTP cables with overall braided shield.
5. S/UTP: Bundle of UTP cables with overall braided shield.
6. UTP: Unshielded twisted pair.

- B. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.
- C. EMI: Electromagnetic interference.
- D. IDC: Insulation displacement connector.

1.5 SEQUENCING

- A. Wet-work in spaces must be completely dry, and HVAC system must be operating and maintaining ambient temperature and humidity conditions within manufacturer's recommended limits, before delivering and installing cables and connecting materials.

1.6 ACTION SUBMITTALS

- A. Product Data:
 - 1. Backbone communications cable.
 - 2. Communications-, audio/video-, data-, and other signaling-circuit accessories.
- B. Shop Drawings:
 - 1. Cable labeling schedules.
 - 2. Cabling administration diagrams.
 - 3. Wiring diagrams.
 - 4. Cross-connect and patch panel details.
 - 5. Twisted-pair cable testing plan.
- C. Field quality-control reports.
- D. Sustainable design submittals.
 - 1. Backbone communications cable.

1.7 INFORMATIONAL SUBMITTALS

- A. Manufacturers' Published Instructions:
 - 1. Backbone communications cable.
 - 2. Communications-, audio/video-, data-, and other signaling-circuit accessories.
- B. Field Reports:
 - 1. Factory Test Reports:
 - a. Backbone communications cable.

1.8 CLOSEOUT SUBMITTALS

- A. Warranty documentation.

1.9 MAINTENANCE MATERIAL SUBMITTALS

- A. Spare Parts: For communications-, audio/video-, data-, and other signaling-circuit accessories.
- B. Special Tools: For communications-, audio/video-, data-, and other signaling-circuit accessories.

1.10 DELIVERY, STORAGE, AND HANDLING

- A. Test cables upon receipt at Project site.
 - 1. Test each pair of twisted-pair cable for open and short circuits.

1.11 WARRANTY FOR COMMUNICATIONS COPPER BACKBONE CABLE ASSEMBLIES

- A. Special Installer Extended Warranty: Installer warrants that fabricated and installed communications copper backbone cable assemblies perform in accordance with specified requirements and agrees to repair or replace cable assemblies that fail to perform as specified within extended-warranty period.
 - 1. Extended-Warranty Period: **[Two][Three][Four]<Insert number>** years from date of Substantial Completion; full coverage for labor, materials, and equipment.

PART 2 - PRODUCTS

2.1 BACKBONE COMMUNICATIONS CABLES

- A. Description: This category covers multiple conductor jacketed communications cable for telephone and other communications circuits for use in risers and plenums as described in Article 800 of NFPA 70.
- B. Performance Criteria:
 - 1. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - 2. Listing Criteria:
 - a. Certified Cable: UL CCN DUZX; including UL 444.
 - b. Verified Cable: UL CCN DVBI; including TIA-568.2.
 - c. Type CMP: NFPA 262.
 - d. Type CMR: UL 1666.
 - e. Limited Smoke: Marked "-LS" in accordance with UL 1685.
 - f. Halogen-Free: Marked "-HF" in accordance with UL Subject 2885.
 - g. Low Smoke and Halogen-Free: Marked "-LSHF" in accordance with IEC 61034-2.
 - h. Cable Heating Test: Marked "-LP" with current rating and temperature rating.
- C. Source Quality Control:
 - 1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.



2. Sustainable Design Submittals: Prepare and submit documentation for the following:
 - a. Product Data: For each conductor and cable indicating lead content of less than 300 parts per million.
 - b. Environmental Product Declaration: For each product.
 - c. Health Product Declaration: For each product.
 - d. Sourcing of Raw Materials: Corporate sustainability report for each manufacturer.
 - e. Third-Party Certifications: For each product.
 - f. Third-Party Certified Life Cycle Assessment: For each product.
3. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.
4. Factory Tests:
 - a. Owner will witness required factory tests. Notify Architect at least 14 days before date of tests and indicate their approximate duration.
 - b. Testing Administrator: **[Owner will engage][Engage]** qualified electrical testing agency to evaluate cable reels.
 - c. Factory Tests and Inspections: Test and inspect cable on reels, by, or under supervision of, qualified electrical testing laboratory recognized by authorities having jurisdiction, in accordance with TIA-568.2 before delivering to site. Affix label with name and date of **[manufacturer's][qualified electrical testing laboratory's]** certification of system compliance.
 - d. Nonconforming Work:
 - 1) Cable reels that do not pass tests and inspections will be considered defective.
 - e. Factory Test Reports: Prepare and submit factory test and inspection reports.

D. UL DUZX and DVBI - Type CMP, Category 3 Communications Cable :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[CommScope, Inc]**
 - b. **[Hitachi Cable America Inc.]**
 - c. **[Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - d. **[Mohawk; a division of Belden Networking, Inc.]**
 - e. **[Molex Premise Networks]**
 - f. **[Panduit Corp]**
 - g. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - h. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - i. **[West Penn Wire; brand of Belden, Inc.]**
 - j. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[CommScope, Inc]**
 - b. **[Hitachi Cable America Inc.]**
 - c. **[Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell**

- Incorporated]
 - d. [Mohawk; a division of Belden Networking, Inc.]
 - e. [Molex Premise Networks]
 - f. [Panduit Corp]
 - g. [Prysmian Cables and Systems; Prysmian Group North America]
 - h. [Superior Essex Inc.; subsidiary of LS Corp.]
 - i. [West Penn Wire; brand of Belden, Inc.]
 - j. <Insert manufacturer's name>
 - 3. Product Marking: Type CMP; Category 3.
 - 4. Options:
 - a. Quantity of Pairs: [25][50][100]<Insert number>.
 - b. Shielding/Screening: [UTP][FTP][F/UTP][F/FTP].
 - c. Jacket:
[White][Gray][Blue][Yellow][Orange][Pink][Green][Red][Black][Brown][Beige][Mauve]<Insert color> thermoplastic.
- E. UL DUZX and DVBI - Type CMP, Category 5e Communications Cable :
 - 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [CommScope, Inc]
 - b. [Hitachi Cable America Inc.]
 - c. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - d. [Mohawk; a division of Belden Networking, Inc.]
 - e. [Molex Premise Networks]
 - f. [Panduit Corp]
 - g. [Prysmian Cables and Systems; Prysmian Group North America]
 - h. [Superior Essex Inc.; subsidiary of LS Corp.]
 - i. [West Penn Wire; brand of Belden, Inc.]
 - j. <Insert manufacturer's name>
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [CommScope, Inc]
 - b. [Hitachi Cable America Inc.]
 - c. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - d. [Mohawk; a division of Belden Networking, Inc.]
 - e. [Molex Premise Networks]
 - f. [Panduit Corp]
 - g. [Prysmian Cables and Systems; Prysmian Group North America]
 - h. [Superior Essex Inc.; subsidiary of LS Corp.]
 - i. [West Penn Wire; brand of Belden, Inc.]
 - j. <Insert manufacturer's name>
- F. UL DUZX and DVBI - Type CMP, Category 6 Communications Cable :
 - 1. Manufacturers: Subject to compliance with requirements, [provide products by the

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

- a. [CommScope, Inc]
- b. [Hitachi Cable America Inc.]
- c. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
- d. [Mohawk; a division of Belden Networking, Inc.]
- e. [Molex Premise Networks]
- f. [Panduit Corp]
- g. [Prysmian Cables and Systems; Prysmian Group North America]
- h. [Superior Essex Inc.; subsidiary of LS Corp.]
- i. <Insert manufacturer's name>

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

- a. [CommScope, Inc]
- b. [Hitachi Cable America Inc.]
- c. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
- d. [Mohawk; a division of Belden Networking, Inc.]
- e. [Molex Premise Networks]
- f. [Panduit Corp]
- g. [Prysmian Cables and Systems; Prysmian Group North America]
- h. [Superior Essex Inc.; subsidiary of LS Corp.]
- i. <Insert manufacturer's name>

3. Product Marking: Type CMP; Category 6.

4. Options:

- a. Quantity of Pairs: [24][Four]<Insert number>.
- b. Shielding/Screening: [UTP][FTP][F/UTP][F/FTP].
- c. Jacket: [White][Gray][Blue][Yellow]<Insert color> thermoplastic.

G. UL DUZX and DVBI - Type CMP, Category 6A Communications Cable :

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

- a. [CommScope, Inc]
- b. [Hitachi Cable America Inc.]
- c. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
- d. [Molex Premise Networks]
- e. [Panduit Corp]
- f. [Prysmian Cables and Systems; Prysmian Group North America]
- g. [Superior Essex Inc.; subsidiary of LS Corp.]
- h. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert

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

- a. [CommScope, Inc]
 - b. [Hitachi Cable America Inc.]
 - c. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - d. [Molex Premise Networks]
 - e. [Panduit Corp]
 - f. [Prysmian Cables and Systems; Prysmian Group North America]
 - g. [Superior Essex Inc.; subsidiary of LS Corp.]
 - h. <Insert manufacturer's name>
3. Product Marking: Type CMP; Category 6A.
 4. Options:
 - a. Quantity of Pairs: [Four]<Insert number>.
 - b. Shielding/Screening: [UTP][FTP][F/UTP][F/FTP].
 - c. Jacket: [White][Gray][Blue][Yellow]<Insert color> thermoplastic.

H. UL DUZX and DVBI - Type CMR, Category 3 Communications Cable :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. [Belden Inc.]
 - b. [CommScope, Inc]
 - c. [Hitachi Cable America Inc.]
 - d. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - e. [Leviton Manufacturing Co., Inc.]
 - f. [Mohawk; a division of Belden Networking, Inc.]
 - g. [Molex Premise Networks]
 - h. [Panduit Corp]
 - i. [Prysmian Cables and Systems; Prysmian Group North America]
 - j. [Superior Essex Inc.; subsidiary of LS Corp.]
 - k. [West Penn Wire; brand of Belden, Inc.]
 - l. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert **manufacturer's name; product name or designation**> or comparable product by one of the following:
 - a. [Belden Inc.]
 - b. [CommScope, Inc]
 - c. [Hitachi Cable America Inc.]
 - d. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - e. [Leviton Manufacturing Co., Inc.]
 - f. [Mohawk; a division of Belden Networking, Inc.]
 - g. [Molex Premise Networks]
 - h. [Panduit Corp]
 - i. [Prysmian Cables and Systems; Prysmian Group North America]
 - j. [Superior Essex Inc.; subsidiary of LS Corp.]



- k. **[West Penn Wire; brand of Belden, Inc.]**
 - l. **<Insert manufacturer's name>**
 - 3. Product Marking: Type CMR; Category 3.
 - 4. Options:
 - a. Quantity of Pairs: **[25][50][100]<Insert number>**.
 - b. Shielding/Screening: **[UTP][FTP][F/UTP][F/FTP]**.
 - c. Jacket: **[White][Gray][Blue][Yellow][Orange][Pink][Green][Red][Black][Brown][Beige][Mauve]<Insert color>** thermoplastic.
- I. UL DUZX and DVBI - Type CMR, Category 5e Communications Cable :
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Belden Inc.]**
 - b. **[CommScope, Inc]**
 - c. **[Hitachi Cable America Inc.]**
 - d. **[Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - e. **[Leviton Manufacturing Co., Inc.]**
 - f. **[Mohawk; a division of Belden Networking, Inc.]**
 - g. **[Molex Premise Networks]**
 - h. **[Panduit Corp]**
 - i. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - j. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - k. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Belden Inc.]**
 - b. **[CommScope, Inc]**
 - c. **[Hitachi Cable America Inc.]**
 - d. **[Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - e. **[Leviton Manufacturing Co., Inc.]**
 - f. **[Mohawk; a division of Belden Networking, Inc.]**
 - g. **[Molex Premise Networks]**
 - h. **[Panduit Corp]**
 - i. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - j. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - k. **<Insert manufacturer's name>**
 - 3. Product Marking: Type CMR; Category 5e.
 - 4. Options:
 - a. Quantity of Pairs: **[25][50]<Insert number>**.
 - b. Shielding/Screening: **[UTP][FTP][F/UTP][F/FTP]**.
 - c. Jacket: **[White][Gray]<Insert color>** thermoplastic.

J. UL DUZX and DVBI - Type CMR, Category 6 Communications Cable :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Belden Inc.]**
 - b. **[CommScope, Inc]**
 - c. **[Hitachi Cable America Inc.]**
 - d. **[Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - e. **[Leviton Manufacturing Co., Inc.]**
 - f. **[Mohawk; a division of Belden Networking, Inc.]**
 - g. **[Molex Premise Networks]**
 - h. **[Panduit Corp]**
 - i. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - j. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - k. **[TE Connectivity Ltd.]**
 - l. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Belden Inc.]**
 - b. **[CommScope, Inc]**
 - c. **[Hitachi Cable America Inc.]**
 - d. **[Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - e. **[Leviton Manufacturing Co., Inc.]**
 - f. **[Mohawk; a division of Belden Networking, Inc.]**
 - g. **[Molex Premise Networks]**
 - h. **[Panduit Corp]**
 - i. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - j. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - k. **[TE Connectivity Ltd.]**
 - l. **<Insert manufacturer's name>**
3. Product Marking: Type CMR; Category 6.
4. Options:
 - a. Quantity of Pairs: **[24][Four]<Insert number>**.
 - b. Shielding/Screening: **[UTP][FTP][F/UTP][F/FTP]**.
 - c. Jacket: **[White][Gray][Blue][Yellow]<Insert color>** thermoplastic.

K. UL DUZX and DVBI - Type CMR, Category 6A Communications Cable :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Belden Inc.]**
 - b. **[CommScope, Inc]**
 - c. **[Hitachi Cable America Inc.]**

- d. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - e. [Molex Premise Networks]
 - f. [Panduit Corp]
 - g. [Prysmian Cables and Systems; Prysmian Group North America]
 - h. [Superior Essex Inc.; subsidiary of LS Corp.]
 - i. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Belden Inc.]
 - b. [CommScope, Inc]
 - c. [Hitachi Cable America Inc.]
 - d. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - e. [Molex Premise Networks]
 - f. [Panduit Corp]
 - g. [Prysmian Cables and Systems; Prysmian Group North America]
 - h. [Superior Essex Inc.; subsidiary of LS Corp.]
 - i. <Insert manufacturer's name>
3. Product Marking: Type CMR; Category 6A.
4. Options:
- a. Quantity of Pairs: [Four]<Insert number>.
 - b. Shielding/Screening: [UTP][FTP][F/UTP][F/FTP].
 - c. Jacket: [White][Gray][Blue][Yellow]<Insert color> thermoplastic.
- L. UL DUZX and DVBI - Type CMR, Category 8 Communications Cable :
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
- a. [CommScope, Inc]
 - b. [Superior Essex Inc.; subsidiary of LS Corp.]
 - c. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [CommScope, Inc]
 - b. [Superior Essex Inc.; subsidiary of LS Corp.]
 - c. <Insert manufacturer's name>
3. Product Marking: Type CMR; Category 8.
4. Options:
- a. Quantity of Pairs: [Four]<Insert number>.
 - b. Shielding/Screening: [F/FTP][S/FTP].
 - c. Jacket: [White][Gray][Blue][Yellow]<Insert color> thermoplastic.

M. UL DUZX and DVBI - Type CMR-LS, Category 3 Communications Cable :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - c. **<Insert manufacturer's name>**
3. Product Marking: Type CMR-LS; Category 3.
4. Options:
 - a. Quantity of Pairs: **[25][50][100]<Insert number>**.
 - b. Shielding/Screening: **[UTP][FTP][F/UTP][F/FTP]**.
 - c. Jacket:
[White][Gray][Blue][Yellow][Orange][Pink][Green][Red][Black][Brown][Beige][Mauve]<Insert color> thermoplastic.

N. UL DUZX and DVBI - Type CMR-LS, Category 5e Communications Cable :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - c. **<Insert manufacturer's name>**
3. Product Marking: Type CMR-LS; Category 5e.
4. Options:
 - a. Quantity of Pairs: **[25][50]<Insert number>**.
 - b. Shielding/Screening: **[UTP][FTP][F/UTP][F/FTP]**.

c. Jacket: **[White][Gray]<Insert color>** thermoplastic.

O. UL DUZX and DVBI - Type CMR-LS, Category 6 Communications Cable :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - c. **<Insert manufacturer's name>**
3. Product Marking: Type CMR-LS; Category 6.
4. Options:
 - a. Quantity of Pairs: **[24][Four]<Insert number>**.
 - b. Shielding/Screening: **[UTP][FTP][F/UTP][F/FTP]**.
 - c. Jacket: **[White][Gray][Blue][Yellow]<Insert color>** thermoplastic.

P. UL DUZX and DVBI - Type CMR-LSHF, Category 3 Communications Cable :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - b. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - c. **<Insert manufacturer's name>**
3. Product Marking: Type CMR-LSHF; Category 3.
4. Options:
 - a. Quantity of Pairs: **[25][50][100]<Insert number>**.

- b. Shielding/Screening: [UTP][FTP][F/UTP][F/FTP].
- c. Jacket: [White][Gray][Blue][Yellow][Orange][Pink][Green][Red][Black][Brown][Beige][Mauve]<Insert color> thermoplastic.

Q. UL DUZX and DVBI - Type CMR-LSHF, Category 5e Communications Cable :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [CommScope, Inc]
 - b. [Hitachi Cable America Inc.]
 - c. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - d. [Superior Essex Inc.; subsidiary of LS Corp.]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [CommScope, Inc]
 - b. [Hitachi Cable America Inc.]
 - c. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - d. [Superior Essex Inc.; subsidiary of LS Corp.]
 - e. <Insert manufacturer's name>
3. Product Marking: Type CMR-LSHF; Category 5e.
4. Options:
 - a. Quantity of Pairs: [25][50]<Insert number>.
 - b. Shielding/Screening: [UTP][FTP][F/UTP][F/FTP].
 - c. Jacket: [White][Gray]<Insert color> thermoplastic.

R. UL DUZX and DVBI - Type CMR-LSHF, Category 6 Communications Cable :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [CommScope, Inc]
 - b. [Hitachi Cable America Inc.]
 - c. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - d. [Superior Essex Inc.; subsidiary of LS Corp.]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [CommScope, Inc]

- b. [Hitachi Cable America Inc.]
 - c. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - d. [Superior Essex Inc.; subsidiary of LS Corp.]
 - e. <Insert manufacturer's name>
- 3. Product Marking: Type CMR-LSHF; Category 6.
 - 4. Options:
 - a. Quantity of Pairs: [24][Four]<Insert number>.
 - b. Shielding/Screening: [UTP][FTP][F/UTP][F/FTP].
 - c. Jacket: [White][Gray][Blue][Yellow]<Insert color> thermoplastic.

2.2 COMMUNICATIONS-, AUDIO/VIDEO-, DATA-, AND OTHER SIGNALING-CIRCUIT ACCESSORIES

- A. Description: This category covers devices intended for use in residential or commercial communications-station applications for connections to communications circuit as defined in Article 800 of NFPA 70.
- B. Performance Criteria:
 - 1. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - b. <Insert requirements>.
 - 2. Listing Criteria:
 - a. Communications-Circuit Accessories: UL CCN DUXR; including UL 1863.
 - b. Audio/Video-, Data-, and Other Signaling-Circuit Accessories: UL CCN DUXR; including UL 1977.
 - c. For Use in Air-Handling Spaces: UL 2043.
- C. Source Quality Control:
 - 1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
 - 2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.
- D. UL DUXR - Connecting Block :
 - 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [CommScope, Inc]
 - b. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - c. [Leviton Manufacturing Co., Inc.]
 - d. [Panduit Corp]

- e. **[Siemon Co. (The)]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[CommScope, Inc]**
 - b. **[Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **[Panduit Corp]**
 - e. **[Siemon Co. (The)]**
 - f. **<Insert manufacturer's name>**
3. Options:
- a. Configuration: **[110-style IDC for Category 5e][110-style IDC for Category 6][66-style IDC for Category 5e]**.
 - b. Quantity of Terminations: Number of cables terminated on block, plus **[25]<Insert number>** percent spare, integral with connector bodies, including plugs and jacks where indicated.
- E. UL DUXR - Cross-Connect :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
- a. **[Belden Inc.]**
 - b. **[CommScope, Inc]**
 - c. **[Panduit Corp]**
 - d. **[Siemon Co. (The)]**
 - e. **[TE Connectivity Ltd.]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[Belden Inc.]**
 - b. **[CommScope, Inc]**
 - c. **[Panduit Corp]**
 - d. **[Siemon Co. (The)]**
 - e. **[TE Connectivity Ltd.]**
 - f. **<Insert manufacturer's name>**
3. Options:
- a. Number of Terminals per Field: **[One]<Insert number>** for each conductor in assigned cables.
 - b. Performance Rating: **[Category 5e][Category 6][Category 6A][Category 8]**.
- F. UL DUXR - Patch Panel :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Belden Inc.]**
 - b. **[CommScope, Inc]**
 - c. **[Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - d. **[Leviton Manufacturing Co., Inc.]**
 - e. **[Panduit Corp]**
 - f. **[Siemon Co. (The)]**
 - g. **[TE Connectivity Ltd.]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Belden Inc.]**
 - b. **[CommScope, Inc]**
 - c. **[Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
 - d. **[Leviton Manufacturing Co., Inc.]**
 - e. **[Panduit Corp]**
 - f. **[Siemon Co. (The)]**
 - g. **[TE Connectivity Ltd.]**
 - h. **<Insert manufacturer's name>**
3. General Characteristics:
 - a. Universal T568A and T568B wiring labels.
 - b. Labeling areas adjacent to conductors.
 - c. Replaceable connectors.
 - d. 24 or 48 ports.
 - e. Construction: 16-gauge steel and mountable on **19 inch (483 mm)** equipment racks.
4. Options:
 - a. Number of Jacks per Field: One for each four-pair **[twisted-pair cable indicated][conductor group of indicated cables, plus spares and blank positions adequate to suit specified expansion criteria]**.
 - b. Performance Rating: **[Category 5e][Category 6][Category 6A][Category 8]**.

G. UL DUXR - 8P8C Plugs and Plug Assemblies :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Belden Inc.]**
 - b. **[CommScope, Inc]**
 - c. **[Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**

- d. [Leviton Manufacturing Co., Inc.]
 - e. [Molex Premise Networks]
 - f. [Panduit Corp]
 - g. [Siemon Co. (The)]
 - h. [TE Connectivity Ltd.]
 - i. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Belden Inc.]
 - b. [CommScope, Inc]
 - c. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - d. [Leviton Manufacturing Co., Inc.]
 - e. [Molex Premise Networks]
 - f. [Panduit Corp]
 - g. [Siemon Co. (The)]
 - h. [TE Connectivity Ltd.]
 - i. <Insert manufacturer's name>
- 3. General Characteristics:
 - a. Male; 8P8C; color-coded modular telecommunications connector designed for termination of a single, four-pair, 100 Ω UTP or FTP cable.
 - b. Marked to indicate transmission performance.
- 4. Options:
 - a. Performance Rating: [Category 5e][Category 6][Category 6A][Category 8].

H. UL DUXR - 8P8C Jacks and Jack Assemblies :

- 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Belden Inc.]
 - b. [CommScope, Inc]
 - c. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 - d. [Leviton Manufacturing Co., Inc.]
 - e. [Molex Premise Networks]
 - f. [Panduit Corp]
 - g. [Siemon Co. (The)]
 - h. [TE Connectivity Ltd.]
 - i. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Belden Inc.]
 - b. [CommScope, Inc]

- c. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
- d. [Leviton Manufacturing Co., Inc.]
- e. [Molex Premise Networks]
- f. [Panduit Corp]
- g. [Siemon Co. (The)]
- h. [TE Connectivity Ltd.]
- i. <Insert manufacturer's name>

3. General Characteristics:

- a. Female; 8P8C; color-coded modular telecommunications connector designed for termination of a single, four-pair, 100 Ω UTP or FTP cable.
- b. Designed to snap into patch panel or cover plate.
- c. Marked to indicate transmission performance.

4. Options:

- a. Performance Rating: [Category 5e][Category 6][Category 6A][Category 8].

I. UL DUXR - Patch Cords :

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

- a. [Belden Inc.]
- b. [CommScope, Inc]
- c. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
- d. [Leviton Manufacturing Co., Inc.]
- e. [Molex Premise Networks]
- f. [Panduit Corp]
- g. [Siemon Co. (The)]
- h. <Insert manufacturer's name>

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

- a. [Belden Inc.]
- b. [CommScope, Inc]
- c. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
- d. [Leviton Manufacturing Co., Inc.]
- e. [Molex Premise Networks]
- f. [Panduit Corp]
- g. [Siemon Co. (The)]
- h. <Insert manufacturer's name>

3. General Characteristics:

- a. Factory-made, four-pair cables; terminated with an 8P8C plug at each end.
- b. Bend-relief-compliant boots and color-coded icons to ensure Category 6 performance.

- c. Latch guards to protect against snagging.
 - d. Color-coded boots for circuit identification.
- 4. Options:
 - a. Length: [3 ft (0.9 m)][4 ft (1.2 m)]<Insert length>.
 - b. Performance Rating: [Category 5e][Category 6][Category 6A][Category 8].
- J. Accessories:
 - 1. Spare Parts: Furnish to Owner spare parts, for repairing cable assemblies and accessories, that are packaged with protective covering for storage on-site and identified with labels describing contents.[**Include the following:**]
 - a. Connecting Blocks: [One]<Insert number> of each type.
 - b. Patch Panels: [One]<Insert number> of each type.
 - c. Plugs: [Ten]<Insert number> of each type.
 - d. Jacks: [Ten]<Insert number> of each type.
 - 2. Special Tools: Furnish to Owner proprietary equipment, keys, and software required to operate, maintain, repair, adjust, or implement future changes to cable assemblies and accessories, that are packaged with protective covering for storage on-site and identified with labels describing contents.[**Include the following:**]
 - a. <Insert name of special tool>.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Shop Drawings: Prepare and submit the following:
 - 1. Cable Labeling Schedules: Submit electronic files[**using software and format requested by Owner**].
 - 2. Cabling Administration Diagrams: Submit diagrams and supporting electronic files[**using software and format requested by Owner**].
 - a. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.
 - 3. Wiring Diagrams:
 - a. Telecommunications rooms plans and elevations.
 - b. Telecommunications pathways.
 - c. Telecommunications system access points.
 - d. Telecommunications grounding system.
 - e. Cross-connects.
 - f. Patch panels.
 - g. Patch cords.
 - 4. Cross-Connect and Patch Panel Details: Include mounting assemblies, elevations, and physical relationship between installed components.
 - 5. Twisted-Pair Cable Testing Plan: Include list of cables to be tested, identification of tests to be

performed, pass/fail criteria, and copy of testing procedures (may be separate volume). Indicate Installer's required tests for warranty compliance.

3.2 SELECTION OF COMMUNICATIONS COPPER BACKBONE CABLING

A. Air-Handling Spaces:

1. Type CMP[**in listed plenum communications raceway**][**in listed cable routing assembly**].
2. Type CMR or Type CMP[**Type CM, Type CMG, or Type CMX**] in metallic conduit installed in accordance with Rule 300.22 of NFPA 70.

B. Vertical Chases:

1. Type CMR.
2. Type CMP or Type CMR[**in listed plenum or riser communications raceway**][**in metallic conduit installed in accordance with Rule 300.22 of NFPA 70**].

3.3 INSTALLATION OF COMMUNICATIONS COPPER BACKBONE CABLING

A. Comply with manufacturer's published instructions.

B. Reference Standards for Installation:

1. Communications Cable Assemblies: Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with BICSI N1.
2. Consult Architect for resolution of conflicting requirements.

C. Special Installation Techniques:

1. Cabling system consists of backbone cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for backbone-to-backbone cross-connection.
 - a. Provide interconnections between communications equipment rooms, main terminal space, and entrance facilities in the telecommunications cabling system structure.
 - b. Backbone cabling cross-connects may be located in communications equipment rooms or at entrance facilities. Bridged taps and splitters may not be used as part of backbone cabling.
2. Drawings indicate general arrangement of pathways and fittings.
3. Wiring Methods:
 - a. Raceway and Tray: Install cables in raceways and cable trays, except within consoles, cabinets, desks, and counters[**and except in accessible ceiling spaces, attics, and gypsum board partitions where unenclosed wiring method may be used**]. Conceal raceway and cables, except in unfinished spaces.
 - 1) Install plenum cable in environmental air spaces, including plenum ceilings.
 - 2) Comply with requirements for raceways and boxes specified in Section 270528 "Pathways for Communications Systems."
 - b. Open-Cable: Route conductors and cables in accessible ceilings, walls, and floors where possible.

- c. Within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools. Install cables parallel with or at right angles to sides and back of enclosure.
- 4. General Requirements for Cabling:
 - a. Install 110-style IDC termination hardware unless otherwise indicated.
 - b. Do not untwist twisted-pair cables more than **1/2 inch (12 mm)** from the point of termination to maintain cable geometry.
 - c. Terminate all conductors; no cable may contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
 - d. Cables may not be spliced. Secure and support cables at intervals not exceeding **30 inch (760 mm)** and not more than **6 inch (150 mm)** from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
 - e. Install lacing bars to restrain cables, prevent straining connections, and prevent bending cables to smaller radii than minimums recommended by manufacturer.
 - f. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii. Use lacing bars and distribution spools.
 - g. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation, and replace it with new cable.
 - h. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps may not be used for heating.
 - i. In the communications equipment room, install **10 ft (3 m)** long service loop on each end of cable.
 - j. Pulling Cable: Monitor cable pull tensions.
- 5. Open-Cable Installation:
 - a. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
 - b. Suspend twisted-pair cabling, not in a wireway or pathway, a minimum of **8 inch (200 mm)** above ceilings by cable supports not more than **[5 ft (1.5 m)]<Insert dimension>** apart.
 - c. Cable may not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.
- 6. Installation of Cable Routed Exposed under Raised Floors:
 - a. Install plenum-rated cable only.
 - b. Install cabling after the flooring system has been installed in raised floor areas.
 - c. Coil cable **[6 ft (1.8 m)]<Insert dimension>** long not less than **[12 inch (300 mm)]<Insert dimension>** in diameter below each feed point.
- 7. Group connecting hardware for cables into separate logical fields.
- 8. Separation from EMI Sources:
 - a. Comply with BICSI N1 for separating unshielded copper communication cable from potential EMI sources, including electrical power lines and equipment.
 - b. Separate open communications cables or cables in nonmetallic raceways from unshielded power conductors and electrical equipment as follows:
 - 1) Power Rating Less Than 2 kVA: Minimum **5 inch (127 mm)**.
 - 2) Power Rating between 2 and 5 kVA: Minimum **12 inch (300 mm)**.
 - 3) Power Rating More Than 5 kVA: Minimum **24 inch (600 mm)**.

- c. Separate communications cables in grounded metallic raceways from unshielded power lines or electrical equipment as follows:
 - 1) Power Rating Less Than 2 kVA: Minimum **2-1/2 inch (64 mm)**.
 - 2) Power Rating between 2 and 5 kVA: Minimum **6 inch (150 mm)**.
 - 3) Power Rating More Than 5 kVA: Minimum **12 inch (300 mm)**.
 - d. Separate communications cables in grounded metallic raceways from power lines and electrical equipment located in grounded metallic conduits or enclosures as follows:
 - 1) Power Rating Less Than 2 kVA: No minimum distance.
 - 2) Power Rating between 2 and 5 kVA: Minimum **3 inch (76 mm)**.
 - 3) Power Rating More Than 5 kVA: Minimum **6 inch (150 mm)**.
 - e. Separate communications cables from electrical motors and transformers rated 5 kVA or 5 HP and larger minimum **48 inch (1200 mm)**.
 - f. Separate communications cables from fluorescent luminaires minimum **5 inch (127 mm)**.
 9. Identify system components, wiring, and cabling in accordance with TIA-606.
 - a. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.
 - b. Paint and label colors for equipment identification must comply with TIA-606 for **[Class 2][Class 3][Class 4]** level of administration[, **including optional identification requirements of this standard**].
 10. Cable and Wire Identification:
 - a. Label each cable within **4 inch (100 mm)** of each termination and tap, where it is accessible in cabinet or junction or outlet box, and elsewhere as indicated.
 - b. Each wire connected to building-mounted devices is not required to be numbered at device if wire color is consistent with associated wire connected and numbered within panel or cabinet.
 - c. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding **15 ft (4.5 m)**.
 - d. Label each terminal strip, and screw terminal in each cabinet, rack, or panel.
 - 1) Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group, extended from panel or cabinet to building-mounted device, with name and number of particular device.
 - 2) Label each unit and field within distribution racks and frames.
 - e. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and -connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use different color for jacks and plugs of each service.
 11. Cable Schedule: Install in prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish electronic copy of final comprehensive schedules for Project.
 12. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, **[backbone pathways and cables,][entrance pathways and cables,]** terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways,

- and equipment grounding conductors.
13. **<Insert more stringent installation requirements that supplement or supersede listed standards and manufacturers' published instructions>.**

D. Interfaces with Other Work:

1. Entrance Facilities: Coordinate backbone cabling with Section 271100 "Communications Equipment Room Fittings" for cabinets, racks, and protectors and demarcation point provided by communications service provider.
2. Coordinate with Section 078413 "Penetration Firestopping" for sealing fire-rated penetrations.
3. Coordinate with Section 260533.16 "Boxes and Covers for Electrical Systems" for installation of outlet boxes and cover plates.
4. Coordinate with Section 270526 "Grounding and Bonding for Communications Systems" for grounding communications cabling and connectors.
5. Coordinate with Section 270528 "Pathways for Communications Systems" for installation of provisions for routing and terminating cable assemblies.
6. Coordinate with Section 270529 "Hangers and Supports for Communications Systems" for installation of cable supports.
7. Coordinate with Section 270536 "Cable Trays for Communications Systems" for installation of cable trays.
8. Coordinate installation of new products for **<Insert system or product family/category>** with existing conditions.
 - a. **<Insert requirements for transition between new and existing>.**
9. Coordinate with **<Insert Section number and title>** for **<Insert description of interfacing related Work>.**
 - a. **<Insert requirements for transition between this Section and related Work>.**

3.4 FIELD QUALITY CONTROL OF COMMUNICATIONS COPPER BACKBONE CABLING

A. Acceptance Testing Preparation:

1. **<Insert requirements>.**

B. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>.**

C. Tests and Inspections:

1. Perform manufacturer's recommended tests and inspections.
2. Visually inspect jacket materials for certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA-568.1.
3. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
4. Test cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.
 - a. Test instruments must meet or exceed applicable requirements in TIA-568.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test

equipment manufacturer for channel or link test configuration.

D. Nonconforming Work:

1. Cable assemblies will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective cable assemblies and retest.

E. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

3.5 PROTECTION

- A. After installation, protect cable assemblies and accessories from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 27 13 13 00



Task	Specification	Specification Description
27 13 13 13	26 05 13 00	Medium-Voltage Cables
27 13 13 13	26 05 19 00	Low-Voltage Electrical Power Conductors and Cables
27 13 13 13	27 13 13 00	Communications Copper Backbone Cabling



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SECTION 27 13 23 00 - COMMUNICATIONS OPTICAL FIBER BACKBONE CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Type OFNR optical fiber cable.
2. Type OFCR optical fiber cable.
3. Type OFNP optical fiber cable.
4. Type OFCP optical fiber cable.
5. Types OFN and OFNG optical fiber cable.
6. Types OFC and OFCG optical fiber cable.
7. Optical fiber cable hardware.

1.2 DEFINITIONS

- A. Conductive Cable: Cable containing non-current-carrying electrically-conductive members such as metallic strength members and metallic vapor barriers.
- B. Cross-Connect: A facility enabling termination of cable elements and their interconnection or cross-connection.
- C. Type OFCP: Conductive cable for use in plenums, ducts, and other spaces used for environmental air.
- D. Type OFCR: Conductive cable for use as riser in vertical shafts or from floor to floor.
- E. Type OFNP: Nonconductive cable for use in plenums, ducts, and other spaces used for environmental air.
- F. Type OFNR: Nonconductive cable for use as riser in vertical shafts or from floor to floor.
- G. Types OFC and OFCG: Conductive cable for general purpose use.
- H. Types OFN and OFNG: Nonconductive cable for general purpose use.

1.3 COORDINATION

- A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

1.4 ACTION SUBMITTALS

A. Product Data:

1. Type OFNR optical fiber cable.
2. Type OFCR optical fiber cable.
3. Type OFNP optical fiber cable.

4. Type OFCP optical fiber cable.
5. Types OFN and OFNG optical fiber cable.
6. Types OFC and OFCG optical fiber cable.
7. Optical fiber cable hardware.

B. Shop Drawings:

1. System Labeling Schedules:

- a. Electronic copy of labeling schedules, in software and format selected by Owner.
- b. Electronic copy of labeling schedules that are part of cabling and asset identification system of software.

2. Cabling administration drawings and printouts.

3. Wiring diagrams showing typical schematic arrangement, including the following:

- a. Telecommunications rooms plans and elevations.
- b. Telecommunications pathways.
- c. Telecommunications system access points.
- d. Telecommunications grounding system.
- e. Cross-connects.
- f. Patch panels.
- g. Patch cords.

4. Cross-Connect and Patch-Panel Drawings: Detail mounting assemblies and show elevations and physical relationship between installed components.

C. Certificates: For each type of product.

D. Field Quality-Control Reports: Optical fiber cable testing plan.

E. Sustainable Design Submittals:

1. Product Data: For each conductor and cable indicating lead content.
2. Environmental Product Declaration: For each product.
3. Health Product Declaration: For each product.
4. Sourcing of Raw Materials: Corporate sustainability report for each manufacturer.
5. Environmental Product Declaration: For each product.
6. Environmental Product Declaration: For each product.
7. Environmental Product Declaration: For each product.
8. Third-Party Certifications: For each product.
9. Third-Party Certified Life Cycle Assessment: For each product.

1.5 INFORMATIONAL SUBMITTALS

A. Source quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Contracts:

1. Software service agreement.

- B. Maintenance Data: For optical fiber cable, splices, and connectors.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Extra Stock Material: Furnish to Owner extra materials[, **from same production run,**] that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.[**Include the following:**]
 - 1. Patch-Panel Units: [**One**]<Insert number> of each type.
 - 2. Plugs: [**10**]<Insert number> of each type.
 - 3. Jacks: [**10**]<Insert number> of each type.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet-work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during remainder of construction period.
- B. Test cables upon receipt at Project site.
 - 1. Test optical fiber cable to determine continuity of strand end to end. Use [**optical fiber flashlight**][or][**optical loss test set**]<Insert test instrument>.
 - 2. Test optical fiber cable while on reels. Use optical time domain reflectometer to verify cable length and locate cable defects, splices, and connector, including loss value of each. Retain test data and include record in maintenance data.

PART 2 - PRODUCTS

2.1 TYPE OFNR OPTICAL FIBER CABLE

- A. Type OFNR Optical Fiber Cable: This category covers jacketed optical fiber cable for use as risers in vertical runs in shaft or between floors within buildings in accordance with Article 770 of NFPA 70 containing no electrically conductive materials.
- B. Performance Criteria:
 - 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - 2. Listing Criteria: UL CCN QAYK; including UL 1651.
 - 3. General Characteristics:
 - a. Performance: TIA-568.3.
 - b. Inside Plant Mechanical Properties: ICEA S-83-596.
 - c. Inside-Outside Plant Mechanical Properties: ICEA S-104-696.
 - d. Jacket:
 - 1) Cable cordage jacket, fiber, unit, and group color in accordance with TIA-598.
 - 2) Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed **40 inch (1 m)**.



C. Type OFNR, Designation OM1, Multimode Optical Fiber Cable :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Belden Inc.]**
 - b. **[Berk-Tek, a Leviton Company]**
 - c. **[CommScope, Inc]**
 - d. **[Corning Optical Communications; Corning Incorporated]**
 - e. **[General Cable; Prysmian Group North America]**
 - f. **[Hitachi Cable America Inc.]**
 - g. **[Mohawk; a division of Belden Networking, Inc.]**
 - h. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - i. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - j. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Belden Inc.]**
 - b. **[Berk-Tek, a Leviton Company]**
 - c. **[CommScope, Inc]**
 - d. **[Corning Optical Communications; Corning Incorporated]**
 - e. **[General Cable; Prysmian Group North America]**
 - f. **[Hitachi Cable America Inc.]**
 - g. **[Mohawk; a division of Belden Networking, Inc.]**
 - h. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - i. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - j. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Additional Characteristics:
 - a. Construction: TIA-492AAAA; 62.5 μm core diameter, 125 μm cladding diameter.
 - b. Minimum Overfilled Modal Bandwidth-Length Product: 200 MHz-km at 850 nm wavelength; 500 MHz-km at 1300 nm wavelength.
5. Options:
 - a. Configuration: **[4][6][8][12][24][48]<Insert number>**-fiber, tight buffer, optical fiber cable.
 - b. Maximum Attenuation: **[3.50 dB/km]<Insert dB/km>** at 850 nm wavelength; **[1.5 dB/km]<Insert dB/km>** at 1300 nm wavelength.
 - c. Jacket Color: **[Orange]<Insert color>**.

D. Type OFNR, Designation OM2, Multimode Optical Fiber Cable :

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

- b. **[Belden Inc.]**
 - c. **[Berk-Tek, a Leviton Company]**
 - d. **[CommScope, Inc]**
 - e. **[Corning Optical Communications; Corning Incorporated]**
 - f. **[General Cable; Prysmian Group North America]**
 - g. **[Hitachi Cable America Inc.]**
 - h. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - i. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[AMP NETCONNECT; a TE Connectivity Ltd. company]**
 - b. **[Belden Inc.]**
 - c. **[Berk-Tek, a Leviton Company]**
 - d. **[CommScope, Inc]**
 - e. **[Corning Optical Communications; Corning Incorporated]**
 - f. **[General Cable; Prysmian Group North America]**
 - g. **[Hitachi Cable America Inc.]**
 - h. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - i. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain products from single manufacturer.
 4. Additional Characteristics:
 - a. Construction: TIA-492AAAB; 50 µm core diameter, 125 µm cladding diameter.
 - b. Minimum Overfilled Modal Bandwidth-Length Product: 500 MHz-km at 850 nm wavelength; 500 MHz-km at 1300 nm wavelength.
 5. Options:
 - a. Configuration: **[4][6][8][12][24][48]<Insert number>**-fiber, tight buffer, optical fiber cable.
 - b. Maximum Attenuation: **[3.50 dB/km]<Insert dB/km>** at 850 nm wavelength; **[1.5 dB/km]<Insert dB/km>** at 1300 nm wavelength.
 - c. Jacket Color: **[Orange]<Insert color>**.
- E. Type OFNR, Designation OM3, Multimode Optical Fiber Cable :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[AMP NETCONNECT; a TE Connectivity Ltd. company]**
 - b. **[Belden Inc.]**
 - c. **[CommScope, Inc]**
 - d. **[Corning Optical Communications; Corning Incorporated]**
 - e. **[Hitachi Cable America Inc.]**
 - f. **[TE Connectivity Ltd.]**
 - g. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[AMP NETCONNECT; a TE Connectivity Ltd. company]**
 - b. **[Belden Inc.]**
 - c. **[CommScope, Inc]**
 - d. **[Corning Optical Communications; Corning Incorporated]**
 - e. **[Hitachi Cable America Inc.]**
 - f. **[TE Connectivity Ltd.]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Additional Characteristics:
- a. Construction: TIA-492AAAC; 850 nm laser-optimized, 50 µm core diameter, 125 µm cladding diameter.
 - b. Minimum Overfilled Modal Bandwidth-Length Product: 1500 MHz-km at 850 nm wavelength; 500 MHz-km at 1300 nm wavelength.
 - c. Minimum Effective Modal Bandwidth-Length Product: 2000 MHz-km at 850 nm wavelength.
5. Options:
- a. Configuration: **[4][6][8][12][24][48]<Insert number>**-fiber, tight buffer, optical fiber cable.
 - b. Maximum Attenuation: **[3.50 dB/km]<Insert dB/km>** at 850 nm wavelength; **[1.5 dB/km]<Insert dB/km>** at 1300 nm wavelength.
 - c. Jacket Color: **[Aqua]<Insert color>**.

F. Type OFNR, Designation OM4, Multimode Optical Fiber Cable :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
- a. **[Belden Inc.]**
 - b. **[CommScope, Inc]**
 - c. **[Corning Optical Communications; Corning Incorporated]**
 - d. **[Hitachi Cable America Inc.]**
 - e. **[Mohawk; a division of Belden Networking, Inc.]**
 - f. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - g. **[TE Connectivity Ltd.]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[Belden Inc.]**
 - b. **[CommScope, Inc]**
 - c. **[Corning Optical Communications; Corning Incorporated]**
 - d. **[Hitachi Cable America Inc.]**
 - e. **[Mohawk; a division of Belden Networking, Inc.]**
 - f. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - g. **[TE Connectivity Ltd.]**
 - h. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.

4. Additional Characteristics:

- a. Construction: TIA-492AAAD; 850 nm laser-optimized, 50 μm core diameter, 125 μm cladding diameter.
- b. Minimum Overfilled Modal Bandwidth-Length Product: 3500 MHz-km at 850 nm wavelength; 500 MHz-km at 1300 nm wavelength.
- c. Minimum Effective Modal Bandwidth-Length Product: 4700 MHz-km at 850 nm wavelength.

5. Options:

- a. Configuration: [4][6][8][12][24][48]<Insert number>-fiber, tight buffer, optical fiber cable.
- b. Maximum Attenuation: [3.50 dB/km]<Insert dB/km> at 850 nm wavelength; [1.5 dB/km]<Insert dB/km> at 1300 nm wavelength.
- c. Jacket Color: [Aqua]<Insert color>.

G. Type OFNR, Designation OS1, Inside-Outside Plant, Single-Mode Optical Fiber Cable :

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

- a. [Corning Optical Communications; Corning Incorporated]
- b. [General Cable; Prysmian Group North America]
- c. [Mohawk; a division of Belden Networking, Inc.]
- d. [Superior Essex Inc.; subsidiary of LS Corp.]
- e. [TE Connectivity Ltd.]
- f. <Insert manufacturer's name>

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

- a. [Corning Optical Communications; Corning Incorporated]
- b. [General Cable; Prysmian Group North America]
- c. [Mohawk; a division of Belden Networking, Inc.]
- d. [Superior Essex Inc.; subsidiary of LS Corp.]
- e. [TE Connectivity Ltd.]
- f. <Insert manufacturer's name>

3. Source Limitations: Obtain products from single manufacturer.

4. Additional Characteristics:

- a. Construction: TIA-492CAAA; 9 μm core diameter, 125 μm cladding diameter.
- b. Minimum Overfilled Modal Bandwidth-Length Product: 500 MHz-km at 850 nm wavelength; 500 MHz-km at 1300 nm wavelength.

5. Options:

- a. Configuration:
 - 1) [6][8][12]-fiber, single loose tube, optical fiber cable.
 - 2) [24][36][48][72][96][144]-fiber, stranded loose tube, optical fiber cable.
- b. Maximum Attenuation: [0.5 dB/km]<Insert dB/km> at 1310 nm wavelength; [0.5

dB/km]<Insert dB/km> at 1550 nm wavelength.

c. Jacket Color: **[Yellow]<Insert color>.**

H. Type OFNR, Designation OS2, Inside-Outside Plant, Single-Mode Optical Fiber Cable :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[3M]**
 - b. **[Belden Inc.]**
 - c. **[Berk-Tek, a Leviton Company]**
 - d. **[CommScope, Inc]**
 - e. **[Hitachi Cable America Inc.]**
 - f. **[Mohawk; a division of Belden Networking, Inc.]**
 - g. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[3M]**
 - b. **[Belden Inc.]**
 - c. **[Berk-Tek, a Leviton Company]**
 - d. **[CommScope, Inc]**
 - e. **[Hitachi Cable America Inc.]**
 - f. **[Mohawk; a division of Belden Networking, Inc.]**
 - g. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - h. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Additional Characteristics:
 - a. Construction: TIA-492CAAB; 9 µm core diameter, 125 µm cladding diameter, with low water peak.
 - b. Minimum Overfilled Modal Bandwidth-Length Product: 500 MHz-km at 850 nm wavelength; 500 MHz-km at 1300 nm wavelength.
5. Options:
 - a. Configuration:
 - 1) **[6][8][12]-fiber, single loose tube, optical fiber cable.**
 - 2) **[24][36][48][72][96][144]-fiber, stranded loose tube, optical fiber cable.**
 - b. Maximum Attenuation: **[0.5 dB/km]<Insert dB/km> at 1310 nm wavelength; [0.5 dB/km]<Insert dB/km> at 1550 nm wavelength.**
 - c. Jacket Color: **[Yellow]<Insert color>.**

I. Type OFNR, Designation OS1, Inside Plant, Single-Mode Optical Fiber Cable :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering**

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

- a. [CommScope, Inc]
 - b. [Corning Optical Communications; Corning Incorporated]
 - c. [General Cable; Prysmian Group North America]
 - d. [Hitachi Cable America Inc.]
 - e. [Mohawk; a division of Belden Networking, Inc.]
 - f. [Superior Essex Inc.; subsidiary of LS Corp.]
 - g. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [CommScope, Inc]
 - b. [Corning Optical Communications; Corning Incorporated]
 - c. [General Cable; Prysmian Group North America]
 - d. [Hitachi Cable America Inc.]
 - e. [Mohawk; a division of Belden Networking, Inc.]
 - f. [Superior Essex Inc.; subsidiary of LS Corp.]
 - g. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Additional Characteristics:
- a. Construction: TIA-492CAAA; 9 μ m core diameter, 125 μ m cladding diameter.
 - b. Minimum Overfilled Modal Bandwidth-Length Product: 500 MHz-km at 850 nm wavelength; 500 MHz-km at 1300 nm wavelength.
5. Options:
- a. Configuration: [6][8][12][24][36][48][72][96][144] fibers, tight buffered, optical fiber cable.
 - b. Maximum Attenuation: [1.0 dB/km]<Insert dB/km> at 1310 nm wavelength; [1.0 dB/km]<Insert dB/km> at 1550 nm wavelength.
 - c. Jacket Color: [Yellow]<Insert color>.
- J. Type OFNR, Designation OS2, Inside Plant, Single-Mode Optical Fiber Cable :
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
- a. [AMP NETCONNECT; a TE Connectivity Ltd. company]
 - b. [Belden Inc.]
 - c. [CommScope, Inc]
 - d. [General Cable; Prysmian Group North America]
 - e. [Hitachi Cable America Inc.]
 - f. [Mohawk; a division of Belden Networking, Inc.]
 - g. [Superior Essex Inc.; subsidiary of LS Corp.]
 - h. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. **[AMP NETCONNECT; a TE Connectivity Ltd. company]**
 - b. **[Belden Inc.]**
 - c. **[CommScope, Inc]**
 - d. **[General Cable; Prysmian Group North America]**
 - e. **[Hitachi Cable America Inc.]**
 - f. **[Mohawk; a division of Belden Networking, Inc.]**
 - g. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - h. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Additional Characteristics:
 - a. Construction: TIA-492CAAB; 9 µm core diameter, 125 µm cladding diameter, with low water peak.
 - b. Minimum Overfilled Modal Bandwidth-Length Product: 500 MHz-km at 850 nm wavelength; 500 MHz-km at 1300 nm wavelength.
5. Options:
 - a. Configuration:
 - 1) **[6][8][12]**-fiber, single loose tube, optical fiber cable.
 - 2) **[24][36][48][72][96][144]**-fiber, stranded loose tube, optical fiber cable.
 - b. Maximum Attenuation: **[0.5 dB/km]<Insert dB/km>** at 1310 nm wavelength; **[0.5 dB/km]<Insert dB/km>** at 1550 nm wavelength.
 - c. Jacket Color: **[Yellow]<Insert color>**.

2.2 TYPE OFCR OPTICAL FIBER CABLE

- A. Type OFCR Optical Fiber Cable: This category covers jacketed optical fiber cable for use as risers in vertical runs in shaft or between floors within buildings in accordance with Article 770 of NFPA 70 containing noncurrent-carrying electrically conductive materials.
- B. Performance Criteria:
 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 2. Listing Criteria: UL CCN QAYK; including UL 1651.
 3. General Characteristics:
 - a. Performance: TIA-568.3.
 - b. Inside Plant Mechanical Properties: ICEA S-83-596.
 - c. Inside-Outside Plant Mechanical Properties: ICEA S-104-696.
 - d. Jacket:
 - 1) Cable cordage jacket, fiber, unit, and group color in accordance with TIA-598.
 - 2) Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed **40 inch (1 m)**.
- C. Type OFCR, Designation OM1, Multimode Optical Fiber Cable :
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the**

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

- a. [Belden Inc.]
- b. [Berk-Tek, a Leviton Company]
- c. [CommScope, Inc]
- d. [Corning Optical Communications; Corning Incorporated]
- e. [General Cable; Prysmian Group North America]
- f. [Hitachi Cable America Inc.]
- g. [Mohawk; a division of Belden Networking, Inc.]
- h. [Prysmian Cables and Systems; Prysmian Group North America]
- i. [Superior Essex Inc.; subsidiary of LS Corp.]
- j. <Insert manufacturer's name>

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

- a. [Belden Inc.]
- b. [Berk-Tek, a Leviton Company]
- c. [CommScope, Inc]
- d. [Corning Optical Communications; Corning Incorporated]
- e. [General Cable; Prysmian Group North America]
- f. [Hitachi Cable America Inc.]
- g. [Mohawk; a division of Belden Networking, Inc.]
- h. [Prysmian Cables and Systems; Prysmian Group North America]
- i. [Superior Essex Inc.; subsidiary of LS Corp.]
- j. <Insert manufacturer's name>

3. Source Limitations: Obtain products from single manufacturer.
4. Additional Characteristics:

- a. Construction: TIA-492AAAA; 62.5 µm core diameter, 125 µm cladding diameter.
- b. Minimum Overfilled Modal Bandwidth-Length Product: 200 MHz-km at 850 nm wavelength; 500 MHz-km at 1300 nm wavelength.

5. Options:

- a. Configuration: [4][6][8][12][24][48]<Insert number>-fiber, tight buffer, optical fiber cable.
- b. Maximum Attenuation: [3.50 dB/km]<Insert dB/km> at 850 nm wavelength; [1.5 dB/km]<Insert dB/km> at 1300 nm wavelength.
- c. Jacket Color: [Orange]<Insert color>.
- d. Armor: [Steel][Aluminum].

- D. Type OFCR, Designation OM2, Multimode Optical Fiber Cable :

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

- a. [Belden Inc.]
- b. [Berk-Tek, a Leviton Company]
- c. [CommScope, Inc]
- d. [Corning Optical Communications; Corning Incorporated]

- e. **[General Cable; Prysmian Group North America]**
 - f. **[Hitachi Cable America Inc.]**
 - g. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Belden Inc.]**
 - b. **[Berk-Tek, a Leviton Company]**
 - c. **[CommScope, Inc]**
 - d. **[Corning Optical Communications; Corning Incorporated]**
 - e. **[General Cable; Prysmian Group North America]**
 - f. **[Hitachi Cable America Inc.]**
 - g. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - h. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain products from single manufacturer.
 4. Additional Characteristics:
 - a. Construction: TIA-492AAAB; 50 µm core diameter, 125 µm cladding diameter.
 - b. Minimum Overfilled Modal Bandwidth-Length Product: 500 MHz-km at 850 nm wavelength; 500 MHz-km at 1300 nm wavelength.
 5. Options:
 - a. Configuration: **[4][6][8][12][24][48]<Insert number>**-fiber, tight buffer, optical fiber cable.
 - b. Maximum Attenuation: **[3.50 dB/km]<Insert dB/km>** at 850 nm wavelength; **[1.5 dB/km]<Insert dB/km>** at 1300 nm wavelength.
 - c. Jacket Color: **[Orange]<Insert color>**.
 - d. Armor: **[Steel][Aluminum]**.
- E. Type OFCR, Designation OM3, Multimode Optical Fiber Cable :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Belden Inc.]**
 - b. **[CommScope, Inc]**
 - c. **[Corning Optical Communications; Corning Incorporated]**
 - d. **[Hitachi Cable America Inc.]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Belden Inc.]**
 - b. **[CommScope, Inc]**
 - c. **[Corning Optical Communications; Corning Incorporated]**
 - d. **[Hitachi Cable America Inc.]**
 - e. **<Insert manufacturer's name>**

3. Source Limitations: Obtain products from single manufacturer.
4. Additional Characteristics:
 - a. Construction: TIA-492AAAC; 850 nm laser-optimized, 50 μ m core diameter, 125 μ m cladding diameter.
 - b. Minimum Overfilled Modal Bandwidth-Length Product: 1500 MHz-km at 850 nm wavelength; 500 MHz-km at 1300 nm wavelength.
 - c. Minimum Effective Modal Bandwidth-Length Product: 2000 MHz-km at 850 nm wavelength.
5. Options:
 - a. Configuration: [4][6][8][12][24][48]<Insert number>-fiber, tight buffer, optical fiber cable.
 - b. Maximum Attenuation: [3.50 dB/km]<Insert dB/km> at 850 nm wavelength; [1.5 dB/km]<Insert dB/km> at 1300 nm wavelength.
 - c. Jacket Color: [Aqua]<Insert color>.
 - d. Armor: [Steel][Aluminum].

F. Type OFCR, Designation OM4, Multimode Optical Fiber Cable :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. [Belden Inc.]
 - b. [CommScope, Inc]
 - c. [Corning Optical Communications; Corning Incorporated]
 - d. [Hitachi Cable America Inc.]
 - e. [Mohawk; a division of Belden Networking, Inc.]
 - f. [Superior Essex Inc.; subsidiary of LS Corp.]
 - g. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert **manufacturer's name; product name or designation**> or comparable product by one of the following:
 - a. [Belden Inc.]
 - b. [CommScope, Inc]
 - c. [Corning Optical Communications; Corning Incorporated]
 - d. [Hitachi Cable America Inc.]
 - e. [Mohawk; a division of Belden Networking, Inc.]
 - f. [Superior Essex Inc.; subsidiary of LS Corp.]
 - g. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Additional Characteristics:
 - a. Construction: TIA-492AAAD; 850 nm laser-optimized, 50 μ m core diameter, 125 μ m cladding diameter.
 - b. Minimum Overfilled Modal Bandwidth-Length Product: 3500 MHz-km at 850 nm wavelength; 500 MHz-km at 1300 nm wavelength.
 - c. Minimum Effective Modal Bandwidth-Length Product: 4700 MHz-km at 850 nm wavelength.
5. Options:



- a. Configuration: [4][6][8][12][24][48]<Insert number>-fiber, tight buffer, optical fiber cable.
- b. Maximum Attenuation: [3.50 dB/km]<Insert dB/km> at 850 nm wavelength; [1.5 dB/km]<Insert dB/km> at 1300 nm wavelength.
- c. Jacket Color: [Aqua]<Insert color>.
- d. Armor: [Steel][Aluminum].

G. Type OFCR, Designation OS1, Inside-Outside Plant, Single-Mode Optical Fiber Cable :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Corning Optical Communications; Corning Incorporated]
 - b. [General Cable; Prysmian Group North America]
 - c. [Mohawk; a division of Belden Networking, Inc.]
 - d. [Superior Essex Inc.; subsidiary of LS Corp.]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Corning Optical Communications; Corning Incorporated]
 - b. [General Cable; Prysmian Group North America]
 - c. [Mohawk; a division of Belden Networking, Inc.]
 - d. [Superior Essex Inc.; subsidiary of LS Corp.]
 - e. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Additional Characteristics:
 - a. Construction: TIA-492CAAA; 9 µm core diameter, 125 µm cladding diameter.
 - b. Minimum Overfilled Modal Bandwidth-Length Product: 500 MHz-km at 850 nm wavelength; 500 MHz-km at 1300 nm wavelength.
5. Options:
 - a. Configuration:
 - 1) [6][8][12]-fiber, single loose tube, optical fiber cable.
 - 2) [24][36][48][72][96][144]-fiber, stranded loose tube, optical fiber cable.
 - b. Maximum Attenuation: [0.5 dB/km]<Insert dB/km> at 1310 nm wavelength; [0.5 dB/km]<Insert dB/km> at 1550 nm wavelength.
 - c. Jacket Color: [Yellow]<Insert color>.
 - d. Armor: [Steel][Aluminum].

H. Type OFCR, Designation OS2, Inside-Outside Plant, Single-Mode Optical Fiber Cable :

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

- a. [Belden Inc.]
 - b. [Berk-Tek, a Leviton Company]
 - c. [CommScope, Inc]
 - d. [Hitachi Cable America Inc.]
 - e. [Mohawk; a division of Belden Networking, Inc.]
 - f. [Superior Essex Inc.; subsidiary of LS Corp.]
 - g. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Belden Inc.]
 - b. [Berk-Tek, a Leviton Company]
 - c. [CommScope, Inc]
 - d. [Hitachi Cable America Inc.]
 - e. [Mohawk; a division of Belden Networking, Inc.]
 - f. [Superior Essex Inc.; subsidiary of LS Corp.]
 - g. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Additional Characteristics:
 - a. Construction: TIA-492CAAB; 9 µm core diameter, 125 µm cladding diameter, with low water peak.
 - b. Minimum Overfilled Modal Bandwidth-Length Product: 500 MHz-km at 850 nm wavelength; 500 MHz-km at 1300 nm wavelength.
5. Options:
 - a. Configuration:
 - 1) [6][8][12]-fiber, single loose tube, optical fiber cable.
 - 2) [24][36][48][72][96][144]-fiber, stranded loose tube, optical fiber cable.
 - b. Maximum Attenuation: [0.5 dB/km]<Insert dB/km> at 1310 nm wavelength; [0.5 dB/km]<Insert dB/km> at 1550 nm wavelength.
 - c. Jacket Color: [Yellow]<Insert color>.
 - d. Armor: [Steel][Aluminum].
- I. Type OFCR, Designation OS1, Inside Plant, Single-Mode Optical Fiber Cable :
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [CommScope, Inc]
 - b. [Corning Optical Communications; Corning Incorporated]
 - c. [General Cable; Prysmian Group North America]
 - d. [Hitachi Cable America Inc.]
 - e. [Mohawk; a division of Belden Networking, Inc.]
 - f. [Superior Essex Inc.; subsidiary of LS Corp.]
 - g. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert

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

- a. **[CommScope, Inc]**
 - b. **[Corning Optical Communications; Corning Incorporated]**
 - c. **[General Cable; Prysmian Group North America]**
 - d. **[Hitachi Cable America Inc.]**
 - e. **[Mohawk; a division of Belden Networking, Inc.]**
 - f. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
 4. Additional Characteristics:
 - a. Construction: TIA-492CAAA; 9 µm core diameter, 125 µm cladding diameter.
 - b. Minimum Overfilled Modal Bandwidth-Length Product: 500 MHz-km at 850 nm wavelength; 500 MHz-km at 1300 nm wavelength.
 5. Options:
 - a. Configuration: **[6][8][12][24][36][48][72][96][144]** fibers, tight buffered, optical fiber cable.
 - b. Maximum Attenuation: **[1.0 dB/km]<Insert dB/km>** at 1310 nm wavelength; **[1.0 dB/km]<Insert dB/km>** at 1550 nm wavelength.
 - c. Jacket Color: **[Yellow]<Insert color>**.
 - d. Armor: **[Steel][Aluminum]**.

J. Type OFCR, Designation OS2, Inside Plant, Single-Mode Optical Fiber Cable :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[CommScope, Inc]**
 - b. **[General Cable; Prysmian Group North America]**
 - c. **[Hitachi Cable America Inc.]**
 - d. **[Mohawk; a division of Belden Networking, Inc.]**
 - e. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[CommScope, Inc]**
 - b. **[General Cable; Prysmian Group North America]**
 - c. **[Hitachi Cable America Inc.]**
 - d. **[Mohawk; a division of Belden Networking, Inc.]**
 - e. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - f. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Additional Characteristics:
 - a. Construction: TIA-492CAAB; 9 µm core diameter, 125 µm cladding diameter, with low

- water peak.
 - b. Minimum Overfilled Modal Bandwidth-Length Product: 500 MHz-km at 850 nm wavelength; 500 MHz-km at 1300 nm wavelength.
- 5. Options:
 - a. Configuration:
 - 1) [6][8][12]-fiber, single loose tube, optical fiber cable.
 - 2) [24][36][48][72][96][144]-fiber, stranded loose tube, optical fiber cable.
 - b. Maximum Attenuation: [0.5 dB/km]<Insert dB/km> at 1310 nm wavelength; [0.5 dB/km]<Insert dB/km> at 1550 nm wavelength.
 - c. Jacket Color: [Yellow]<Insert color>.
 - d. Armor: [Steel][Aluminum].

2.3 TYPE OFNP OPTICAL FIBER CABLE

- A. Type OFNP Optical Fiber Cable: This category covers jacketed optical fiber cable for use in vertical runs in plenums, ducts, or other spaces used for environmental air within buildings in accordance with Article 770 of NFPA 70 containing no electrically conductive materials.
- B. Performance Criteria:
 - 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - 2. Listing Criteria: UL CCN QAYK; including UL 1651.
 - 3. General Characteristics:
 - a. Performance: TIA-568.3.
 - b. Inside Plant Mechanical Properties: ICEA S-83-596.
 - c. Inside-Outside Plant Mechanical Properties: ICEA S-104-696.
 - d. Jacket:
 - 1) Cable cordage jacket, fiber, unit, and group color in accordance with TIA-598.
 - 2) Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inch (1 m).
- C. Type OFNP, Designation OM1, Multimode Optical Fiber Cable :
 - 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Belden Inc.]
 - b. [Berk-Tek, a Leviton Company]
 - c. [CommScope, Inc]
 - d. [Corning Optical Communications; Corning Incorporated]
 - e. [General Cable; Prysmian Group North America]
 - f. [Hitachi Cable America Inc.]
 - g. [Mohawk; a division of Belden Networking, Inc.]
 - h. [Prysmian Cables and Systems; Prysmian Group North America]
 - i. [Superior Essex Inc.; subsidiary of LS Corp.]

- j. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Belden Inc.]
 - b. [Berk-Tek, a Leviton Company]
 - c. [CommScope, Inc]
 - d. [Corning Optical Communications; Corning Incorporated]
 - e. [General Cable; Prysmian Group North America]
 - f. [Hitachi Cable America Inc.]
 - g. [Mohawk; a division of Belden Networking, Inc.]
 - h. [Prysmian Cables and Systems; Prysmian Group North America]
 - i. [Superior Essex Inc.; subsidiary of LS Corp.]
 - j. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Additional Characteristics:
- a. Construction: TIA-492AAAA; 62.5 µm core diameter, 125 µm cladding diameter.
 - b. Minimum Overfilled Modal Bandwidth-Length Product: 200 MHz-km at 850 nm wavelength; 500 MHz-km at 1300 nm wavelength.
5. Options:
- a. Configuration: [4][6][8][12][24][48]<Insert number>-fiber, tight buffer, optical fiber cable.
 - b. Maximum Attenuation: [3.50 dB/km]<Insert dB/km> at 850 nm wavelength; [1.5 dB/km]<Insert dB/km> at 1300 nm wavelength.
 - c. Jacket Color: [Orange]<Insert color>.
- D. Type OFNP, Designation OM2, Multimode Optical Fiber Cable :
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
- a. [AMP NETCONNECT; a TE Connectivity Ltd. company]
 - b. [Belden Inc.]
 - c. [Berk-Tek, a Leviton Company]
 - d. [CommScope, Inc]
 - e. [Corning Optical Communications; Corning Incorporated]
 - f. [General Cable; Prysmian Group North America]
 - g. [Hitachi Cable America Inc.]
 - h. [Superior Essex Inc.; subsidiary of LS Corp.]
 - i. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [AMP NETCONNECT; a TE Connectivity Ltd. company]
 - b. [Belden Inc.]
 - c. [Berk-Tek, a Leviton Company]

- d. [CommScope, Inc]
 - e. [Corning Optical Communications; Corning Incorporated]
 - f. [General Cable; Prysmian Group North America]
 - g. [Hitachi Cable America Inc.]
 - h. [Superior Essex Inc.; subsidiary of LS Corp.]
 - i. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
 4. Additional Characteristics:
 - a. Construction: TIA-492AAAB; 50 μ m core diameter, 125 μ m cladding diameter.
 - b. Minimum Overfilled Modal Bandwidth-Length Product: 500 MHz-km at 850 nm wavelength; 500 MHz-km at 1300 nm wavelength.
 5. Options:
 - a. Configuration: [4][6][8][12][24][48]<Insert number>-fiber, tight buffer, optical fiber cable.
 - b. Maximum Attenuation: [3.50 dB/km]<Insert dB/km> at 850 nm wavelength; [1.5 dB/km]<Insert dB/km> at 1300 nm wavelength.
 - c. Jacket Color: [Orange]<Insert color>.
- E. Type OFNP, Designation OM3, Multimode Optical Fiber Cable :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. [AMP NETCONNECT; a TE Connectivity Ltd. company]
 - b. [Belden Inc.]
 - c. [CommScope, Inc]
 - d. [Corning Optical Communications; Corning Incorporated]
 - e. [Hitachi Cable America Inc.]
 - f. [TE Connectivity Ltd.]
 - g. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [AMP NETCONNECT; a TE Connectivity Ltd. company]
 - b. [Belden Inc.]
 - c. [CommScope, Inc]
 - d. [Corning Optical Communications; Corning Incorporated]
 - e. [Hitachi Cable America Inc.]
 - f. [TE Connectivity Ltd.]
 - g. <Insert manufacturer's name>
 3. Source Limitations: Obtain products from single manufacturer.
 4. Additional Characteristics:
 - a. Construction: TIA-492AAAC; 850 nm laser-optimized, 50 μ m core diameter, 125 μ m cladding diameter.
 - b. Minimum Overfilled Modal Bandwidth-Length Product: 1500 MHz-km at 850 nm wavelength; 500 MHz-km at 1300 nm wavelength.
 - c. Minimum Effective Modal Bandwidth-Length Product: 2000 MHz-km at 850 nm

wavelength.

5. Options:

- a. Configuration: [4][6][8][12][24][48]<Insert number>-fiber, tight buffer, optical fiber cable.
- b. Maximum Attenuation: [3.50 dB/km]<Insert dB/km> at 850 nm wavelength; [1.5 dB/km]<Insert dB/km> at 1300 nm wavelength.
- c. Jacket Color: [Aqua]<Insert color>.

F. Type OFNP, Designation OM4, Multimode Optical Fiber Cable :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Belden Inc.]
 - b. [CommScope, Inc]
 - c. [Corning Optical Communications; Corning Incorporated]
 - d. [Hitachi Cable America Inc.]
 - e. [Mohawk; a division of Belden Networking, Inc.]
 - f. [Superior Essex Inc.; subsidiary of LS Corp.]
 - g. [TE Connectivity Ltd.]
 - h. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Belden Inc.]
 - b. [CommScope, Inc]
 - c. [Corning Optical Communications; Corning Incorporated]
 - d. [Hitachi Cable America Inc.]
 - e. [Mohawk; a division of Belden Networking, Inc.]
 - f. [Superior Essex Inc.; subsidiary of LS Corp.]
 - g. [TE Connectivity Ltd.]
 - h. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Additional Characteristics:
 - a. Construction: TIA-492AAAD; 850 nm laser-optimized, 50 µm core diameter, 125 µm cladding diameter.
 - b. Minimum Overfilled Modal Bandwidth-Length Product: 3500 MHz-km at 850 nm wavelength; 500 MHz-km at 1300 nm wavelength.
 - c. Minimum Effective Modal Bandwidth-Length Product: 4700 MHz-km at 850 nm wavelength.
5. Options:
 - a. Configuration: [4][6][8][12][24][48]<Insert number>-fiber, tight buffer, optical fiber cable.
 - b. Maximum Attenuation: [3.50 dB/km]<Insert dB/km> at 850 nm wavelength; [1.5 dB/km]<Insert dB/km> at 1300 nm wavelength.
 - c. Jacket Color: [Aqua]<Insert color>.

G. Type OFNP, Designation OS1, Inside-Outside Plant, Single-Mode Optical Fiber Cable :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Corning Optical Communications; Corning Incorporated]**
 - b. **[General Cable; Prysmian Group North America]**
 - c. **[Mohawk; a division of Belden Networking, Inc.]**
 - d. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - e. **[TE Connectivity Ltd.]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Corning Optical Communications; Corning Incorporated]**
 - b. **[General Cable; Prysmian Group North America]**
 - c. **[Mohawk; a division of Belden Networking, Inc.]**
 - d. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - e. **[TE Connectivity Ltd.]**
 - f. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Additional Characteristics:
 - a. Construction: TIA-492CAAA; 9 µm core diameter, 125 µm cladding diameter.
 - b. Minimum Overfilled Modal Bandwidth-Length Product: 500 MHz-km at 850 nm wavelength; 500 MHz-km at 1300 nm wavelength.
5. Options:
 - a. Configuration:
 - 1) **[6][8][12]-fiber, single loose tube, optical fiber cable.**
 - 2) **[24][36][48][72][96][144]-fiber, stranded loose tube, optical fiber cable.**
 - b. Maximum Attenuation: **[0.5 dB/km]<Insert dB/km>** at 1310 nm wavelength; **[0.5 dB/km]<Insert dB/km>** at 1550 nm wavelength.
 - c. Jacket Color: **[Yellow]<Insert color>**.

H. Type OFNP, Designation OS2, Inside-Outside Plant, Single-Mode Optical Fiber Cable :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Berk-Tek, a Leviton Company]**
 - b. **[CommScope, Inc]**
 - c. **[Hitachi Cable America Inc.]**
 - d. **[Mohawk; a division of Belden Networking, Inc.]**
 - e. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - f. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Berk-Tek, a Leviton Company]**
 - b. **[CommScope, Inc]**
 - c. **[Hitachi Cable America Inc.]**
 - d. **[Mohawk; a division of Belden Networking, Inc.]**
 - e. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - f. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain products from single manufacturer.
 4. Additional Characteristics:
 - a. Construction: TIA-492CAAB; 9 μm core diameter, 125 μm cladding diameter, with low water peak.
 - b. Minimum Overfilled Modal Bandwidth-Length Product: 500 MHz-km at 850 nm wavelength; 500 MHz-km at 1300 nm wavelength.
 5. Options:
 - a. Configuration:
 - 1) **[6][8][12]**-fiber, single loose tube, optical fiber cable.
 - 2) **[24][36][48][72][96][144]**-fiber, stranded loose tube, optical fiber cable.
 - b. Maximum Attenuation: **[0.5 dB/km]<Insert dB/km>** at 1310 nm wavelength; **[0.5 dB/km]<Insert dB/km>** at 1550 nm wavelength.
 - c. Jacket Color: **[Yellow]<Insert color>**.
- I. Type OFNP, Designation OS1, Inside Plant, Single-Mode Optical Fiber Cable :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[CommScope, Inc]**
 - b. **[Corning Optical Communications; Corning Incorporated]**
 - c. **[General Cable; Prysmian Group North America]**
 - d. **[Hitachi Cable America Inc.]**
 - e. **[Mohawk; a division of Belden Networking, Inc.]**
 - f. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - g. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[CommScope, Inc]**
 - b. **[Corning Optical Communications; Corning Incorporated]**
 - c. **[General Cable; Prysmian Group North America]**
 - d. **[Hitachi Cable America Inc.]**
 - e. **[Mohawk; a division of Belden Networking, Inc.]**
 - f. **[Superior Essex Inc.; subsidiary of LS Corp.]**

- g. <Insert manufacturer's name>
 - 3. Source Limitations: Obtain products from single manufacturer.
 - 4. Additional Characteristics:
 - a. Construction: TIA-492CAAA; 9 μ m core diameter, 125 μ m cladding diameter.
 - b. Minimum Overfilled Modal Bandwidth-Length Product: 500 MHz-km at 850 nm wavelength; 500 MHz-km at 1300 nm wavelength.
 - 5. Options:
 - a. Configuration: [6][8][12][24][36][48][72][96][144] fibers, tight buffered, optical fiber cable.
 - b. Maximum Attenuation: [1.0 dB/km]<Insert dB/km> at 1310 nm wavelength; [1.0 dB/km]<Insert dB/km> at 1550 nm wavelength.
 - c. Jacket Color: [Yellow]<Insert color>.
- J. Type OFNP, Designation OS2, Inside Plant, Single-Mode Optical Fiber Cable :
- 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [AMP NETCONNECT; a TE Connectivity Ltd. company]
 - b. [Belden Inc.]
 - c. [CommScope, Inc]
 - d. [General Cable; Prysmian Group North America]
 - e. [Hitachi Cable America Inc.]
 - f. [Mohawk; a division of Belden Networking, Inc.]
 - g. [Superior Essex Inc.; subsidiary of LS Corp.]
 - h. <Insert manufacturer's name>
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [AMP NETCONNECT; a TE Connectivity Ltd. company]
 - b. [Belden Inc.]
 - c. [CommScope, Inc]
 - d. [General Cable; Prysmian Group North America]
 - e. [Hitachi Cable America Inc.]
 - f. [Mohawk; a division of Belden Networking, Inc.]
 - g. [Superior Essex Inc.; subsidiary of LS Corp.]
 - h. <Insert manufacturer's name>
 - 3. Source Limitations: Obtain products from single manufacturer.
 - 4. Additional Characteristics:
 - a. Construction: TIA-492CAAB; 9 μ m core diameter, 125 μ m cladding diameter, with low water peak.
 - b. Minimum Overfilled Modal Bandwidth-Length Product: 500 MHz-km at 850 nm wavelength; 500 MHz-km at 1300 nm wavelength.
 - 5. Options:
 - a. Configuration:



- 1) [6][8][12]-fiber, single loose tube, optical fiber cable.
 - 2) [24][36][48][72][96][144]-fiber, stranded loose tube, optical fiber cable.
- b. Maximum Attenuation: [0.5 dB/km]<Insert dB/km> at 1310 nm wavelength; [0.5 dB/km]<Insert dB/km> at 1550 nm wavelength.
 - c. Jacket Color: [Yellow]<Insert color>.

2.4 TYPE OFCP OPTICAL FIBER CABLE

- A. Type OFCP Optical Fiber Cable: This category covers jacketed optical fiber cable for use in vertical runs in plenums, ducts, or other spaces used for environmental air within buildings in accordance with Article 770 of NFPA 70 containing noncurrent-carrying electrically conductive materials.
- B. Performance Criteria:
 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 2. Listing Criteria: UL CCN QAYK; including UL 1651.
 3. General Characteristics:
 - a. Performance: TIA-568.3.
 - b. Inside Plant Mechanical Properties: ICEA S-83-596.
 - c. Inside-Outside Plant Mechanical Properties: ICEA S-104-696.
 - d. Jacket:
 - 1) Cable cordage jacket, fiber, unit, and group color in accordance with TIA-598.
 - 2) Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inch (1 m).
- C. Type OFCP, Designation OM1, Multimode Optical Fiber Cable :
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Belden Inc.]
 - b. [Berk-Tek, a Leviton Company]
 - c. [CommScope, Inc]
 - d. [General Cable; Prysmian Group North America]
 - e. [Hitachi Cable America Inc.]
 - f. [Mohawk; a division of Belden Networking, Inc.]
 - g. [Prysmian Cables and Systems; Prysmian Group North America]
 - h. [Superior Essex Inc.; subsidiary of LS Corp.]
 - i. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Belden Inc.]
 - b. [Berk-Tek, a Leviton Company]
 - c. [CommScope, Inc]

- d. **[General Cable; Prysmian Group North America]**
 - e. **[Hitachi Cable America Inc.]**
 - f. **[Mohawk; a division of Belden Networking, Inc.]**
 - g. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - h. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - i. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
 4. Additional Characteristics:
 - a. Construction: TIA-492AAAA; 62.5 μm core diameter, 125 μm cladding diameter.
 - b. Minimum Overfilled Modal Bandwidth-Length Product: 200 MHz-km at 850 nm wavelength; 500 MHz-km at 1300 nm wavelength.
 5. Options:
 - a. Configuration: **[4][6][8][12][24][48]<Insert number>-fiber**, tight buffer, optical fiber cable.
 - b. Maximum Attenuation: **[3.50 dB/km]<Insert dB/km>** at 850 nm wavelength; **[1.5 dB/km]<Insert dB/km>** at 1300 nm wavelength.
 - c. Jacket Color: **[Orange]<Insert color>**.
 - d. Armor: **[Steel][Aluminum]**.
- D. Type OFCP, Designation OM2, Multimode Optical Fiber Cable :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Belden Inc.]**
 - b. **[Berk-Tek, a Leviton Company]**
 - c. **[CommScope, Inc]**
 - d. **[General Cable; Prysmian Group North America]**
 - e. **[Hitachi Cable America Inc.]**
 - f. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - g. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Belden Inc.]**
 - b. **[Berk-Tek, a Leviton Company]**
 - c. **[CommScope, Inc]**
 - d. **[General Cable; Prysmian Group North America]**
 - e. **[Hitachi Cable America Inc.]**
 - f. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - g. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain products from single manufacturer.
 4. Additional Characteristics:
 - a. Construction: TIA-492AAAB; 50 μm core diameter, 125 μm cladding diameter.
 - b. Minimum Overfilled Modal Bandwidth-Length Product: 500 MHz-km at 850 nm wavelength; 500 MHz-km at 1300 nm wavelength.

5. Options:

- a. Configuration: [4][6][8][12][24][48]<Insert number>-fiber, tight buffer, optical fiber cable.
- b. Maximum Attenuation: [3.50 dB/km]<Insert dB/km> at 850 nm wavelength; [1.5 dB/km]<Insert dB/km> at 1300 nm wavelength.
- c. Jacket Color: [Orange]<Insert color>.
- d. Armor: [Steel][Aluminum].

E. Type OFCP, Designation OM3, Multimode Optical Fiber Cable :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Belden Inc.]
 - b. [CommScope, Inc]
 - c. [Hitachi Cable America Inc.]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Belden Inc.]
 - b. [CommScope, Inc]
 - c. [Hitachi Cable America Inc.]
 - d. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Additional Characteristics:
 - a. Construction: TIA-492AAAC; 850 nm laser-optimized, 50 µm core diameter, 125 µm cladding diameter.
 - b. Minimum Overfilled Modal Bandwidth-Length Product: 1500 MHz-km at 850 nm wavelength; 500 MHz-km at 1300 nm wavelength.
 - c. Minimum Effective Modal Bandwidth-Length Product: 2000 MHz-km at 850 nm wavelength.
5. Options:
 - a. Configuration: [4][6][8][12][24][48]<Insert number>-fiber, tight buffer, optical fiber cable.
 - b. Maximum Attenuation: [3.50 dB/km]<Insert dB/km> at 850 nm wavelength; [1.5 dB/km]<Insert dB/km> at 1300 nm wavelength.
 - c. Jacket Color: [Aqua]<Insert color>.
 - d. Armor: [Steel][Aluminum].

F. Type OFCP, Designation OM4, Multimode Optical Fiber Cable :

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

- b. **[CommScope, Inc]**
 - c. **[Hitachi Cable America Inc.]**
 - d. **[Mohawk; a division of Belden Networking, Inc.]**
 - e. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - f. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Belden Inc.]**
 - b. **[CommScope, Inc]**
 - c. **[Hitachi Cable America Inc.]**
 - d. **[Mohawk; a division of Belden Networking, Inc.]**
 - e. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - f. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain products from single manufacturer.
 4. Additional Characteristics:
 - a. Construction: TIA-492AAAD; 850 nm laser-optimized, 50 µm core diameter, 125 µm cladding diameter.
 - b. Minimum Overfilled Modal Bandwidth-Length Product: 3500 MHz-km at 850 nm wavelength; 500 MHz-km at 1300 nm wavelength.
 - c. Minimum Effective Modal Bandwidth-Length Product: 4700 MHz-km at 850 nm wavelength.
 5. Options:
 - a. Configuration: **[4][6][8][12][24][48]<Insert number>**-fiber, tight buffer, optical fiber cable.
 - b. Maximum Attenuation: **[3.50 dB/km]<Insert dB/km>** at 850 nm wavelength; **[1.5 dB/km]<Insert dB/km>** at 1300 nm wavelength.
 - c. Jacket Color: **[Aqua]<Insert color>**.
 - d. Armor: **[Steel][Aluminum]**.
- G. Type OFCP, Designation OS1, Inside-Outside Plant, Single-Mode Optical Fiber Cable :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[General Cable; Prysmian Group North America]**
 - b. **[Mohawk; a division of Belden Networking, Inc.]**
 - c. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[General Cable; Prysmian Group North America]**
 - b. **[Mohawk; a division of Belden Networking, Inc.]**
 - c. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - d. **<Insert manufacturer's name>**

3. Source Limitations: Obtain products from single manufacturer.
4. Additional Characteristics:
 - a. Construction: TIA-492CAAA; 9 μ m core diameter, 125 μ m cladding diameter.
 - b. Minimum Overfilled Modal Bandwidth-Length Product: 500 MHz-km at 850 nm wavelength; 500 MHz-km at 1300 nm wavelength.
5. Options:
 - a. Configuration:
 - 1) [6][8][12]-fiber, single loose tube, optical fiber cable.
 - 2) [24][36][48][72][96][144]-fiber, stranded loose tube, optical fiber cable.
 - b. Maximum Attenuation: [0.5 dB/km]<Insert dB/km> at 1310 nm wavelength; [0.5 dB/km]<Insert dB/km> at 1550 nm wavelength.
 - c. Jacket Color: [Yellow]<Insert color>.
 - d. Armor: [Steel][Aluminum].

H. Type OFCP, Designation OS2, Inside-Outside Plant, Single-Mode Optical Fiber Cable :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Berk-Tek, a Leviton Company]
 - b. [CommScope, Inc]
 - c. [Hitachi Cable America Inc.]
 - d. [Mohawk; a division of Belden Networking, Inc.]
 - e. [Superior Essex Inc.; subsidiary of LS Corp.]
 - f. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Berk-Tek, a Leviton Company]
 - b. [CommScope, Inc]
 - c. [Hitachi Cable America Inc.]
 - d. [Mohawk; a division of Belden Networking, Inc.]
 - e. [Superior Essex Inc.; subsidiary of LS Corp.]
 - f. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Additional Characteristics:
 - a. Construction: TIA-492CAAB; 9 μ m core diameter, 125 μ m cladding diameter, with low water peak.
 - b. Minimum Overfilled Modal Bandwidth-Length Product: 500 MHz-km at 850 nm wavelength; 500 MHz-km at 1300 nm wavelength.
5. Options:
 - a. Configuration:

- 1) [6][8][12]-fiber, single loose tube, optical fiber cable.
 - 2) [24][36][48][72][96][144]-fiber, stranded loose tube, optical fiber cable.
 - b. Maximum Attenuation: [0.5 dB/km]<Insert dB/km> at 1310 nm wavelength; [0.5 dB/km]<Insert dB/km> at 1550 nm wavelength.
 - c. Jacket Color: [Yellow]<Insert color>.
 - d. Armor: [Steel][Aluminum].
- I. Type OFCP, Designation OS1, Inside Plant, Single-Mode Optical Fiber Cable :
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [CommScope, Inc]
 - b. [General Cable; Prysmian Group North America]
 - c. [Hitachi Cable America Inc.]
 - d. [Mohawk; a division of Belden Networking, Inc.]
 - e. [Superior Essex Inc.; subsidiary of LS Corp.]
 - f. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [CommScope, Inc]
 - b. [General Cable; Prysmian Group North America]
 - c. [Hitachi Cable America Inc.]
 - d. [Mohawk; a division of Belden Networking, Inc.]
 - e. [Superior Essex Inc.; subsidiary of LS Corp.]
 - f. <Insert manufacturer's name>
 3. Source Limitations: Obtain products from single manufacturer.
 4. Additional Characteristics:
 - a. Construction: TIA-492CAAA; 9 µm core diameter, 125 µm cladding diameter.
 - b. Minimum Overfilled Modal Bandwidth-Length Product: 500 MHz-km at 850 nm wavelength; 500 MHz-km at 1300 nm wavelength.
 5. Options:
 - a. Configuration: [6][8][12][24][36][48][72][96][144] fibers, tight buffered, optical fiber cable.
 - b. Maximum Attenuation: [1.0 dB/km]<Insert dB/km> at 1310 nm wavelength; [1.0 dB/km]<Insert dB/km> at 1550 nm wavelength.
 - c. Jacket Color: [Yellow]<Insert color>.
 - d. Armor: [Steel][Aluminum].
- J. Type OFCP, Designation OS2, Inside Plant, Single-Mode Optical Fiber Cable :
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [CommScope, Inc]

- b. **[General Cable; Prysmian Group North America]**
 - c. **[Hitachi Cable America Inc.]**
 - d. **[Mohawk; a division of Belden Networking, Inc.]**
 - e. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - f. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[CommScope, Inc]**
 - b. **[General Cable; Prysmian Group North America]**
 - c. **[Hitachi Cable America Inc.]**
 - d. **[Mohawk; a division of Belden Networking, Inc.]**
 - e. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - f. **<Insert manufacturer's name>**
- 3. Source Limitations: Obtain products from single manufacturer.
- 4. Additional Characteristics:
 - a. Construction: TIA-492CAAB; 9 µm core diameter, 125 µm cladding diameter, with low water peak.
 - b. Minimum Overfilled Modal Bandwidth-Length Product: 500 MHz-km at 850 nm wavelength; 500 MHz-km at 1300 nm wavelength.
- 5. Options:
 - a. Configuration:
 - 1) **[6][8][12]**-fiber, single loose tube, optical fiber cable.
 - 2) **[24][36][48][72][96][144]**-fiber, stranded loose tube, optical fiber cable.
 - b. Maximum Attenuation: **[0.5 dB/km]<Insert dB/km>** at 1310 nm wavelength; **[0.5 dB/km]<Insert dB/km>** at 1550 nm wavelength.
 - c. Jacket Color: **[Yellow]<Insert color>**.
 - d. Armor: **[Steel][Aluminum]**.

2.5 TYPES OFN AND OFNG OPTICAL FIBER CABLE

- A. Types OFN and OFNG Optical Fiber Cable: This category covers jacketed optical fiber cable for general use within buildings in accordance with Article 770 of NFPA 70 containing no electrically conductive materials.
- B. Performance Criteria:
 - 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - 2. Listing Criteria: UL CCN QAYK; including UL 1651.
 - 3. General Characteristics:
 - a. Performance: TIA-568.3.
 - b. Inside Plant Mechanical Properties: ICEA S-83-596.
 - c. Inside-Outside Plant Mechanical Properties: ICEA S-104-696.

d. Jacket:

- 1) Cable cordage jacket, fiber, unit, and group color in accordance with TIA-598.
- 2) Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed **40 inch (1 m)**.

C. Types OFN and OFNG, Designation OM2, Multimode Optical Fiber Cable :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[AMP NETCONNECT; a TE Connectivity Ltd. company]**
 - b. **[Berk-Tek, a Leviton Company]**
 - c. **[CommScope, Inc]**
 - d. **[Corning Optical Communications; Corning Incorporated]**
 - e. **[General Cable; Prysmian Group North America]**
 - f. **[Hitachi Cable America Inc.]**
 - g. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[AMP NETCONNECT; a TE Connectivity Ltd. company]**
 - b. **[Berk-Tek, a Leviton Company]**
 - c. **[CommScope, Inc]**
 - d. **[Corning Optical Communications; Corning Incorporated]**
 - e. **[General Cable; Prysmian Group North America]**
 - f. **[Hitachi Cable America Inc.]**
 - g. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - h. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Additional Characteristics:
 - a. Construction: TIA-492AAAB; 50 µm core diameter, 125 µm cladding diameter.
 - b. Minimum Overfilled Modal Bandwidth-Length Product: 500 MHz-km at 850 nm wavelength; 500 MHz-km at 1300 nm wavelength.
5. Options:
 - a. Configuration: **[4][6][8][12][24][48]<Insert number>-fiber, tight buffer, optical fiber cable.**
 - b. Maximum Attenuation: **[3.50 dB/km]<Insert dB/km> at 850 nm wavelength; [1.5 dB/km]<Insert dB/km> at 1300 nm wavelength.**
 - c. Jacket Color: **[Orange]<Insert color>.**

D. Types OFN and OFNG, Designation OS1, Inside-Outside Plant, Single-Mode Optical Fiber Cable :

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

- a. [Corning Optical Communications; Corning Incorporated]
 - b. [General Cable; Prysmian Group North America]
 - c. [Mohawk; a division of Belden Networking, Inc.]
 - d. [Superior Essex Inc.; subsidiary of LS Corp.]
 - e. [TE Connectivity Ltd.]
 - f. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Corning Optical Communications; Corning Incorporated]
 - b. [General Cable; Prysmian Group North America]
 - c. [Mohawk; a division of Belden Networking, Inc.]
 - d. [Superior Essex Inc.; subsidiary of LS Corp.]
 - e. [TE Connectivity Ltd.]
 - f. <Insert manufacturer's name>
 3. Source Limitations: Obtain products from single manufacturer.
 4. Additional Characteristics:
 - a. Construction: TIA-492CAAA; 9 µm core diameter, 125 µm cladding diameter.
 - b. Minimum Overfilled Modal Bandwidth-Length Product: 500 MHz-km at 850 nm wavelength; 500 MHz-km at 1300 nm wavelength.
 5. Options:
 - a. Configuration:
 - 1) [6][8][12]-fiber, single loose tube, optical fiber cable.
 - 2) [24][36][48][72][96][144]-fiber, stranded loose tube, optical fiber cable.
 - b. Maximum Attenuation: [0.5 dB/km]<Insert dB/km> at 1310 nm wavelength; [0.5 dB/km]<Insert dB/km> at 1550 nm wavelength.
 - c. Jacket Color: [Yellow]<Insert color>.
- E. Types OFN and OFNG, Designation OS2, Inside-Outside Plant, Single-Mode Optical Fiber Cable :
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Berk-Tek, a Leviton Company]
 - b. [CommScope, Inc]
 - c. [Hitachi Cable America Inc.]
 - d. [Mohawk; a division of Belden Networking, Inc.]
 - e. [Superior Essex Inc.; subsidiary of LS Corp.]
 - f. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Berk-Tek, a Leviton Company]

- b. [CommScope, Inc]
 - c. [Hitachi Cable America Inc.]
 - d. [Mohawk; a division of Belden Networking, Inc.]
 - e. [Superior Essex Inc.; subsidiary of LS Corp.]
 - f. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Additional Characteristics:
- a. Construction: TIA-492CAAB; 9 μ m core diameter, 125 μ m cladding diameter, with low water peak.
 - b. Minimum Overfilled Modal Bandwidth-Length Product: 500 MHz-km at 850 nm wavelength; 500 MHz-km at 1300 nm wavelength.
5. Options:
- a. Configuration:
 - 1) [6][8][12]-fiber, single loose tube, optical fiber cable.
 - 2) [24][36][48][72][96][144]-fiber, stranded loose tube, optical fiber cable.
 - b. Maximum Attenuation: [0.5 dB/km]<Insert dB/km> at 1310 nm wavelength; [0.5 dB/km]<Insert dB/km> at 1550 nm wavelength.
 - c. Jacket Color: [Yellow]<Insert color>.
- F. Types OFN and OFNG, Designation OS1, Inside Plant, Single-Mode Optical Fiber Cable :
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
- a. [CommScope, Inc]
 - b. [Corning Optical Communications; Corning Incorporated]
 - c. [General Cable; Prysmian Group North America]
 - d. [Hitachi Cable America Inc.]
 - e. [Mohawk; a division of Belden Networking, Inc.]
 - f. [Superior Essex Inc.; subsidiary of LS Corp.]
 - g. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [CommScope, Inc]
 - b. [Corning Optical Communications; Corning Incorporated]
 - c. [General Cable; Prysmian Group North America]
 - d. [Hitachi Cable America Inc.]
 - e. [Mohawk; a division of Belden Networking, Inc.]
 - f. [Superior Essex Inc.; subsidiary of LS Corp.]
 - g. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Additional Characteristics:
- a. Construction: TIA-492CAAA; 9 μ m core diameter, 125 μ m cladding diameter.

- b. Minimum Overfilled Modal Bandwidth-Length Product: 500 MHz-km at 850 nm wavelength; 500 MHz-km at 1300 nm wavelength.

5. Options:

- a. Configuration: [6][8][12][24][36][48][72][96][144] fibers, tight buffered, optical fiber cable.
- b. Maximum Attenuation: [1.0 dB/km]<Insert dB/km> at 1310 nm wavelength; [1.0 dB/km]<Insert dB/km> at 1550 nm wavelength.
- c. Jacket Color: [Yellow]<Insert color>.

2.6 TYPES OFC AND OFCG OPTICAL FIBER CABLE

- A. Types OFC and OFCG Optical Fiber Cable: This category covers jacketed optical fiber cable for general use within buildings in accordance with Article 770 of NFPA 70 containing noncurrent-carrying electrically conductive materials.

- B. Performance Criteria:

- 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- 2. Listing Criteria: UL CCN QAYK; including UL 1651.
- 3. General Characteristics:
 - a. Performance: TIA-568.3.
 - b. Inside Plant Mechanical Properties: ICEA S-83-596.
 - c. Inside-Outside Plant Mechanical Properties: ICEA S-104-696.
 - d. Jacket:
 - 1) Cable cordage jacket, fiber, unit, and group color in accordance with TIA-598.
 - 2) Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inch (1 m).

- C. Types OFC and OFCG, Designation OM2, Multimode Optical Fiber Cable :

- 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Berk-Tek, a Leviton Company]
 - b. [CommScope, Inc]
 - c. [General Cable; Prysmian Group North America]
 - d. [Hitachi Cable America Inc.]
 - e. [Superior Essex Inc.; subsidiary of LS Corp.]
 - f. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Berk-Tek, a Leviton Company]
 - b. [CommScope, Inc]
 - c. [General Cable; Prysmian Group North America]

- d. **[Hitachi Cable America Inc.]**
 - e. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - f. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
 4. Additional Characteristics:
 - a. Construction: TIA-492AAAB; 50 µm core diameter, 125 µm cladding diameter.
 - b. Minimum Overfilled Modal Bandwidth-Length Product: 500 MHz-km at 850 nm wavelength; 500 MHz-km at 1300 nm wavelength.
 5. Options:
 - a. Configuration: **[4][6][8][12][24][48]<Insert number>**-fiber, tight buffer, optical fiber cable.
 - b. Maximum Attenuation: **[3.50 dB/km]<Insert dB/km>** at 850 nm wavelength; **[1.5 dB/km]<Insert dB/km>** at 1300 nm wavelength.
 - c. Jacket Color: **[Orange]<Insert color>**.
 - d. Armor: **[Steel][Aluminum]**.
- D. Types OFC and OFCG, Designation OS1, Inside-Outside Plant, Single-Mode Optical Fiber Cable :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[General Cable; Prysmian Group North America]**
 - b. **[Mohawk; a division of Belden Networking, Inc.]**
 - c. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[General Cable; Prysmian Group North America]**
 - b. **[Mohawk; a division of Belden Networking, Inc.]**
 - c. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - d. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain products from single manufacturer.
 4. Additional Characteristics:
 - a. Construction: TIA-492CAAA; 9 µm core diameter, 125 µm cladding diameter.
 - b. Minimum Overfilled Modal Bandwidth-Length Product: 500 MHz-km at 850 nm wavelength; 500 MHz-km at 1300 nm wavelength.
 5. Options:
 - a. Configuration:
 - 1) **[6][8][12]**-fiber, single loose tube, optical fiber cable.
 - 2) **[24][36][48][72][96][144]**-fiber, stranded loose tube, optical fiber cable.
 - b. Maximum Attenuation: **[0.5 dB/km]<Insert dB/km>** at 1310 nm wavelength; **[0.5 dB/km]<Insert dB/km>** at 1550 nm wavelength.

- c. Jacket Color: [Yellow]<Insert color>.
- d. Armor: [Steel][Aluminum].

E. Types OFC and OFCG, Designation OS2, Inside-Outside Plant, Single-Mode Optical Fiber Cable :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. [Berk-Tek, a Leviton Company]
 - b. [CommScope, Inc]
 - c. [Hitachi Cable America Inc.]
 - d. [Mohawk; a division of Belden Networking, Inc.]
 - e. [Superior Essex Inc.; subsidiary of LS Corp.]
 - f. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Berk-Tek, a Leviton Company]
 - b. [CommScope, Inc]
 - c. [Hitachi Cable America Inc.]
 - d. [Mohawk; a division of Belden Networking, Inc.]
 - e. [Superior Essex Inc.; subsidiary of LS Corp.]
 - f. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Additional Characteristics:
 - a. Construction: TIA-492CAAB; 9 µm core diameter, 125 µm cladding diameter, with low water peak.
 - b. Minimum Overfilled Modal Bandwidth-Length Product: 500 MHz-km at 850 nm wavelength; 500 MHz-km at 1300 nm wavelength.
5. Options:
 - a. Configuration:
 - 1) [6][8][12]-fiber, single loose tube, optical fiber cable.
 - 2) [24][36][48][72][96][144]-fiber, stranded loose tube, optical fiber cable.
 - b. Maximum Attenuation: [0.5 dB/km]<Insert dB/km> at 1310 nm wavelength; [0.5 dB/km]<Insert dB/km> at 1550 nm wavelength.
 - c. Jacket Color: [Yellow]<Insert color>.
 - d. Armor: [Steel][Aluminum].

F. Types OFC and OFCG, Designation OS1, Inside Plant, Single-Mode Optical Fiber Cable :

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

- a. [CommScope, Inc]
 - b. [General Cable; Prysmian Group North America]
 - c. [Hitachi Cable America Inc.]
 - d. [Mohawk; a division of Belden Networking, Inc.]
 - e. [Superior Essex Inc.; subsidiary of LS Corp.]
 - f. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [CommScope, Inc]
 - b. [General Cable; Prysmian Group North America]
 - c. [Hitachi Cable America Inc.]
 - d. [Mohawk; a division of Belden Networking, Inc.]
 - e. [Superior Essex Inc.; subsidiary of LS Corp.]
 - f. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Additional Characteristics:
 - a. Construction: TIA-492CAAA; 9 µm core diameter, 125 µm cladding diameter.
 - b. Minimum Overfilled Modal Bandwidth-Length Product: 500 MHz-km at 850 nm wavelength; 500 MHz-km at 1300 nm wavelength.
5. Options:
 - a. Configuration: [6][8][12][24][36][48][72][96][144] fibers, tight buffered, optical fiber cable.
 - b. Maximum Attenuation: [1.0 dB/km]<Insert dB/km> at 1310 nm wavelength; [1.0 dB/km]<Insert dB/km> at 1550 nm wavelength.
 - c. Jacket Color: [Yellow]<Insert color>.
 - d. Armor: [Steel][Aluminum].

2.7 OPTICAL FIBER CABLE HARDWARE

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 1. [American Technology Systems Industries, Inc]
 2. [Belden Inc.]
 3. [Berk-Tek, a Leviton Company]
 4. [CommScope, Inc]
 5. [Corning Optical Communications; Corning Incorporated]
 6. [Dynamac Corporation]
 7. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 8. [Molex Premise Networks]
 9. [Optical Cable Corporation (OCC)]
 10. [Siemon Co. (The)]
 11. [Stewart Connector, a Bel group company; Bel Fuse Inc.]
 12. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [American Technology Systems Industries, Inc]
2. [Belden Inc.]
3. [Berk-Tek, a Leviton Company]
4. [CommScope, Inc]
5. [Corning Optical Communications; Corning Incorporated]
6. [Dynacom Corporation]
7. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
8. [Molex Premise Networks]
9. [Optical Cable Corporation (OCC)]
10. [Siemon Co. (The)]
11. [Stewart Connector, a Bel group company; Bel Fuse Inc.]
12. <Insert manufacturer's name>

C. Performance Criteria:

1. Fiber Optic Connector Intermateability Standard (FOCIS) specifications of TIA-604 series.
2. TIA-568.3.

D. Cross-Connects and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.

1. Number of Connectors per Field: **[One]<Insert number>** for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to suit specified expansion criteria.

E. Patch Cords: Factory-made, dual-fiber cables in **36 inch (900 mm)** lengths.

F. Connector Type: **[Type SC complying with TIA-604-3,][Type ST complying with TIA-604-2,][Type LC complying with TIA-604-10,][Type MT-RJ complying with TIA-604-12,][Type MPO complying with TIA-604-5,]<Insert type>** connectors.

G. Plugs and Plug Assemblies:

1. Male; color-coded modular telecommunications connector designed for termination of single optical fiber cable.
2. Insertion loss not more than **[0.25][0.75]<Insert number>** dB.
3. Marked to indicate transmission performance.

H. Jacks and Jack Assemblies:

1. Female; quick-connect, simplex and duplex; fixed telecommunications connector designed for termination of single optical fiber cable.
2. Insertion loss not more than **[0.25][0.75]<Insert number>** dB.
3. Marked to indicate transmission performance.
4. Designed to snap-in to patch panel or faceplate.

2.8 SOURCE QUALITY CONTROL

- A. Owner will witness required factory tests. Notify Architect at least 14 days before date of tests and indicate their approximate duration.
- B. Testing Adminstrant: **[Owner will engage][Engage]** qualified testing agency to evaluate cables.
- C. Factory Tests and Inspections:

1. Test and inspect multimode optical fiber cables, by, or under supervision of, qualified electrical testing laboratory recognized by authorities having jurisdiction, in accordance with TIA-526-14 and TIA-568.3 before delivering to site. Affix label with name and date of **[manufacturer's][qualified electrical testing laboratory's]** certification of system compliance.
 2. Test and inspect pre-terminated optical fiber cable assemblies, by, or under supervision of, qualified electrical testing laboratory recognized by authorities having jurisdiction, in accordance with TIA-526-14 and TIA-568.3 before delivering to site. Affix label with name and date of **[manufacturer's][qualified electrical testing laboratory's]** certification of system compliance.
- D. Nonconforming Work:
1. Cables that do not pass tests and inspections will be considered defective.
- E. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Coordinate backbone cabling with protectors and demarcation point provided by communications service provider.

3.2 SELECTION OF OPTICAL FIBER TYPE

- A. Installed in Vertical Shaft or Floor-to-Floor Riser:
1. Nonconductive:
 - a. **[Type OFNR][or][Type OFNP][in listed plenum communications raceway].**
 - b. **[Type OFN][Type OFNG][Type OFNR][or][Type OFNP]** in metallic conduit.
 2. Conductive:
 - a. **[Type OFCR][or][Type OFCP][in listed plenum communications raceway].**
 - b. **[Type OFC][Type OFCG][Type OFCR][or][Type OFCP]** in metallic conduit.
- B. Installed in Plenum, Duct, or Other Space Handling Environmental Air:
1. Nonconductive:
 - a. **Type OFNP[in listed plenum communications raceway].**
 - b. **[Type OFN][Type OFNG][Type OFNR][or][Type OFNP]** in metallic conduit.
 2. Conductive:
 - a. **Type OFCP[in listed plenum communications raceway].**
 - b. **[Type OFC][Type OFCG][Type OFCR][or][Type OFCP]** in metallic conduit.
- C. Installed in Location Other Than Riser or Plenum:
1. Nonconductive: **[Type OFN][Type OFNG][Type OFNR][or][Type OFNP]** in metallic conduit.
 2. Conductive: **[Type OFC][Type OFCG][Type OFCR][or][Type OFCP]** in metallic conduit.

3.3 INSTALLATION OF OPTICAL FIBER BACKBONE CABLES

- A. Optical fiber backbone cabling system must provide interconnections between communications equipment rooms, main terminal space, and entrance facilities in telecommunications cabling system structure. Cabling system consists of backbone cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for backbone-to-backbone cross-connection.
- B. Backbone cabling cross-connects may be located in communications equipment rooms or at entrance facilities. Bridged taps and splitters may not be used as part of backbone cabling.
- C. Comply with BICSI N1, NECA NEIS 1, and NECA NEIS 301.
- D. Backbone cabling system must comply with transmission standards in TIA-568.1.
- E. Telecommunications Pathways and Spaces: Comply with TIA-569.
- F. Wiring Methods:
 - 1. Not in Raceway: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
 - 2. In Raceway: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters[**and except in accessible ceiling spaces, in attics, and in gypsum board partitions where unenclosed wiring method may be used**]. Conceal raceway and cables except in unfinished spaces.
 - a. Install plenum cable in environmental airspaces, including plenum ceilings.
 - b. Comply with requirements for pathways specified in Section 270528 "Pathways for Communications Systems."
 - 3. In Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.
- G. Optical Fiber Cabling Installation:
 - 1. Comply with TIA-568.1 and TIA-568.3.
 - 2. Comply with BICSI ITSIMM, Ch. 6, "Cable Termination Practices."
 - 3. Terminate all cables; no cable may contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
 - 4. Cables may not be spliced. Secure and support cables at intervals not exceeding **30 inch (760 mm)** and not more than **6 inch (150 mm)** from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
 - 5. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
 - 6. Bundle, lace, and train cable to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, "Cabling Termination Practices" Chapter. Use lacing bars and distribution spools.
 - 7. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
 - 8. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps may not be used for heating.
 - 9. In communications equipment room, provide **10 ft (3 m)** long service loop on each end of cable.
 - 10. Pulling Cable: Comply with BICSI ITSIMM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
 - 11. Cable may be terminated on connecting hardware that is rack or cabinet mounted.

H. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Cable may not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

I. Installation of Cable Exposed under Raised Floors:

1. Install plenum-rated cable only.
2. Install cabling after flooring system has been installed in raised floor areas.
3. Coil cable [6 ft (1.8 m)]<Insert size> long not less than [12 inch (300 mm)]<Insert size> in diameter below each feed point.

J. Group connecting hardware for cables into separate logical fields.

3.4 FIRESTOPPING

- A. Comply with requirements in Section 078413 "Penetration Firestopping."
- B. Comply with TIA-569, Annex A, "Firestopping."
- C. Comply with BICSI ITSIMM, "Firestopping" Chapter.

3.5 GROUNDING

- A. Install grounding in accordance with BICSI ITSIMM, "Grounding (Earthing), Bonding, and Electrical Protection" Chapter.
- B. Comply with TIA-607 and NECA/BICSI-607.
- C. Locate grounding bus bar to minimize length of bonding conductors. Fasten to wall allowing at least **2 inch (50 mm)** clearance behind grounding bus bar. Connect grounding bus bar with minimum 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.
- D. Bond metallic equipment to grounding bus bar, using not smaller than 6 AWG equipment grounding conductor.

3.6 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with TIA-606. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
 1. Administration Class: **[Class 1][Class 2][Class 3][Class 4]**.
 2. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.
- B. Paint and label colors for equipment identification must comply with TIA-606 for **[Class 2][Class 3][Class 4]** level of administration **[including optional identification requirements of this standard]**.
- C. Comply with requirements in Section 271523 "Communications Optical Fiber Horizontal Cabling" for cable and asset management software.



- D. Cable Schedule: Install in prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish electronic copy of final comprehensive schedules for Project.
- E. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, **[backbone pathways and cables],[entrance pathways and cables,]** terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.
- F. Cable and Wire Identification:
 - 1. Label each cable within **4 inch (100 mm)** of each termination and tap, where it is accessible in cabinet or junction or outlet box, and elsewhere as indicated.
 - 2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
 - 3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding **15 ft (4.5 m)**.
 - 4. Label each unit and field within distribution racks and frames.
 - 5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use different color for jacks and plugs of each service.
- G. Labels must be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA 606, for the following:
 - 1. Flexible vinyl or polyester that flexes as cables are bent.

3.7 FIELD QUALITY CONTROL

- A. Acceptance Testing Preparation:
 - 1. **<Insert requirements>**.
- B. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.
- C. Tests and Inspections:
 - 1. Visually inspect optical fiber jacket materials for qualified electrical testing laboratory certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA-568.1.
 - 2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
 - 3. Optical Fiber Cable Tests:
 - a. Test instruments must meet or exceed applicable requirements in TIA-568.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
 - b. Link End-to-End Attenuation Tests:
 - 1) Horizontal and multimode backbone link measurements: Test at 850 or 1300 nm in one direction in accordance with TIA-526-14, Method B, One Reference Jumper.

- 2) Attenuation test results for backbone links must be less than 2.0 dB. Attenuation test results must be less than those calculated in accordance with equation in TIA-568.1.

D. Nonconforming Work:

1. Cables will be considered defective if they do not pass tests and inspections.
2. Remove and replace defective cables and retest.

E. Collect, assemble, and submit test and inspection reports.

1. Data for each measurement must be documented.
2. Data for field quality-control report submittals must be printed in summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from instrument to computer, saved as text files, and printed and submitted.

F. Manufacturer Services:

1. Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.

3.8 MAINTENANCE

A. Software Service Agreement:

1. Technical Support: Beginning at Substantial Completion, verify that software service agreement includes software support for **[two]<Insert number>** years.
2. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within **[two]<Insert number>** years from date of Substantial Completion. **[Verify that upgrading software includes operating system and new or revised licenses for using software.]**
 - a. Upgrade Notice: No fewer than **[30]<Insert number>** days to allow Owner to schedule and access the system **[and to upgrade computer equipment if necessary.]**
3. Upgrade Reports: Prepare report after each update, documenting upgrades installed.

END OF SECTION 27 13 23 00



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Task	Specification	Specification Description
27 13 23 13	27 13 23 00	Communications Optical Fiber Backbone Cabling



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SECTION 27 15 13 00 - COMMUNICATIONS COPPER HORIZONTAL CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Category 3 twisted pair cable.
2. Category 5e twisted pair cable.
3. Category 6 twisted pair cable.
4. Category 6a twisted pair cable.
5. Category 7 twisted pair cable.
6. Twisted pair cable hardware.
7. Multiuser telecommunications outlet assembly (MUTOA).
8. Cable management system.
9. Identification products.

B. Related Requirements:

1. Section 270513 "Conductors and Cables for Communications Systems" for data cabling associated with system panels and devices.

1.2 DEFINITIONS

- A. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.
- B. EMI: Electromagnetic interference.
- C. FTP: Shielded twisted pair.
- D. F/FTP: Overall foil screened cable with foil screened twisted pair.
- E. F/UTP: Overall foil screened cable with unscreened twisted pair.
- F. IDC: Insulation displacement connector.
- G. Jack: Also commonly called an "outlet," it is the fixed, female connector.
- H. LAN: Local area network.
- I. Plug: Also commonly called a "connector," it is the removable, male telecommunications connector.
- J. RCDD: Registered Communications Distribution Designer.
- K. Screen: A metallic layer, either a foil or braid, placed around a pair or group of conductors.
- L. Shield: A metallic layer, either a foil or braid, placed around a pair or group of conductors.
- M. S/FTP: Overall braid screened cable with foil screened twisted pair.

- N. S/UTP: Overall braid screened cable with unscreened twisted pairs.
- O. UTP: Unscreened (unshielded) twisted pair.

1.3 COPPER HORIZONTAL CABLING DESCRIPTION

- A. Horizontal cable cabling system shall provide interconnections between Distributor A, Distributor B, or Distributor C, and the equipment outlet, otherwise known as "Cabling Subsystem 1," in the telecommunications cabling system structure. Cabling system consists of horizontal cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for horizontal-to-horizontal cross-connection.
 - 1. TIA-568-C.1 requires that a minimum of two equipment outlets be installed for each work area.
 - 2. Horizontal cabling shall contain no more than one transition point or consolidation point between the horizontal cross-connect and the telecommunications equipment outlet.
 - 3. Bridged taps and splices shall not be installed in the horizontal cabling.
- B. A work area is approximately **100 sq. ft. (9.3 sq. m)**, and includes the components that extend from the equipment outlets to the station equipment.
- C. The maximum allowable horizontal cable length is **295 feet (90 m)**. This maximum allowable length does not include an allowance for the length of **16 feet (4.9 m)** to the workstation equipment or in the horizontal cross-connect.

1.4 ACTION SUBMITTALS

- A. Product Data:
 - 1. Category 3 twisted pair cable.
 - 2. Category 5e twisted pair cable.
 - 3. Category 6 twisted pair cable.
 - 4. Category 6a twisted pair cable.
 - 5. Category 7 twisted pair cable.
 - 6. Twisted pair cable hardware.
 - 7. Multiuser telecommunications outlet assembly (MUTOA).
 - 8. Cable management system.
 - 9. Identification products.
- B. Shop Drawings: Reviewed and stamped by RCDD.
 - 1. System Labeling Schedules:
 - a. Electronic copy of labeling schedules, in software and format selected by Owner.
 - b. Electronic copy of labeling schedules that are part of cabling and asset identification system of software.
 - 2. Cabling administration Drawings and printouts.
 - 3. Wiring diagrams and installation details of telecommunications equipment, to show location and layout of telecommunications equipment, including the following:
 - a. Telecommunications rooms plans and elevations.
 - b. Telecommunications pathways.

- c. Telecommunications system access points.
 - d. Telecommunications grounding system.
 - e. Telecommunications conductor drop locations.
 - f. Typical telecommunications details.
 - g. Mechanical, electrical, and plumbing systems.
- C. Twisted pair cable testing plan.
- D. Sustainable Design Submittals:
 - 1. Product Data: For each conductor and cable indicating lead content.
 - 2. Environmental Product Declaration: For each product.
 - 3. Health Product Declaration: For each product.
 - 4. Sourcing of Raw Materials: Corporate sustainability report for each manufacturer.
 - 5. Environmental Product Declaration: For each product.
 - 6. Environmental Product Declaration: For each product.
 - 7. Environmental Product Declaration: For each product.
 - 8. Third-Party Certifications: For each product.
 - 9. Third-Party Certified Life Cycle Assessment: For each product.
- E. Samples: For telecommunications jacks and plugs, **[in specified finish, one for each type and configuration][and cover plates for color selection and evaluation of technical features]**.
- F. Field quality-control reports.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For **[RCDD,][Installer,]**installation supervisor, and field inspector.
- B. Product Certificates: For each type of product.
- C. Source quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For splices and connectors to include in maintenance manuals.
- B. Software and Firmware Operational Documentation:
 - 1. Software operating and upgrade manuals.
 - 2. Program Software Backup: On USB media or compact disk, complete with data files.
 - 3. Device address list.
 - 4. Printout of software application and graphic screens.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Connecting Blocks: **[One]<Insert number>** of each type.
 - 2. Cover Plates: **[One]<Insert number>** of each type.
 - 3. Jacks: **[Ten]<Insert number>** of each type.



4. Multiuser Telecommunications Outlet Assemblies: **[One]<Insert number>** of each type.
5. Patch-Panel Units: **[One]<Insert number>** of each type.
6. Plugs: **[Ten]<Insert number>** of each type.

1.8 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
 1. Layout Responsibility: Preparation of Shop Drawings[**and cabling administration Drawings**][, **cabling administration Drawings, and field testing program development**] by an RCDD.
 2. Installation Supervision: Installation shall be under the direct supervision of **[Technician][Level 2 Installer]**, who shall be present at all times when Work of this Section is performed at Project site.
 3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.
- B. Testing Agency Qualifications: Testing agency must have personnel certified by BICSI on staff.
 1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Test cables upon receipt at Project site.
 1. Test each pair of twisted pair cable for open and short circuits.

1.10 PROJECT CONDITIONS

- A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.11 COORDINATION

- A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. General Performance: Horizontal cabling system shall comply with transmission standards in TIA-568-C.1, when tested according to test procedures of this standard.
- B. Telecommunications Pathways and Spaces: Comply with TIA-569-D.
- C. Grounding: Comply with TIA-607-B.

2.2 GENERAL CABLE CHARACTERISTICS

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with the applicable standard and NFPA 70 for the following types:
 - 1. Communications, Plenum Rated:
 - a. Type CMP complying with UL 1685[**or Type CMP in listed plenum communications raceway**][**or Type CMP in listed cable routing assembly**].
 - b. Type CM, Type CMG, Type CMP, Type CMR, or Type CMX in metallic conduit installed according to NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
 - 2. Communications, Non-Plenum Rated:
 - a. Type CMR complying with UL 1666[**and ICEA S-103-701**].
 - b. Type CMP or Type CMR in listed plenum or riser communications raceway.
 - c. Type CMP or Type CMR in metallic conduit installed according to NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
- B. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1. Flame-Spread Index: **[25]<Insert value>** or less.
 - 2. Smoke-Developed Index: **[50][450]<Insert value>** or less.
- C. RoHS compliant.

2.3 CATEGORY 3 TWISTED PAIR CABLE

- A. Category 3 Twisted Pair Cable: Four-pair, balanced twisted pair cable, certified to meet transmission characteristics of Category 3 cable at frequencies up to 16 MHz.
- B. Manufacturers: Subject to compliance with requirements, [**provide products by the following**][**provide products by one of the following**][**available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following**]:
 - 1. **[Hitachi Cable America Inc.]**
 - 2. **[Mohawk; a division of Belden Networking, Inc.]**
 - 3. **<Insert manufacturer's name>**
- C. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Hitachi Cable America Inc.]**
 - 2. **[Mohawk; a division of Belden Networking, Inc.]**
 - 3. **<Insert manufacturer's name>**
- D. Standard: Comply with ICEA S-90-661, NEMA WC 63.1, and TIA-568-C.2 for Category 3 cables.
- E. Conductors: 100-ohm, 24 AWG solid copper.
 - 1. Lead Content: Less than 300 parts per million.

- F. Shielding/Screening: **[Unshielded twisted pairs (UTP)][Shielded twisted pairs (FTP)][Screened twisted pairs (F/UTP)][Screened and shielded twisted pairs (F/FTP)].**
- G. Cable Rating: **[Riser][Plenum].**
- H. Jacket: **[White][Gray][Blue][Yellow][Orange][Pink][Green][Red][Black][Brown][Beige][Mauve]<Insert color> thermoplastic.**

2.4 CATEGORY 5e TWISTED PAIR CABLE

- A. Category 5e Twisted Pair Cable: Four-pair, balanced twisted pair cable, certified to meet transmission characteristics of Category 5e cable at frequencies up to 100 MHz.
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1. **[AMP NETCONNECT; a TE Connectivity Ltd. company]**
 - 2. **[Belden Inc.]**
 - 3. **[Berk-Tek, a Leviton Company]**
 - 4. **[CommScope, Inc]**
 - 5. **[General Cable; Prysmian Group North America]**
 - 6. **[Hitachi Cable America Inc.]**
 - 7. **[Mohawk; a division of Belden Networking, Inc.]**
 - 8. **[West Penn Wire; brand of Belden, Inc.]**
 - 9. **<Insert manufacturer's name>**
- C. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[AMP NETCONNECT; a TE Connectivity Ltd. company]**
 - 2. **[Belden Inc.]**
 - 3. **[Berk-Tek, a Leviton Company]**
 - 4. **[CommScope, Inc]**
 - 5. **[General Cable; Prysmian Group North America]**
 - 6. **[Hitachi Cable America Inc.]**
 - 7. **[Mohawk; a division of Belden Networking, Inc.]**
 - 8. **[West Penn Wire; brand of Belden, Inc.]**
 - 9. **<Insert manufacturer's name>**
- D. Standard: Comply with ICEA S-90-661, NEMA WC 63.1, and TIA-568-C.2 for Category 5e cables.
- E. Conductors: 100-ohm, 24 AWG solid copper.
 - 1. Lead Content: Less than 300 parts per million.
- F. Shielding/Screening: **[Unshielded twisted pairs (UTP)][Shielded twisted pairs (FTP)][Screened twisted pairs (F/UTP)][Screened and shielded twisted pairs (F/FTP)].**
- G. Cable Rating: **[Riser][Plenum].**
- H. Jacket: **[White][Gray]<Insert color> thermoplastic.**

2.5 CATEGORY 6 TWISTED PAIR CABLE

- A. Category 6 Twisted Pair Cable: Four-pair, balanced -twisted pair cable,[**with internal spline,**] certified to meet transmission characteristics of Category 6 cable at frequencies up to 250 MHz.
- B. Manufacturers: Subject to compliance with requirements, [**provide products by the following**][**provide products by one of the following**][**available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following**]:
1. [3M]
 2. [AMP NETCONNECT; a TE Connectivity Ltd. company]
 3. [Belden Inc.]
 4. [Berk-Tek, a Leviton Company]
 5. [CommScope, Inc]
 6. [General Cable; Prysmian Group North America]
 7. [Genesis; Resideo Technologies, Inc.]
 8. [Hitachi Cable America Inc.]
 9. [Mohawk; a division of Belden Networking, Inc.]
 10. [Prysmian Cables and Systems; Prysmian Group North America]
 11. [Superior Essex Inc.; subsidiary of LS Corp.]
 12. <Insert manufacturer's name>
- C. Basis-of-Design Product: Subject to compliance with requirements, provide <**Insert manufacturer's name; product name or designation**> or comparable product by one of the following:
1. [3M]
 2. [AMP NETCONNECT; a TE Connectivity Ltd. company]
 3. [Belden Inc.]
 4. [Berk-Tek, a Leviton Company]
 5. [CommScope, Inc]
 6. [General Cable; Prysmian Group North America]
 7. [Genesis; Resideo Technologies, Inc.]
 8. [Hitachi Cable America Inc.]
 9. [Mohawk; a division of Belden Networking, Inc.]
 10. [Prysmian Cables and Systems; Prysmian Group North America]
 11. [Superior Essex Inc.; subsidiary of LS Corp.]
 12. <Insert manufacturer's name>
- D. Standard: Comply with NEMA WC 66/ICEA S-116-732 and TIA-568-C.2 for Category 6 cables.
- E. Conductors: 100-ohm, 23 AWG solid copper.
1. Lead Content: Less than 300 parts per million.
- F. Shielding/Screening: [**Unshielded twisted pairs (UTP)**][**Shielded twisted pairs (FTP)**][**Screened twisted pairs (F/UTP)**][**Screened and shielded twisted pairs (F/FTP)**].
- G. Cable Rating: [**Riser**][**Plenum**].
- H. Jacket: [**White**][**Gray**][**Blue**][**Yellow**]<**Insert color**> thermoplastic.

2.6 CATEGORY 6a TWISTED PAIR CABLE

- A. Category 6a Twisted Pair Cable: Four-pair, balanced twisted pair cable,[**with internal spline,**] certified to meet transmission characteristics of Category 6a cable at frequencies up to 500 MHz.



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

1. **[3M]**
2. **[AMP NETCONNECT; a TE Connectivity Ltd. company]**
3. **[Belden Inc.]**
4. **[Berk-Tek, a Leviton Company]**
5. **[CommScope, Inc]**
6. **[General Cable; Prysmian Group North America]**
7. **[Genesis; Resideo Technologies, Inc.]**
8. **[Hitachi Cable America Inc.]**
9. **[Mohawk; a division of Belden Networking, Inc.]**
10. **[Prysmian Cables and Systems; Prysmian Group North America]**
11. **[Superior Essex Inc.; subsidiary of LS Corp.]**
12. **<Insert manufacturer's name>**

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

1. **[3M]**
2. **[AMP NETCONNECT; a TE Connectivity Ltd. company]**
3. **[Belden Inc.]**
4. **[Berk-Tek, a Leviton Company]**
5. **[CommScope, Inc]**
6. **[General Cable; Prysmian Group North America]**
7. **[Genesis; Resideo Technologies, Inc.]**
8. **[Hitachi Cable America Inc.]**
9. **[Mohawk; a division of Belden Networking, Inc.]**
10. **[Prysmian Cables and Systems; Prysmian Group North America]**
11. **[Superior Essex Inc.; subsidiary of LS Corp.]**
12. **<Insert manufacturer's name>**

- D. Standard: Comply with TIA-568-C.2 for Category 6a cables.

- E. Conductors: 100-ohm, 23 AWG solid copper.

1. Lead Content: Less than 300 parts per million.

- F. Shielding/Screening: **[Unshielded twisted pairs (UTP)][Shielded twisted pairs (FTP)][Screened twisted pairs (F/UTP)][Screened and shielded twisted pairs (F/FTP)]**.

- G. Cable Rating: **[Riser][Plenum]**.

- H. Jacket: **[White][Gray][Blue][Yellow]<Insert color>** thermoplastic.

2.7 CATEGORY 7 TWISTED PAIR CABLE

- A. Category 7 Twisted Pair Cable: Four-pair, balanced twisted pair cable, **[with internal spline,]** certified to meet transmission characteristics of Category 7 cable at frequencies up to 600 MHz.

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

1. [Hitachi Cable America Inc.]
 2. [Siemon Co. (The)]
 3. <Insert manufacturer's name>
- C. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [Hitachi Cable America Inc.]
 2. [Siemon Co. (The)]
 3. <Insert manufacturer's name>
- D. Standard: Comply with ISO 11801, Category F.
- E. Conductors: 100-ohm, 22 AWG solid copper.
1. Lead Content: Less than 300 parts per million.
- F. Shielding/Screening: Overall [foil shield with foil shielded twisted pairs (F/FTP)][braided shield with foil shielded twisted pairs (S/FTP)].
- G. Cable Rating: [Riser][Plenum].
- H. Jacket: [White][Gray][Blue][Yellow]<Insert color> thermoplastic.

2.8 TWISTED PAIR CABLE HARDWARE

- A. Twisted Pair Cable Hardware: Hardware designed to connect, splice, and terminate twisted pair copper communications cable.
- B. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
1. [3M]
 2. [American Technology Systems Industries, Inc]
 3. [AMP NETCONNECT; a TE Connectivity Ltd. company]
 4. [Belden Inc.]
 5. [Berk-Tek, a Leviton Company]
 6. [CommScope, Inc]
 7. [DynaCom Corporation]
 8. [General Cable; Prysmian Group North America]
 9. [Genesis; Resideo Technologies, Inc.]
 10. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
 11. [Leviton Manufacturing Co., Inc.]
 12. [Mohawk; a division of Belden Networking, Inc.]
 13. [Molex Premise Networks]
 14. [Panduit Corp]
 15. [Prysmian Cables and Systems; Prysmian Group North America]
 16. [Siemon Co. (The)]
 17. [Superior Essex Inc.; subsidiary of LS Corp.]
 18. <Insert manufacturer's name>
- C. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [3M]
2. [American Technology Systems Industries, Inc]
3. [AMP NETCONNECT; a TE Connectivity Ltd. company]
4. [Belden Inc.]
5. [Berk-Tek, a Leviton Company]
6. [CommScope, Inc]
7. [Dynacom Corporation]
8. [General Cable; Prysmian Group North America]
9. [Genesis; Resideo Technologies, Inc.]
10. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
11. [Leviton Manufacturing Co., Inc.]
12. [Mohawk; a division of Belden Networking, Inc.]
13. [Molex Premise Networks]
14. [Panduit Corp]
15. [Prysmian Cables and Systems; Prysmian Group North America]
16. [Siemon Co. (The)]
17. [Superior Essex Inc.; subsidiary of LS Corp.]
18. <Insert manufacturer's name>

D. General Requirements for Twisted Pair Cable Hardware:

1. Comply with the performance requirements of [Category 5e][Category 6][Category 6a][Category 7].
2. Comply with TIA-568-C.2, IDC type, with modules designed for punch-down caps or tools.
3. Cables shall be terminated with connecting hardware of same category or higher.

E. Source Limitations: [Obtain twisted pair cable hardware from single source from single manufacturer.][Obtain twisted pair cable hardware from same manufacturer as twisted pair cable, from single source.]

F. Connecting Blocks:

1. 110-style IDC for Category 5e.
2. 66-style IDC for Category 5e.
3. 110-style IDC for Category 6.
4. 110-style IDC for Category 6a.
5. Provide blocks for the number of cables terminated on the block, plus [25]<Insert number> percent spare, integral with connector bodies, including plugs and jacks where indicated.

G. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.

1. Number of Terminals per Field: [One]<Insert number> for each conductor in assigned cables.

H. Patch Panel: Modular panels housing numbered jack units with IDC-type connectors at each jack location for permanent termination of pair groups of installed cables.

1. Features:

- a. Universal T568A and T568B wiring labels.
- b. Labeling areas adjacent to conductors.
- c. Replaceable connectors.
- d. 24 or 48 ports.

2. Construction: 16-gauge steel and mountable on 19-inch (483 mm) equipment racks.

3. Number of Jacks per Field: One for each four-pair **[cable indicated][conductor group of indicated cables, plus spares and blank positions adequate to suit specified expansion criteria]**.
 - I. Patch Cords: Factory-made, four-pair cables in **[36-inch (900-mm)][48-inch (1200-mm)]<Insert length>** lengths; terminated with an eight-position modular plug at each end.
 1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure performance. Patch cords shall have latch guards to protect against snagging.
 2. Patch cords shall have color-coded boots for circuit identification.
 - J. Plugs and Plug Assemblies:
 1. Male; eight position; color-coded modular telecommunications connector designed for termination of a single four-pair, 100-ohm, unshielded or shielded twisted pair cable.
 2. Standard: Comply with TIA-568-C.2.
 3. Marked to indicate transmission performance.
 - K. Jacks and Jack Assemblies:
 1. Female; eight position; modular; fixed telecommunications connector designed for termination of a single four-pair, 100-ohm, unshielded or shielded twisted pair cable.
 2. Designed to snap-in to a patch panel or cover plate.
 3. Standard: Comply with TIA-568-C.2.
 4. Marked to indicate transmission performance.
 - L. Cover Plate:
 1. **[Two][Four][Six]** port, vertical single gang cover plates designed to mount to single gang wall boxes.
 2. **[Eight][Ten][Twelve]** port, vertical double gang cover plates designed to mount to double gang wall boxes.
 3. Plastic Cover Plate: High-impact plastic. Coordinate color with Section 260533.16 "Boxes and Covers for Electrical Systems."
 4. Metal Cover Plate: **[Stainless steel][Brass]<Insert description>**, complying with requirements in Section 260533.16 "Boxes and Covers for Electrical Systems."
 5. For use with snap-in jacks accommodating any combination of twisted pair, optical fiber, and coaxial work area cords.
 - a. Flush mounting jacks, positioning the cord at a 45-degree angle.
 - M. Legend:
 1. Machine printed, in the field, using adhesive-tape label.
 2. Snap-in, clear-label covers and machine-printed paper inserts.
- 2.9 MULTIUSER TELECOMMUNICATIONS OUTLET ASSEMBLY (MUTOA)
- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 1. **[Belden Inc.]**
 2. **[Chatsworth Products, Inc.]**
 3. **[Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**



4. [Molex Premise Networks]
5. [Ortronics, Inc.]
6. [Panduit Corp]
7. [Siemon Co. (The)]
8. <Insert manufacturer's name>

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

1. [Belden Inc.]
2. [Chatsworth Products, Inc.]
3. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
4. [Molex Premise Networks]
5. [Ortronics, Inc.]
6. [Panduit Corp]
7. [Siemon Co. (The)]
8. <Insert manufacturer's name>

C. Description: MUTOAs shall meet the requirements of "Twisted Pair Cable Hardware" Article.

1. Number of Terminals per Field: [One]<Insert number> for each conductor in assigned cables.
2. Number of Connectors per Field:
 - a. [One]<Insert number> for each four-pair unshielded or shielded twisted pair cable indicated.
 - b. [One]<Insert number> for each four-pair unshielded or shielded twisted pair group of indicated cables, plus [25]<Insert number> percent spare positions.
3. Mounting: [Recessed in ceiling][Wall][Desk][Furniture].
4. NRTL listed as complying with UL 50 and UL 1863.
5. Label shall include maximum length of work area cords, based on TIA-568-C.1.
6. When installed in plenums used for environmental air, NRTL listed as complying with UL 2043.

2.10 CABLE MANAGEMENT SYSTEM

A. Cable Management System: Computer-based cable management system, with integrated database[**and graphic**] capabilities.

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

1. [iTRACS Corporation]
2. [Telsoft Solutions]
3. <Insert manufacturer's name>

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

1. [iTRACS Corporation]
2. [Telsoft Solutions]
3. <Insert manufacturer's name>

D. Document physical characteristics by recording the network, TIA details, and connections between

equipment and cable.

- E. Information shall be presented in database view[, **schematic plans, or technical drawings**].

1. **[Microsoft Visio Professional][or][AutoCAD]** drawing software shall be used as drawing and schematic plans software.

- F. System shall interface with the following testing and recording devices:

1. Direct upload tests from circuit testing instrument into the personal computer.
2. Direct download circuit labeling into labeling printer.

2.11 IDENTIFICATION PRODUCTS

- A. Comply with TIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.12 SOURCE QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to evaluate cables.
- B. Factory test cables on reels according to TIA-568-C.1.
- C. Factory test twisted pair cables according to TIA-568-C.2.
- D. Cable will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 WIRING METHODS

- A. Routing:
1. Install cables in raceways and cable trays, except within consoles, cabinets, desks, and counters[**and except in accessible ceiling spaces, attics, and gypsum board partitions where unenclosed wiring method may be used**]. Conceal raceway and cables, except in unfinished spaces.
 - a. Install plenum cable in environmental air spaces, including plenum ceilings.
 - b. Comply with requirements for raceways and boxes specified in Section 270528 "Pathways for Communications Systems."
 2. Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- B. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools. Install conductors parallel with or at right angles to sides and back of enclosure.

3.2 INSTALLATION OF PATHWAYS

- A. Comply with requirements for demarcation point, cabinets, and racks specified in Section 271100 "Communications Equipment Room Fittings."
- B. Comply with Section 270528 "Pathways for Communications Systems."
- C. Comply with Section 260529 "Hangers and Supports for Electrical Systems."
- D. Comply with Section 260536 "Cable Trays for Electrical Systems."
- E. Drawings indicate general arrangement of pathways and fittings.

3.3 INSTALLATION OF TWISTED PAIR HORIZONTAL CABLES

- A. Comply with NECA 1 and NECA/BICSI 568.
- B. General Requirements for Cabling:
 - 1. Comply with TIA-568-C.0, TIA-568-C.1, and TIA-568-C.2.
 - 2. Comply with BICSI's "Information Transport Systems Installation Methods Manual (ITSIMM), Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section.
 - 3. Install 110-style IDC termination hardware unless otherwise indicated.
 - 4. Do not untwist twisted pair cables more than **1/2 inch (12 mm)** from the point of termination to maintain cable geometry.
 - 5. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
 - 6. MUTOA shall not be used as a cross-connect point.
 - 7. Consolidation points may be used only for making a direct connection to equipment outlets:
 - a. Do not use consolidation point as a cross-connect point, as a patch connection, or for direct connection to workstation equipment.
 - b. Locate consolidation points for twisted pair cables at least **49 feet (15 m)** from communications equipment room.
 - 8. Cables may not be spliced. Secure and support cables at intervals not exceeding **30 inches (760 mm)** and not more than **6 inches (150 mm)** from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
 - 9. Install lacing bars to restrain cables, prevent straining connections, and prevent bending cables to smaller radii than minimums recommended by manufacturer.
 - 10. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI Information Transport Systems Installation Methods Manual, Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section. Use lacing bars and distribution spools.
 - 11. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation, and replace it with new cable.
 - 12. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
 - 13. In the communications equipment room, install a **10-foot- (3-m-)** long service loop on each end of cable.
 - 14. Pulling Cable: Comply with BICSI Information Transport Systems Installation Methods Manual, Ch. 5, "Copper Structured Cabling Systems," "Pulling and Installing Cable" Section. Monitor cable pull tensions.

C. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend twisted pair cabling, not in a wireway or pathway, a minimum of **8 inches (200 mm)** above ceilings by cable supports not more than **[60 inches (1524 mm)]<Insert dimension>** apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

D. Installation of Cable Routed Exposed under Raised Floors:

1. Install plenum-rated cable only.
2. Install cabling after the flooring system has been installed in raised floor areas.
3. Coil cable **[6 feet (1800 mm)]<Insert size>** long not less than **[12 inches (300 mm)]<Insert size>** in diameter below each feed point.

E. Group connecting hardware for cables into separate logical fields.

F. Separation from EMI Sources:

1. Comply with recommendations from BICSI's "Telecommunications Distribution Methods Manual" and TIA-569-D for separating unshielded copper communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of **5 inches (127 mm)**.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of **12 inches (300 mm)**.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of **24 inches (600 mm)**.
3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of **2-1/2 inches (64 mm)**.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of **6 inches (150 mm)**.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of **12 inches (300 mm)**.
4. Separation between communications cables in grounded metallic raceways, power lines, and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of **3 inches (76 mm)**.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of **6 inches (150 mm)**.
5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of **48 inches (1200 mm)**.
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of **5 inches (127 mm)**.

3.4 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA-569-D, Annex A, "Firestopping."



- C. Comply with "Firestopping Systems" Article in BICSI's "Telecommunications Distribution Methods Manual."

3.5 GROUNDING

- A. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems" for grounding conductors and connectors.
- B. Install grounding according to the "Grounding, Bonding, and Electrical Protection" chapter in BICSI's "Telecommunications Distribution Methods Manual."
- C. Comply with TIA-607-B and NECA/BICSI-607.
- D. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall, allowing at least a **2-inch (50-mm)** clearance behind the grounding bus bar. Connect grounding bus bar to suitable electrical building ground, using a minimum No. 4 AWG grounding electrode conductor.
- E. Bond metallic equipment to the grounding bus bar, using not smaller than a No. 6 AWG equipment grounding conductor.

3.6 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
 - 1. Administration Class: **[Class 1][Class 2][Class 3][Class 4]**.
 - 2. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.
- B. Paint and label colors for equipment identification shall comply with TIA-606-B for **[Class 2][Class 3][Class 4]** level of administration[, **including optional identification requirements of this standard**].
- C. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.
- D. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.
- E. Cable and Wire Identification:
 - 1. Label each cable within **4 inches (100 mm)** of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
 - 2. Each wire connected to building-mounted devices is not required to be numbered at the device if wire color is consistent with associated wire connected and numbered within panel or cabinet.
 - 3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding **15 feet (4.5 m)**.
 - 4. Label each terminal strip, and screw terminal in each cabinet, rack, or panel.
 - a. Individually number wiring conductors connected to terminal strips, and identify each cable

- or wiring group, extended from a panel or cabinet to a building-mounted device, with the name and number of a particular device.
- b. Label each unit and field within distribution racks and frames.
- 5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and -connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.
- F. Labels shall be preprinted or computer-printed type, with a printing area and font color that contrast with cable jacket color but still comply with TIA-606-B requirements for the following:
 - 1. Cables use flexible vinyl or polyester that flexes as cables are bent.

3.7 FIELD QUALITY CONTROL

- A. Acceptance Testing Preparation:
 - 1. **<Insert requirements>.**
- B. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>.**
- C. Tests and Inspections:
 - 1. Visually inspect jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA-568-C.1.
 - 2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
 - 3. Test twisted pair cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.
 - a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
- D. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similarly to Table 10.1 in BICSI's "Telecommunications Distribution Methods Manual," or shall be transferred from the instrument to the computer, saved as text files, printed, and submitted.
- E. Nonconforming Work:
 - 1. End-to-end cabling will be considered defective if it does not pass tests and inspections.
 - 2. Remove and replace cabling where test results indicate that they do not comply with specified requirements.
- F. Collect, assemble, and submit test and inspection reports.
- G. Manufacturer Services:



1. Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.

3.8 MAINTENANCE

A. Software Service Agreement:

1. Technical Support: Beginning at Substantial Completion, verify that software service agreement includes software support for **[two]<Insert number>** years.
2. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within **[two]<Insert number>** years from date of Substantial Completion. **[Verify that upgrading software includes operating system and new or revised licenses for using software.]**
 - a. Upgrade Notice: No fewer than **[30]<Insert number>** days to allow Owner to schedule and access the system **[and to upgrade computer equipment if necessary].**
3. Upgrade Reports: Prepare report after each update, documenting upgrades installed.

END OF SECTION 27 15 13 00



Task	Specification	Specification Description
27 15 13 00	26 05 13 00	Medium-Voltage Cables
27 15 13 00	26 05 19 00	Low-Voltage Electrical Power Conductors and Cables
27 15 13 00	26 05 23 00	Control-Voltage Electrical Power Cables



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SECTION 27 15 23 00 - COMMUNICATIONS OPTICAL FIBER HORIZONTAL CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. 62.5/125-micrometer, multimode, optical fiber cable (OM1).
2. 50/125 micrometer, multimode, optical fiber cable (OM2).
3. 850 nanometer laser-optimized 50/125 micrometer multimode optical fiber cable (OM3).
4. 850 nanometer laser-optimized 50/125 micrometer multimode optical fiber cable (OM4).
5. 9/125 micrometer, single-mode, indoor-outdoor optical fiber cable (OS1).
6. 9/125 micrometer, single-mode, indoor-outdoor optical fiber cable (OS2).
7. Optical fiber cable hardware.
8. Cross-connects and patch panels.
9. Grounding.
10. Identification products.

1.2 DEFINITIONS

- A. BICSI: Building Industry Consulting Service International.
- B. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.
- C. RCDD: Registered Communications Distribution Designer.

1.3 OPTICAL FIBER HORIZONTAL CABLING DESCRIPTION

- A. Optical fiber horizontal cabling system is to provide interconnections between Distributor A, Distributor B, or Distributor C and the equipment outlet, otherwise known as "Cabling Subsystem 1" in the telecommunications cabling system structure. Cabling system consists of horizontal cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for horizontal-to-horizontal cross-connection.
1. TIA-568-C.1 requires that a minimum of two equipment outlets be installed for each work area.
 2. Horizontal cabling is to contain no more than one transition point or consolidation point between the horizontal cross-connect and the equipment outlet.
 3. Bridged taps and splices are not to be installed in the horizontal cabling.
- B. A work area is approximately **100 sq. ft. (9.3 sq. m)**, and includes the components that extend from the equipment outlets to the equipment.
- C. The maximum allowable horizontal cable length is **295 feet (90 m)**. This maximum allowable length does not include an allowance for the length of **16 feet (4.9 m)** to the workstation equipment or in the horizontal cross-connect.

1.4 ACTION SUBMITTALS

A. Product Data:

1. 62.5/125-micrometer, multimode, optical fiber cable (OM1).
2. 50/125 micrometer, multimode, optical fiber cable (OM2).
3. 850 nanometer laser-optimized 50/125 micrometer multimode optical fiber cable (OM3).
4. 850 nanometer laser-optimized 50/125 micrometer multimode optical fiber cable (OM4).
5. 9/125 micrometer, single-mode, indoor-outdoor optical fiber cable (OS1).
6. 9/125 micrometer, single-mode, indoor-outdoor optical fiber cable (OS2).
7. Optical fiber cable hardware.
8. Cross-connects and patch panels.
9. Grounding.
10. Identification products.

B. Shop Drawings: Reviewed and stamped by RCDD.

1. System Labeling Schedules:

- a. Electronic copy of labeling schedules, in software and format selected by Owner.
- b. Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.

2. Cabling administration Drawings and printouts.

3. Wiring diagrams and installation details of telecommunications equipment, to show location and layout of telecommunications equipment, including the following:

- a. Telecommunications rooms plans and elevations.
- b. Telecommunications pathways.
- c. Telecommunications system access points.
- d. Telecommunications grounding system.
- e. Telecommunications conductor drop locations.
- f. Typical telecommunications details.
- g. Mechanical, electrical, and plumbing systems.

C. Fiber optic cable testing plan.

D. Sustainable Design Submittals:

1. Environmental Product Declaration: For each product.
2. Health Product Declaration: For each product.
3. Sourcing of Raw Materials: Corporate sustainability report for each manufacturer.
4. Environmental Product Declaration: For each product.
5. Environmental Product Declaration: For each product.
6. Environmental Product Declaration: For each product.
7. Third-Party Certifications: For each product.
8. Third-Party Certified Life Cycle Assessment: For each product.

E. Samples: For telecommunications jacks and plugs, **[in specified finish, one for each type and configuration][and faceplates for color selection and evaluation of technical features]**.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For **[RCDD],[Installer]**, installation supervisor, and field inspector.

- B. Product Certificates: For each type of product.
- C. Source quality-control reports.
- D. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Software and Firmware Operational Documentation:
 - 1. Software operating and upgrade manuals.
 - 2. Program Software Backup: On USB media or compact disk, complete with data files.
 - 3. Device address list.
 - 4. Printout of software application and graphic screens.
- B. Maintenance Data: For optical fiber cable, splices, and connectors to include in maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Connecting Blocks: **[One]<Insert number>** of each type.
 - 2. Jacks: **[Ten]<Insert number>** of each type.
 - 3. Patch-Panel Units: **[One]<Insert number>** of each type.
 - 4. Plugs: **[Ten]<Insert number>** of each type.

1.8 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
 - 1. Layout Responsibility: Preparation of Shop Drawings[**and Cabling Administration Drawings**][, **Cabling Administration Drawings, and field testing program development**] by an **[RCDD][Technician]**.
 - 2. Installation Supervision: Installation is to be under the direct supervision of **[Technician][Level 2 Installer]**, who is to be present at all times when Work of this Section is performed at Project site.
 - 3. Testing Supervisor: Currently certified by BICSI as an **[RCDD][Technician]**.
- B. Testing Agency Qualifications: Testing agency must have personnel certified by BICSI on staff.
 - 1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Test cables upon receipt at Project site.
 - 1. Test optical fiber cable to determine the continuity of the strand end to end. Use **[optical fiber flashlight][or][optical loss test set]<Insert test instrument>**.
 - 2. Test optical fiber cable while on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector, including the loss value of each.

Retain test data and include the record in maintenance data.

1.10 PROJECT CONDITIONS

- A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.11 COORDINATION

- A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications equipment and service suppliers.

1.12 SOFTWARE SERVICE AGREEMENT

- A. Technical Support: Beginning with Substantial Completion, provide software support for **[two]<Insert number>** years.
- B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within **[two]<Insert number>** years from date of Substantial Completion. Upgrading software is to include operating system. Upgrade is to include new or revised licenses for use of software.
 - 1. Provide **[30]<Insert number>** days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

PART 2 - PRODUCTS**2.1 PERFORMANCE REQUIREMENTS**

- A. General Performance: Horizontal cabling system is to comply with transmission standards in TIA-568-C.1, when tested according to test procedures of this standard.
- B. Telecommunications Pathways and Spaces: Comply with TIA-569-D.
- C. Grounding: Comply with TIA-607-B.

2.2 62.5/125-MICROMETER, MULTIMODE, OPTICAL FIBER CABLE (OM1)

- A. Description: Multimode, 62.5/125-micrometer, **[1][2][4]<Insert number>-fiber, [nonconductive][conductive]**, tight buffer, optical fiber cable.
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Belden Inc.]**

2. [Berk-Tek, a Leviton Company]
 3. [CommScope, Inc]
 4. [Corning Optical Communications; Corning Incorporated]
 5. [General Cable; Prysmian Group North America]
 6. [Hitachi Cable America Inc.]
 7. [Mohawk; a division of Belden Networking, Inc.]
 8. [Prysmian Cables and Systems; Prysmian Group North America]
 9. [Superior Essex Inc.; subsidiary of LS Corp.]
 10. <Insert manufacturer's name>
- C. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [Belden Inc.]
 2. [Berk-Tek, a Leviton Company]
 3. [CommScope, Inc]
 4. [Corning Optical Communications; Corning Incorporated]
 5. [General Cable; Prysmian Group North America]
 6. [Hitachi Cable America Inc.]
 7. [Mohawk; a division of Belden Networking, Inc.]
 8. [Prysmian Cables and Systems; Prysmian Group North America]
 9. [Superior Essex Inc.; subsidiary of LS Corp.]
 10. <Insert manufacturer's name>
- D. Standards:
1. Comply with ICEA S-83-596 for mechanical properties.
 2. Comply with TIA-568-C.3 for performance specifications.
 3. Comply with TIA-492AAAA for detailed specifications.
- E. Conductive cable is to be [steel][aluminum] armored type.
- F. Maximum Attenuation: [3.50]<Insert number> dB/km at 850 nm; [1.5]<Insert number> dB/km at 1300 nm.
- G. Minimum Overfilled Modal Bandwidth-length Product: 200 MHz-km at 850 nm; 500 MHz-km at 1300 nm.
- H. Jacket:
1. Jacket Color: [Orange]<Insert color>.
 2. Cable cordage jacket, fiber, unit, and group color is to be according to TIA-598-D.
 3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed **40 inches (1000 mm)**.
- I. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
1. Plenum Rated, Nonconductive:
 - a. Type OFNP, complying with NFPA 262.
 - b. Type OFNP in listed plenum communications raceway.
 - c. Type OFNP or Type OFNR in metallic conduit.
 - d. Type OFNP, complying with NFPA 262; Type OFNP in listed plenum communications raceway; or Type OFNP or Type OFNR in metallic conduit.
 2. Plenum Rated, Conductive:



- a. Type OFCP complying with NFPA 262.
- b. Type OFCP or Type OFNP in listed plenum communications raceway.
- c. Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."

2.3 50/125 MICROMETER, MULTIMODE, OPTICAL FIBER CABLE (OM2)

- A. Description: Multimode, 50/125-micrometer, [1][2][4]<Insert number>-fiber, [nonconductive][conductive], tight buffer, optical fiber cable.
- B. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 1. [AMP NETCONNECT; a TE Connectivity Ltd. company]
 2. [Belden Inc.]
 3. [Berk-Tek, a Leviton Company]
 4. [CommScope, Inc]
 5. [Corning Optical Communications; Corning Incorporated]
 6. [General Cable; Prysmian Group North America]
 7. [Hitachi Cable America Inc.]
 8. [Superior Essex Inc.; subsidiary of LS Corp.]
 9. <Insert manufacturer's name>
- C. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 1. [AMP NETCONNECT; a TE Connectivity Ltd. company]
 2. [Belden Inc.]
 3. [Berk-Tek, a Leviton Company]
 4. [CommScope, Inc]
 5. [Corning Optical Communications; Corning Incorporated]
 6. [General Cable; Prysmian Group North America]
 7. [Hitachi Cable America Inc.]
 8. [Superior Essex Inc.; subsidiary of LS Corp.]
 9. <Insert manufacturer's name>
- D. Standards:
 1. Comply with ICEA S-83-596 for mechanical properties.
 2. Comply with TIA-568-C.3 for performance specifications.
 3. Comply with TIA-492AAAB for detailed specifications.
- E. Conductive cable is to be [steel][aluminum] armored type.
- F. Maximum Attenuation: [3.50]<Insert number> dB/km at 850 nm; [1.5]<Insert number> dB/km at 1300 nm.
- G. Minimum Overfilled Modal Bandwidth-length Product: 500 MHz-km at 850 nm; 500 MHz-km at 1300 nm.
- H. Jacket:
 1. Jacket Color: [Orange]<Insert color>.
 2. Cable cordage jacket, fiber, unit, and group color are to be according to TIA-598-D.

3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed **40 inches (1000 mm)**.
- I. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
 1. Plenum Rated, Nonconductive:
 - a. Type OFNP, complying with NFPA 262.
 - b. Type OFNP in listed plenum communications raceway.
 - c. Type OFNP or Type OFNR in metallic conduit.
 - d. Type OFNP, complying with NFPA 262; Type OFNP in listed plenum communications raceway; or Type OFNP or Type OFNR in metallic conduit.
 2. Plenum Rated, Conductive:
 - a. Type OFCP[**or Type OFNP**], complying with NFPA 262.
 - b. Type OFCP or Type OFNP in listed plenum communications raceway.
 - c. Type OFC, Type OFN, Type OFCG, Type OFNG, Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
- 2.4 850 NANOMETER LASER-OPTIMIZED, 50/125 MICROMETER, MULTIMODE OPTICAL FIBER CABLE (OM3)
 - A. Description: Multimode, 50/125-micrometer, [1][2][4]<Insert number>-fiber, [nonconductive][conductive], tight buffer, optical fiber cable.
 - B. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 1. [AMP NETCONNECT; a TE Connectivity Ltd. company]
 2. [Belden Inc.]
 3. [CommScope, Inc]
 4. [Corning Optical Communications; Corning Incorporated]
 5. [Hitachi Cable America Inc.]
 6. [TE Connectivity Ltd.]
 7. <Insert manufacturer's name>
 - C. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 1. [AMP NETCONNECT; a TE Connectivity Ltd. company]
 2. [Belden Inc.]
 3. [CommScope, Inc]
 4. [Corning Optical Communications; Corning Incorporated]
 5. [Hitachi Cable America Inc.]
 6. [TE Connectivity Ltd.]
 7. <Insert manufacturer's name>
 - D. Standards:
 1. Comply with ICEA S-83-596 for mechanical properties.
 2. Comply with TIA-568-C.3 for performance specifications.



3. Comply with TIA-492AAAC for detailed specifications.
 - E. Conductive cable is to be **[steel][aluminum]** armored type.
 - F. Maximum Attenuation: **[3.50]<Insert number>** dB/km at 850 nm; **[1.5]<Insert number>** dB/km at 1300 nm.
 - G. Minimum Overfilled Modal Bandwidth-length Product: 1500 MHz-km at 850 nm; 500 MHz-km at 1300 nm.
 - H. Minimum Effective Modal Bandwidth-length Product: 2000 MHz-km at 850 nm.
 - I. Jacket:
 1. Jacket Color: **[Aqua]<Insert color>**.
 2. Cable cordage jacket, fiber, unit, and group color are to be according to TIA-598-D.
 3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed **40 inches (1000 mm)**.
 - J. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
 1. Plenum Rated, Nonconductive:
 - a. Type OFNP, complying with NFPA 262.
 - b. Type OFNP in listed plenum communications raceway.
 - c. Type OFNP or Type OFNR in metallic conduit.
 - d. Type OFNP, complying with NFPA 262; Type OFNP in listed plenum communications raceway; or Type OFNP or Type OFNR in metallic conduit.
 2. Plenum Rated, Conductive:
 - a. Type OFCP **[or Type OFNP]**, complying with NFPA 262.
 - b. Type OFCP or Type OFNP in listed plenum communications raceway.
 - c. Type OFNG, Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
- 2.5 850 NANOMETER LASER-OPTIMIZED, 50/125 MICROMETER, MULTIMODE OPTICAL FIBER CABLE (OM4)
- A. Description: Multimode, 50/125-micrometer, **[1][2][4]<Insert number>**-fiber, **[nonconductive][conductive]**, tight buffer, optical fiber cable.
 - B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 1. **[Belden Inc.]**
 2. **[CommScope, Inc]**
 3. **[Corning Optical Communications; Corning Incorporated]**
 4. **[Hitachi Cable America Inc.]**
 5. **[Mohawk; a division of Belden Networking, Inc.]**

6. [Superior Essex Inc.; subsidiary of LS Corp.]
 7. [TE Connectivity Ltd.]
 8. <Insert manufacturer's name>
- C. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [Belden Inc.]
 2. [CommScope, Inc]
 3. [Corning Optical Communications; Corning Incorporated]
 4. [Hitachi Cable America Inc.]
 5. [Mohawk; a division of Belden Networking, Inc.]
 6. [Superior Essex Inc.; subsidiary of LS Corp.]
 7. [TE Connectivity Ltd.]
 8. <Insert manufacturer's name>
- D. Standards:
1. Comply with ICEA S-83-596 for mechanical properties.
 2. Comply with TIA-568-C.3 for performance specifications.
 3. Comply with TIA-492AAAD for detailed specifications.
- E. Conductive cable is to be [steel][aluminum] armored type.
- F. Maximum Attenuation: [3.50]<Insert number> dB/km at 850 nm; [1.5]<Insert number> dB/km at 1300 nm.
- G. Minimum Overfilled Modal Bandwidth-length Product: 3500 MHz-km at 850 nm; 500 MHz-km at 1300 nm.
- H. Minimum Effective Modal Bandwidth-length Product: 4700 MHz-km at 850 nm.
- I. Jacket:
1. Jacket Color: [Aqua]<Insert color>.
 2. Cable cordage jacket, fiber, unit, and group color are to be according to TIA-598-D.
 3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed **40 inches (1000 mm)**.
- J. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
1. Plenum Rated, Nonconductive:
 - a. Type OFNP, complying with NFPA 262.
 - b. Type OFNP in listed plenum communications raceway.
 - c. Type OFNP or Type OFNR in metallic conduit.
 - d. Type OFNP, complying with NFPA 262; Type OFNP in listed plenum communications raceway; or Type OFN, Type OFNG, Type OFNP, or Type OFNR in metallic conduit.
 2. Plenum Rated, Conductive:
 - a. Type OFCP, complying with NFPA 262.
 - b. Type OFCP or Type OFNP in listed plenum communications raceway.
 - c. Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."



- 2.6 9/125 MICROMETER SINGLE-MODE, INDOOR-OUTDOOR OPTICAL FIBER CABLE (OS1)
- A. Description: Single mode, 9/125-micrometer, [1][2]<Insert number> fibers, tight buffered, [nonconductive][conductive] optical fiber cable.
 - B. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - 1. [3M]
 - 2. [Belden Inc.]
 - 3. [Corning Optical Communications; Corning Incorporated]
 - 4. [General Cable; Prysmian Group North America]
 - 5. [Mohawk; a division of Belden Networking, Inc.]
 - 6. [Superior Essex Inc.; subsidiary of LS Corp.]
 - 7. [TE Connectivity Ltd.]
 - 8. <Insert manufacturer's name>
 - C. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1. [3M]
 - 2. [Belden Inc.]
 - 3. [Corning Optical Communications; Corning Incorporated]
 - 4. [General Cable; Prysmian Group North America]
 - 5. [Mohawk; a division of Belden Networking, Inc.]
 - 6. [Superior Essex Inc.; subsidiary of LS Corp.]
 - 7. [TE Connectivity Ltd.]
 - 8. <Insert manufacturer's name>
 - D. Conductive cable is to be [steel][aluminum] armored type.
 - E. Maximum Attenuation: [0.5]<Insert number> dB/km at 1310 nm; [0.5]<Insert number> dB/km at 1550 nm.
 - F. Jacket:
 - 1. Jacket Color: [Yellow]<Insert color>.
 - 2. Cable cordage jacket, fiber, unit, and group color are to be according to TIA-598-D.
 - 3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed **40 inches (1000 mm)**.
 - G. Standards:
 - 1. Comply with TIA-492CAAA for detailed specifications.
 - 2. Comply with TIA-568-C.3 for performance specifications.
 - 3. Comply with ICEA S-104-696 for mechanical properties.
 - H. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
 - 1. Plenum Rated, Nonconductive:
 - a. Type OFNP, complying with NFPA 262.
 - b. Type OFNP in listed plenum communications raceway.

- c. Type OFNP or Type OFNR in metallic conduit.
 - d. Type OFNP, complying with NFPA 262; Type OFNP in listed plenum communications raceway; or Type OFN, Type OFNG, Type OFNP, or Type OFNR in metallic conduit.
 - 2. Plenum Rated, Conductive:
 - a. Type OFCP, complying with NFPA 262.
 - b. Type OFCP or Type OFNP in listed plenum communications raceway.
 - c. Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
- 2.7 9/125 MICROMETER, SINGLE-MODE, INDOOR-OUTDOOR OPTICAL FIBER CABLE (OS2)
- A. Description: Single mode, 9/125-micrometer, [1][2]<Insert number> fibers, tight buffered, [nonconductive][conductive] optical fiber cable.
 - B. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - 1. [3M]
 - 2. [Belden Inc.]
 - 3. [Berk-Tek, a Leviton Company]
 - 4. [CommScope, Inc]
 - 5. [Hitachi Cable America Inc.]
 - 6. [Mohawk; a division of Belden Networking, Inc.]
 - 7. [Superior Essex Inc.; subsidiary of LS Corp.]
 - 8. <Insert manufacturer's name>
 - C. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1. [3M]
 - 2. [Belden Inc.]
 - 3. [Berk-Tek, a Leviton Company]
 - 4. [CommScope, Inc]
 - 5. [Hitachi Cable America Inc.]
 - 6. [Mohawk; a division of Belden Networking, Inc.]
 - 7. [Superior Essex Inc.; subsidiary of LS Corp.]
 - 8. <Insert manufacturer's name>
 - D. Conductive cable is to be [steel][aluminum] armored type.
 - E. Maximum Attenuation: [0.5]<Insert number> dB/km at 1310 nm; [0.5]<Insert number> dB/km at 1550 nm.
 - F. Jacket:
 - 1. Jacket Color: [Yellow]<Insert color>.
 - 2. Cable cordage jacket, fiber, unit, and group color are to be according to TIA-598-D.
 - 3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).
 - G. Standards:

1. Comply with TIA-492CAAB for detailed specifications.
2. Comply with TIA-568-C.3 for performance specifications.
3. Comply with ICEA S-104-696 for mechanical properties.

H. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:

1. Plenum Rated, Nonconductive:
 - a. Type OFNP, complying with NFPA 262.
 - b. Type OFNP in listed plenum communications raceway.
 - c. Type OFNP or Type OFNR in metallic conduit.
 - d. Type OFNP, complying with NFPA 262; Type OFNP in listed plenum communications raceway; or Type OFN, Type OFNG, Type OFNP, or Type OFNR in metallic conduit.
2. Plenum Rated, Conductive:
 - a. Type OFCP, complying with NFPA 262.
 - b. Type OFCP or Type OFNP in listed plenum communications raceway.
 - c. Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."

2.8 OPTICAL FIBER CABLE HARDWARE

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

1. **[American Technology Systems Industries, Inc]**
2. **[Belden Inc.]**
3. **[Berk-Tek, a Leviton Company]**
4. **[CommScope, Inc]**
5. **[Corning Optical Communications; Corning Incorporated]**
6. **[Dynacom Corporation]**
7. **[Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
8. **[Molex Premise Networks]**
9. **[Optical Cable Corporation (OCC)]**
10. **[Siemon Co. (The)]**
11. **[Stewart Connector, a Bel group company; Bel Fuse Inc.]**
12. **<Insert manufacturer's name>**

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

1. **[American Technology Systems Industries, Inc]**
2. **[Belden Inc.]**
3. **[Berk-Tek, a Leviton Company]**
4. **[CommScope, Inc]**
5. **[Corning Optical Communications; Corning Incorporated]**
6. **[Dynacom Corporation]**
7. **[Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]**
8. **[Molex Premise Networks]**
9. **[Optical Cable Corporation (OCC)]**
10. **[Siemon Co. (The)]**

11. **[Stewart Connector, a Bel group company; Bel Fuse Inc.]**
12. **<Insert manufacturer's name>**

C. Standards:

1. Comply with Fiber Optic Connector Intermateability Standard (FOCIS) specifications of the TIA-604 series.
2. Comply with TIA-568-C.3.

D. Cross-Connects and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.

1. Number of Connectors per Field: **[One]<Insert number>** for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to suit specified expansion criteria.

E. Patch Cords: Factory-made, single-fiber cables in **36-inch (900-mm)** lengths.

F. Connector Type: **[Type SC complying with TIA-604-3-B],[Type ST complying with TIA-604-2-B],[Type LC complying with TIA-604-10-B],[Type MT-RJ complying with TIA-604-12],[Type MPO complying with TIA-604-5-D],<Insert type>** connectors.

G. Plugs and Plug Assemblies:

1. Male; color-coded modular telecommunications connector designed for termination of a single optical fiber cable.
2. Insertion loss not more than **[0.25][0.75]<Insert number>** dB.
3. Marked to indicate transmission performance.

H. Jacks and Jack Assemblies:

1. Female; quick-connect, simplex and duplex; fixed telecommunications connector designed for termination of a single optical fiber cable.
2. Insertion loss not more than **[0.25][0.75]<Insert number>** dB.
3. Marked to indicate transmission performance.
4. Designed to snap-in to a patch panel or faceplate.

I. Faceplate:

1. **[Two][Four][Six]** -port, vertical single-gang faceplates designed to mount to single-gang wall boxes.
2. **[Eight][Ten][Twelve]** -port, vertical double-gang faceplates designed to mount to double-gang wall boxes.
3. Plastic Faceplate: High-impact plastic. Coordinate color with Section 262726 "Wiring Devices."
4. Metal Faceplate: **[Stainless steel][Brass]<Insert description>**, complying with requirements in Section 262726 "Wiring Devices."
5. For use with snap-in jacks accommodating any combination of twisted pair, optical fiber, and coaxial work area cords.
 - a. Flush mounting jacks, positioning the cord at a 45-degree angle.

2.9 GROUNDING

- A. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems" for grounding conductors and connectors.

- B. Comply with TIA-607-B.

2.10 IDENTIFICATION PRODUCTS

- A. Comply with TIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.11 SOURCE QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to evaluate cables.
- B. Factory test multimode optical fiber cables according to TIA-526-14-B and TIA-568-C.3.
- C. Factory test preterminated optical fiber cable assemblies according to TIA-526-14-B and TIA-568-C.3.
- D. Cable will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 WIRING METHODS

- A. Wiring Method, Raceways: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters[**and except in accessible ceiling spaces, in attics, and in gypsum board partitions where unenclosed wiring method may be used**]. Conceal raceway and cables except in unfinished spaces.
 - 1. Install plenum cable in environmental air spaces, including plenum ceilings.
 - 2. Comply with requirements for pathways specified in Section 270528 "Pathways for Communications Systems."
- B. Wiring Method, Concealed: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.2 INSTALLATION OF OPTICAL FIBER BACKBONE CABLES

- A. Comply with NECA 1, NECA 301 and NECA/BICSI 568.
- B. General Requirements for Optical Fiber Cabling Installation:
 - 1. Comply with TIA-568-C.1 and TIA-568-C.3.
 - 2. Comply with BICSI ITSIMM, Ch. 6, "Cable Termination Practices."
 - 3. Terminate all cables; no cable is to contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.

4. Cables may not be spliced. Secure and support cables at intervals not exceeding **30 inches (760 mm)** and not more than **6 inches (150 mm)** from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
5. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
6. Bundle, lace, and train cable to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, "Cabling Termination Practices" Chapter. Use lacing bars and distribution spools.
7. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
8. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps are not to be used for heating.
9. In the communications equipment room, provide a **10-foot- (3-m-)** long service loop on each end of cable.
10. Pulling Cable: Comply with BICSI ITSIMM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
11. Cable may be terminated on connecting hardware that is rack or cabinet mounted.

C. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Cable is not to be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

D. Installation of Cable Routed Exposed under Raised Floors:

1. Install plenum-rated cable only.
2. Install cabling after the flooring system has been installed in raised floor areas.
3. Coil cable [**6 feet (1800 mm)**]**<Insert size>** long not less than [**12 inches (300 mm)**]**<Insert size>** in diameter below each feed point.

E. Group connecting hardware for cables into separate logical fields.

3.3 FIRESTOPPING

- A. Comply with requirements in Section 078413 "Penetration Firestopping."
- B. Comply with TIA-569-D, Annex A, "Firestopping."
- C. Comply with BICSI ITSIMM, "Firestopping" Chapter.

3.4 INSTALLATION OF GROUNDING

- A. Install grounding according to BICSI ITSIMM, "Grounding (Earthing), Bonding, and Electrical Protection" Chapter.
- B. Comply with TIA-607-B and NECA/BICSI-607.
- C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least **2-inch (50-mm)** clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.
- D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment

grounding conductor.

3.5 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
 - 1. Administration Class: **[Class 1][Class 2][Class 3][Class 4]**.
 - 2. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.
- B. Paint and label colors for equipment identification are to comply with TIA-606-B for **[Class 2][Class 3][Class 4]** level of administration **[including optional identification requirements of this standard]**.
- C. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.
- D. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, **[horizontal pathways and cables],[entrance pathways and cables,]** terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.
- E. Cable and Wire Identification:
 - 1. Label each cable within **4 inches (100 mm)** of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
 - 2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
 - 3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding **15 feet (4.5 m)**.
 - 4. Label each unit and field within distribution racks and frames.
 - 5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.
- F. Labels are to be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA 606-B, for the following:
 - 1. Flexible vinyl or polyester that flexes as cables are bent.

3.6 FIELD QUALITY CONTROL

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

D. Tests and Inspections:

1. Visually inspect optical fiber jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA-568-C.1.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
3. Optical Fiber Cable Tests:
 - a. Test instruments are to meet or exceed applicable requirements in TIA-568-C.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
 - b. Link End-to-End Attenuation Tests:
 - 1) Horizontal and Multimode Horizontal Link Measurements: Test at 850 or 1300 nm in one direction according to TIA-526-14-B, Method B, One Reference Jumper.
 - 2) Attenuation test results for horizontal links are to be less than 2.0 dB. Attenuation test results are to be less than those calculated according to equation in TIA-568-C.1.

- E. Data for each measurement are to be documented. Data for submittals are to be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.
- F. Remove and replace cabling where test results indicate that it does not comply with specified requirements.
- G. End-to-end cabling will be considered defective if it does not pass tests and inspections.
- H. Prepare test and inspection reports.

END OF SECTION 27 15 23 00



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SECTION 27 15 33 00 - COMMUNICATIONS COAXIAL HORIZONTAL CABLING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Communications coaxial cable.
 - 2. CATV coaxial cable.
 - 3. Coaxial cable hardware.
 - 4. Grounding.
 - 5. Identification products.

1.2 DEFINITIONS

- A. BICSI: Building Industry Consulting Service International.
- B. EMI: Electromagnetic interference.
- C. IDC: Insulation displacement connector.
- D. LAN: Local area network.
- E. RCDD: Registered Communications Distribution Designer.

1.3 COAXIAL HORIZONTAL CABLING DESCRIPTION

- A. Coaxial horizontal cabling system is to provide interconnections between Distributor A, Distributor B, or Distributor C and the equipment outlet, otherwise known as "Cabling Subsystem 1" in the telecommunications cabling system structure. Cabling system consists of horizontal cables, mechanical terminations, and patch cords or jumpers used for horizontal-to-horizontal cross-connection.

1.4 ACTION SUBMITTALS

- A. Product Data:
 - 1. Communications coaxial cable.
 - 2. CATV coaxial cable.
 - 3. Coaxial cable hardware.
 - 4. Grounding.
 - 5. Identification products.
- B. Product Data Submittals: For each product.
 - 1. Nominal OD.
 - 2. Minimum bending radius.
 - 3. Maximum pulling tension.

C. Shop Drawings:

1. System Labeling Schedule:
 - a. Electronic copy of labeling schedules, in software and format selected by Owner.
 - b. Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
2. Cabling administration drawings and printouts.

D. Sustainable Design Submittals:

1. Environmental Product Declaration: For each product.
2. Health Product Declaration: For each product.
3. Sourcing of Raw Materials: Corporate sustainability report for each manufacturer.
4. Environmental Product Declaration: For each product.
5. Environmental Product Declaration: For each product.
6. Environmental Product Declaration: For each product.
7. Third-Party Certifications: For each product.
8. Third-Party Certified Life Cycle Assessment: For each product.
9. Samples: For telecommunications jacks and plugs, **[in specified finish, one for each type and configuration][and faceplates for color selection and evaluation of technical features]**.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For **[RCDD,][Installer,]**installation supervisor, and field inspector.
- B. Source quality-control reports.
- C. Field quality-control reports.
- D. Maintenance Data: For splices and connectors to include in maintenance manuals.

1.6 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For coaxial cable, splices, and connectors to include in maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Connecting Blocks: **[One]<Insert number>** of each type.
 2. Jacks: **[Ten]<Insert number>** of each type.
 3. Patch-Panel Units: **[One]<Insert number>** of each type.
 4. Plugs: **[Ten]<Insert number>** of each type.

1.8 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: Preparation of Shop Drawings[**and Cabling Administration Drawings**][, **Cabling Administration Drawings, and field testing program development**] by an **[RCDD][Technician]**.
 2. Installation Supervision: Installation is to be under the direct supervision of **[Technician][Level 2 Installer]**, who is to be present at all times when Work of this Section is performed at Project site.
- B. Testing Agency Qualifications: Testing agency must have personnel certified by BICSI on staff.
1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Test cables upon receipt at Project site.
1. Test each coaxial cable **[on the reel]** for continuity.

1.10 PROJECT CONDITIONS

- A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.11 COORDINATION

- A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. General Performance: Horizontal cabling system is to comply with transmission standards in TIA-568-C.1, when tested according to test procedures of this standard, and the requirements of TIA-568-C.4.
- B. Telecommunications Pathways and Spaces: Comply with TIA-569-D.
- C. Grounding: Comply with TIA-607-B.

2.2 GENERAL CABLE CHARACTERISTICS

- A. Communications Cable: Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with the applicable standard and NFPA 70 for the following types:
1. Communications, Plenum Rated, Type CMP: Complying with UL 1685[**or Type CMP in listed plenum communications raceway**][**or Type CMP in listed cable routing assembly**].
 2. Communications, Plenum Rated: Type CM, Type CMG, Type CMP, Type CMR, or Type CMX in metallic conduit installed in accordance with NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."



- B. CATV Cable: Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with the applicable standard and NFPA 70 for the following types:
 - 1. CATV Plenum Rated: Type CATVP [installed in riser raceways or cable routing assemblies], complying with NFPA 262.
 - 2. CATV Cable: Type CATV[, or CATVP or CATVR][installed in general purpose, riser, or plenum communications raceways or cable routing assemblies] in fireproof riser shafts with firestops at each penetration.

2.3 COMMUNICATIONS COAXIAL CABLE

- A. Description: Coaxial cable with a 75-ohm characteristic impedance designed for broadband data transmission.
- B. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - 1. [Alpha Wire; brand of Belden, Inc.]
 - 2. [Belden Inc.]
 - 3. [CommScope, Inc]
 - 4. [Prysmian Cables and Systems; Prysmian Group North America]
 - 5. [Southwire Company, LLC]
 - 6. <Insert manufacturer's name>
- C. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1. [Alpha Wire; brand of Belden, Inc.]
 - 2. [Belden Inc.]
 - 3. [CommScope, Inc]
 - 4. [Prysmian Cables and Systems; Prysmian Group North America]
 - 5. [Southwire Company, LLC]
 - 6. <Insert manufacturer's name>
- D. NFPA and UL compliance, listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 13, and with NFPA 70, "Class 1, Class 2, and Class 3 Remote-Control, Signaling, and Power-Limited Circuits" and "Communications Circuits" articles. Types are as follows:
 - 1. RG-6/U: UL Type [CMP][and][CL2P].
 - a. No. [16][18]<Insert size> AWG, solid, copper-covered steel conductor.
 - b. Plenum rated.
 - c. Gas-injected, foam-PE insulation.
 - d. Shielded with 100 percent aluminum tape and [40][60] percent aluminum braid.
 - e. Double shielded with 100 percent aluminum foil shield, 60 percent aluminum braided inner shield, and 40 percent aluminum braided outer shield.
 - f. Jacketed with [black][white] PVC or PE.
 - g. Suitable for indoor installations.
 - 2. RG-11/U: UL Type [CMP][and][CL2P].
 - a. No. [14]<Insert size> AWG, solid, copper-covered steel conductor.
 - b. Plenum rated. Suitable for outdoor installations in ambient temperatures ranging from

minus 40 to plus 85 deg F (minus 40 to plus 30 deg C).

- c. Gas-injected, foam-PE insulation.
 - d. Shielded with 100 percent aluminum tape and [40][60] percent aluminum braid.
 - e. Double shielded with 100 percent aluminum foil shield, 60 percent aluminum braided inner shield, and 40 percent aluminum braided outer shield.
 - f. Jacketed with sunlight-resistant, [black][white] PVC or PE.
3. RG-59/U: UL Type [CMP][and][CL2P].
- a. No. [20]<Insert size> AWG, solid copper conductor.
 - b. Plenum rated.
 - c. Gas-injected, foam-PE insulation.
 - d. Single shielded with 100 percent aluminum shield and 40 percent aluminum braid.
 - e. PVC jacket.

2.4 CATV COAXIAL CABLE

- A. Description: Coaxial cable with a 75-ohm characteristic impedance designed for CATV transmission.
- B. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
- 1. [Alpha Wire; brand of Belden, Inc.]
 - 2. [Belden Inc.]
 - 3. [CommScope, Inc]
 - 4. [Prysmian Cables and Systems; Prysmian Group North America]
 - 5. [Southwire Company, LLC]
 - 6. <Insert manufacturer's name>
- C. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- 1. [Alpha Wire; brand of Belden, Inc.]
 - 2. [Belden Inc.]
 - 3. [CommScope, Inc]
 - 4. [Prysmian Cables and Systems; Prysmian Group North America]
 - 5. [Southwire Company, LLC]
 - 6. <Insert manufacturer's name>
- D. NFPA and UL compliance, listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1655 and with NFPA 70, "Community Antenna Television and Radio Distribution Systems" Article. Types are as follows:
- 1. RG-6/U: UL Type CATVP.
 - a. No. 18 AWG, solid, copper-covered steel conductor.
 - b. Plenum rated.
 - c. Gas-injected, foam-PE insulation.
 - d. Shielded with 100 percent aluminum tape and [40][60] percent aluminum braid.
 - e. Double shielded with 100 percent aluminum foil shield, 60 percent aluminum braided inner shield, and 40 percent aluminum braided outer shield.
 - f. Jacketed with [black][white] PVC or PE.
 - g. Suitable for indoor installations.



2.5 COAXIAL CABLE HARDWARE

- A. Description: Hardware designed to connect, splice, and terminate coaxial cable with a 75-ohm characteristic impedance.
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Leviton Manufacturing Co., Inc.]**
 - 2. **[Liebert; Vertiv Holdings Co.]**
 - 3. **[Siemon Co. (The)]**
 - 4. **<Insert manufacturer's name>**
- C. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Leviton Manufacturing Co., Inc.]**
 - 2. **[Liebert; Vertiv Holdings Co.]**
 - 3. **[Siemon Co. (The)]**
 - 4. **<Insert manufacturer's name>**
- D. Coaxial-Cable Connectors: Type BNC, 75 ohms.
- E. Jacks and Jack Assemblies: Modular, color-coded, with female Type BNC connectors.
- F. Patch Cords: Factory-made cables in **[36-inch (900-mm)][48-inch (1200-mm)]<Insert length>**lengths; terminated with a male Type BNC connector at each end.
- G. Faceplates:
 - 1. Plastic Faceplate: High-impact plastic. Coordinate color with Section 262726 "Wiring Devices."
 - 2. Metal Faceplate: **[Stainless steel][Brass]<Insert description>**, complying with requirements in Section 262726 "Wiring Devices."
 - 3. For use with snap-in jacks accommodating any combination of twisted pair, optical-fiber, and coaxial work area cords.
 - a. Flush-mounted jacks, positioning the cord at a 90-degree angle from faceplate surface.
 - 4. Legend:
 - a. Factory labeled by silk-screening or engraving **[for][stainless steel][brass]<Insert description>[faceplates]**.
 - b. Machine printed, in the field, using adhesive-tape label.
 - c. Snap-in, clear-label covers and machine-printed paper inserts.

2.6 GROUNDING

- A. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems" for grounding conductors and connectors.
- B. Comply with TIA-607-B.

2.7 IDENTIFICATION PRODUCTS

- A. Comply with TIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.8 SOURCE QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to evaluate cables.
- B. Cable will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 ENTRANCE FACILITIES

- A. Coordinate horizontal cabling with the protectors and demarcation point provided by communications service provider.

3.2 WIRING METHODS

- A. Wiring Method, Raceways: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters[**and except in accessible ceiling spaces, in attics, and in gypsum board partitions where unenclosed wiring method may be used**]. Conceal raceway and cables except in unfinished spaces.
 - 1. Install plenum cable in environmental air spaces, including plenum ceilings.
 - 2. Comply with requirements for raceways and boxes specified in Section 270528 "Pathways for Communications Systems."
- B. Wiring Method, Concealed: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.3 INSTALLATION OF PATHWAYS

- A. Comply with Section 271100 "Communications Equipment Room Fittings." Comply with requirements in Section 270528 "Pathways for Communications Systems" for installation of conduits and wireways.
- B. Comply with Section 270528.29 "Hangers and Supports for Communications Systems."
- C. Drawings indicate general arrangement of pathways and fittings.
- D. Comply with NFPA 70 for pull-box sizing and length of conduit and number of bends between pull points.

- E. Install manufactured conduit sweeps and long-radius elbows whenever possible.
- F. Pathway Installation in Communications Equipment Rooms:
 - 1. Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed, or in the corner of room where multiple sheets of plywood are installed around perimeter walls of room.
 - 2. Install cable trays to route cables if conduits cannot be located in these positions.
 - 3. Secure conduits to backboard when entering room from overhead.
 - 4. Extend conduits [**3 inches (76 mm)**]**<Insert dimension>** above finished floor.
 - 5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.
- G. Backboards: Install backboards with **96-inch (2440-mm)** dimension vertical. Butt adjacent sheets tightly, and form smooth gap-free corners and joints.

3.4 INSTALLATION OF COAXIAL HORIZONTAL CABLES

- A. Comply with NECA 1 and NECA/BICSI 568.
- B. General Requirements for Cabling:
 - 1. Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section.
 - 2. Terminate all conductors; no cable is to contain unterminated elements. Make terminations only at indicated outlets, terminals, and patch panels.
 - 3. Cables may not be spliced. Secure and support cables at intervals not exceeding **30 inches (760 mm)** and not more than **6 inches (150 mm)** from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
 - 4. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
 - 5. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section. Use lacing bars and distribution spools.
 - 6. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
 - 7. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps are not to be used for heating.
 - 8. In the communications equipment room, install a **10-foot- (3-m-)** long service loop on each end of cable.
 - 9. Pulling Cable: Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems," "Pulling Cable" Section. Monitor cable pull tensions.
- C. Open-Cable Installation:
 - 1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
 - 2. Suspend coaxial cable not in a wireway or pathway a minimum of **8 inches (200 mm)** above ceilings by cable supports not more than [**60 inches (1524 mm)**]**<Insert dimension>** apart.
 - 3. Cable is not to be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

D. Installation of Cable Routed Exposed under Raised Floors:

1. Install plenum-rated cable only.
2. Install cabling after the flooring system has been installed in raised floor areas.
3. Coil cable **[6 feet (1800 mm)]<Insert size>** long not less than **[12 inches (300 mm)]<Insert size>** in diameter below each feed point.

E. Outdoor Coaxial Cable Installation:

1. Install outdoor connections in enclosures complying with NEMA 250, Type 4X. Install corrosion-resistant connectors with properly designed O-rings to keep out moisture.
2. Attach antenna lead-in cable to support structure at intervals not exceeding **36 inches (915 mm)**.

F. Group connecting hardware for cables into separate logical fields.

G. Separation from EMI Sources:

1. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment is to be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of **5 inches (127 mm)**.
 - b. Electrical Equipment Rating Between 2 and 5 kVA: A minimum of **12 inches (300 mm)**.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of **24 inches (610 mm)**.
2. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment is to be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of **2-1/2 inches (64 mm)**.
 - b. Electrical Equipment Rating Between 2 and 5 kVA: A minimum of **6 inches (150 mm)**.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of **12 inches (300 mm)**.
3. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures is to be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
 - b. Electrical Equipment Rating Between 2 and 5 kVA: A minimum of **3 inches (76 mm)**.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of **6 inches (150 mm)**.
4. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of **48 inches (1200 mm)**.
5. Separation between Communications Cables and Fluorescent Fixtures: A minimum of **5 inches (127 mm)**.

3.5 FIRESTOPPING

- A. Comply with requirements in Section 078413 "Penetration Firestopping."
- B. Comply with TIA-569-D, Annex A, "Firestopping."
- C. Comply with BICSI TDMM, "Firestopping Systems" Article.



3.6 INSTALLATION OF GROUNDING

- A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
- B. Comply with TIA-607-B and NECA/BICSI-607.
- C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least **2-inch (50-mm)** clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.
- D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

3.7 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Section 260529 "Hangers and Supports for Electrical Systems."
 - 1. Administration Class: **[Class 1][Class 2][Class 3][Class 4]**.
 - 2. Color-code fields and apply colors to voice and data service backboards, connections, covers, and labels.
- B. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.
- C. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, **[horizontal pathways and cables],[entrance pathways and cables,]** terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.
- D. Cable and Wire Identification:
 - 1. Label each cable within **4 inches (100 mm)** of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
 - 2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
 - 3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding **15 feet (4.5 m)**.
 - 4. Label each terminal strip and screw terminal in each cabinet, rack, or panel.
 - a. Individually number wiring conductors connected to terminal strips and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device with name and number of particular device as shown.
 - b. Label each unit and field within distribution racks and frames.
 - 5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communications cabling, use a different color for jacks and plugs of each service.
- E. Labels are to be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA 606-B, for the following:

1. Cables use flexible vinyl or polyester that flexes as cables are bent.

3.8 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**].
- D. Tests and Inspections:
 1. Visually inspect coaxial jacket materials for NRTL certification markings.
 2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
 3. Test coaxial horizontal copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination.
- E. Data for each measurement are to be documented. Data for submittals are to be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.
- F. Remove and replace cabling where test results indicate that they do not comply with specified requirements.
- G. End-to-end cabling will be considered defective if it does not pass tests and inspections.
- H. Prepare test and inspection reports.

END OF SECTION 27 15 33 00



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Task	Specification	Specification Description
27 15 33 00	26 05 13 00	Medium-Voltage Cables
27 15 33 00	26 05 19 00	Low-Voltage Electrical Power Conductors and Cables
27 15 33 00	26 05 23 00	Control-Voltage Electrical Power Cables
27 15 53 00	27 13 23 00	Communications Optical Fiber Backbone Cabling



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SECTION 27 16 00 00 - COMMUNICATIONS HYBRID CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Multimode optical fiber and copper hybrid cable.
2. Single-mode optical fiber and copper hybrid cable.
3. Optical fiber cable-connecting hardware.

B. Related Requirements:

1. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
2. Section 270010 "Supplemental Requirements for Communications" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.

1.2 DEFINITIONS

- A. Cross-Connect:** A facility enabling the termination of cable elements and their interconnection or cross-connection.
- B. PBB:** Primary bonding busbar.
- C. SBB:** Secondary bonding busbar.

1.3 COORDINATION

- A.** Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications equipment and service suppliers.

1.4 SEQUENCING

- A.** Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.5 ACTION SUBMITTALS

A. Product Data:

1. Multimode optical fiber and copper hybrid cable.
2. Single-mode optical fiber and copper hybrid cable.
3. Optical fiber cable-connecting hardware.

- B. Samples:
 - 1. Optical fiber cable-connecting hardware.
- C. Sustainable Design Submittals:
 - 1. Multimode optical fiber and copper hybrid cable.
 - 2. Single-mode optical fiber and copper hybrid cable.
 - 3. Optical fiber cable-connecting hardware.
- D. Shop Drawings: Reviewed and stamped by RCDD.
 - 1. System Labeling Schedules: **[Electronic copy of labeling schedules, in software and format selected by Owner][Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software]**.
 - 2. Cabling administration Drawings and printouts.
 - 3. Wiring diagrams and installation details of telecommunications equipment, to show location and layout of telecommunications equipment, including the following:
 - a. Telecommunications rooms plans and elevations.
 - b. Telecommunications pathways.
 - c. Telecommunications system access points.
 - d. Telecommunications grounding system.
 - e. Telecommunications conductor drop locations.
 - f. Typical telecommunications details.
 - g. Mechanical, electrical, and plumbing systems.
- E. Fiber-optic cable testing plan.
- F. Field quality-control reports.

1.6 INFORMATIONAL SUBMITTALS

- A. Manufacturers' published instructions.
- B. Field Reports:
 - 1. Factory Test Reports:
 - a. Multimode optical fiber and copper hybrid cable.
 - b. Single-mode optical fiber and copper hybrid cable.
 - 2. Manufacturer's field reports for field quality-control support.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Spare Parts: Furnish to Owner spare parts, for repairing cables and cable hardware, that are packaged with protective covering for storage on-site and identified with labels describing contents. **[Include the following:]**
 - 1. Connecting Blocks: **[One]<Insert number>** of each type.
 - 2. Jacks: **[10]<Insert number>** of each type.

3. Patch-Panel Units: **[One]<Insert number>** of each type.
4. Plugs: **[10]<Insert number>** of each type.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Test cables upon receipt at Project site.
 1. Test optical fiber cable to determine the continuity of the strand end to end. Use **[optical fiber flashlight][or][optical loss test set]<Insert test instrument>**.
 2. Test optical fiber cable while on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector, including the loss value of each. Retain test data and include the record in maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. General Performance:
 1. Cabling system must comply with transmission standards in TIA-568.1, when tested in accordance with test procedures of this standard.
 2. Comply with UL 13.
- B. Telecommunications Pathways and Spaces: Comply with TIA-569.
- C. Grounding: Comply with TIA-607.
- D. RoHS compliant.

2.2 MULTIMODE OPTICAL FIBER AND COPPER HYBRID CABLE

- A. Description: **[One][Two][Four]<Insert number>** 62.5/125 μm multimode optical fibers and **[two]<Insert number>** copper conductors sharing a common jacket.
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 1. **[America Fujikura Ltd. (AFL); Fujikura Ltd.]**
 2. **[Berk-Tek, a Leviton Company]**
 3. **[Optical Cable Corporation (OCC)]**
 4. **[TE Connectivity Ltd.]**
 5. **<Insert manufacturer's name>**
- C. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 1. **[America Fujikura Ltd. (AFL); Fujikura Ltd.]**
 2. **[Berk-Tek, a Leviton Company]**
 3. **[Optical Cable Corporation (OCC)]**
 4. **[TE Connectivity Ltd.]**

5. <Insert manufacturer's name>

D. Copper Conductors:

1. Comply with ASTM B3 for stranded conductors.
2. Size: [12 AWG][14 AWG][16 AWG][18 AWG][20 AWG].
3. Insulation: [THWN][THHN]<Insert insulation type>.

E. Optical Fiber:

1. Type: [62.5/125 μ m, multimode, optical fiber cable (OM1)][50/125 μ m, multimode, optical fiber cable (OM2)][850 nm, laser-optimized, 50/125 μ m, multimode optical fiber cable (OM3)][850 nm, laser-optimized, 50/125 μ m multimode optical fiber cable (OM4)].
2. Maximum Attenuation: [0.5]<Insert number> dB/km at 1310 nm; [0.5]<Insert number> dB/km at 1550 nm.

F. Jacket:

1. Jacket Color: [Black][Yellow][Orange]<Insert color>.
2. Imprinted with fiber count, fiber type, copper count, copper size, and aggregate length at regular intervals not to exceed 40 inch (1000 mm).

G. Shield: [Aluminum foil][Aluminum braid]<Insert type>.

H. Armor: [Steel][Aluminum].

I. Listed and labeled, by qualified electrical testing laboratory recognized by authorities having jurisdiction, as complying with NFPA 70, Article 725 for the following types:

1. Plenum Rated: Type CL3P and CL2P, complying with NFPA 262.
2. Riser Rated:
 - a. Type CL3R and CL2R, complying with UL 1666.
 - b. Type CMR, complying with UL 444.
3. Tray Cable: Type PLTC.

2.3 SINGLE-MODE OPTICAL FIBER AND COPPER HYBRID CABLE

A. Description: [One][Two][Four]<Insert number> single-mode optical fibers and [two]<Insert number> copper conductors sharing a common jacket.

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

1. [America Fujikura Ltd. (AFL); Fujikura Ltd.]
2. [Berk-Tek, a Leviton Company]
3. [Optical Cable Corporation (OCC)]
4. [TE Connectivity Ltd.]
5. <Insert manufacturer's name>

C. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's

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

1. **[America Fujikura Ltd. (AFL); Fujikura Ltd.]**
2. **[Berk-Tek, a Leviton Company]**
3. **[Optical Cable Corporation (OCC)]**
4. **[TE Connectivity Ltd.]**
5. **<Insert manufacturer's name>**

D. Copper Conductors:

1. Comply with ASTM B3 for stranded conductors.
2. Size: **[12 AWG][14 AWG][16 AWG][18 AWG][20 AWG]**.
3. Insulation: **[THWN][THHN]<Insert insulation type>**.

E. Optical Fiber:

1. Type: **[9/125 μm, single-mode, indoor-outdoor optical fiber cable (OS1)][9/125 μm, single-mode, indoor-outdoor optical fiber cable (OS2)][9/125 μm, single-mode, ISP optical fiber cable (OS1)][9/125 μm, single-mode, ISP optical fiber cable (OS2)][9/125 μm, single-mode, OSP optical fiber cable (OS1)][9/125 μm, single-mode, OSP optical fiber cable (OS2)]**.
2. Maximum Attenuation: **[0.5]<Insert number> dB/km at 1310 nm; [0.5]<Insert number> dB/km at 1550 nm**.

F. Jacket:

1. Jacket Color: **[Black][Yellow][Orange]<Insert color>**.
2. Imprinted with fiber count, fiber type, copper count, copper size, and aggregate length at regular intervals not to exceed **40 inch (1000 mm)**.

G. Shield: **[Aluminum foil][Aluminum braid]<Insert type>**.

H. Armor: **[Steel][Aluminum]**.

I. Listed and labeled, by qualified electrical testing laboratory recognized by authorities having jurisdiction, as complying with NFPA 70, Article 725 for the following types:

1. Plenum Rated: Type CL3P and CL2P, complying with NFPA 262.
2. Riser Rated:
 - a. Type CL3R and CL2R, complying with UL 1666.
 - b. Type CMR, complying with UL 444.
3. Tray Cable: Type PLTC.

2.4 OPTICAL FIBER CABLE-CONNECTING HARDWARE

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

1. **[American Technology Systems Industries, Inc]**
2. **[Belden Inc.]**
3. **[Berk-Tek, a Leviton Company]**
4. **[CommScope, Inc]**

5. [Corning Optical Communications; Corning Incorporated]
6. [Dynacom Corporation]
7. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
8. [Molex Premise Networks]
9. [Optical Cable Corporation (OCC)]
10. [Siemon Co. (The)]
11. [Stewart Connector, a Bel group company; Bel Fuse Inc.]
12. <Insert manufacturer's name>

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

1. [American Technology Systems Industries, Inc]
2. [Belden Inc.]
3. [Berk-Tek, a Leviton Company]
4. [CommScope, Inc]
5. [Corning Optical Communications; Corning Incorporated]
6. [Dynacom Corporation]
7. [Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated]
8. [Molex Premise Networks]
9. [Optical Cable Corporation (OCC)]
10. [Siemon Co. (The)]
11. [Stewart Connector, a Bel group company; Bel Fuse Inc.]
12. <Insert manufacturer's name>

C. Standards:

1. Comply with Fiber Optic Connector Intermateability Standard (FOCIS) specifications of the TIA-604 series.
2. Comply with TIA-568.3.

D. Connector Type: [Type SC complying with TIA-604-3,][Type ST complying with TIA-604-2,][Type LC complying with TIA-604-10,][Type MT-RJ complying with TIA-604-12,][Type MPO complying with TIA-604-5,]<Insert type> connectors.

E. Plugs and Plug Assemblies:

1. Male; color-coded modular telecommunications connector designed for termination of a single-fiber optic cable.
2. Insertion loss not more than [0.25][0.75]<Insert number> dB.
3. Marked to indicate transmission performance.

F. Jacks and Jack Assemblies:

1. Female; quick-connect, simplex and duplex; fixed telecommunications connector designed for termination of a single-fiber optic cable.
2. Insertion loss not more than [0.25][0.75]<Insert number> dB.
3. Marked to indicate transmission performance.
4. Designed to snap in to a patch panel or cover plate.

G. Patch Cords: Factory-made, single-fiber cables in **36 inch (900 mm)** lengths.

2.5 SOURCE QUALITY CONTROL

- A. Product Data: Prepare and submit catalog cuts, brochures, [**diagrams,**][**schedules,**] and performance data illustrating size, physical appearance, and other characteristics of product.
 - 1. Include product certificates.
- B. Sustainable Design Submittals: Prepare and submit the following documentation:
 - 1. Environmental Product Declaration: For each product.
 - 2. Health Product Declaration: For each product.
 - 3. Sourcing of Raw Materials: Corporate sustainability report for each manufacturer.
 - 4. Environmental Product Declaration: For each product.
 - 5. Environmental Product Declaration: For each product.
 - 6. Environmental Product Declaration: For each product.
 - 7. Third-Party Certifications: For each product.
 - 8. Third-Party Certified Life Cycle Assessment: For each product.
- C. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.
- D. Samples: For telecommunications jacks and plugs, [in specified finish, one for each type and configuration][and cover plates for color selection and evaluation of technical features].
- E. Factory Tests:
 - 1. Owner will witness required factory tests. Notify Architect at least 14 days before date of tests and indicate their approximate duration.
 - 2. Testing Administrator: [Owner will engage][Engage] qualified communications testing agency to evaluate cables.
 - 3. Factory Tests and Inspections: Test and inspect cables, by, or under supervision of, qualified electrical testing laboratory recognized by authorities having jurisdiction, in accordance with BICSI and TIA standards before delivering to site. Affix label with name and date of [manufacturer's][qualified electrical testing laboratory's] certification of system compliance.
 - a. Factory test multimode optical fiber cables in accordance with TIA-526-14 and TIA-568.3.
 - b. Factory test preterminated optical fiber cable assemblies in accordance with TIA-526-14 and TIA-568.3.
 - 4. Nonconforming Work: Cables that do not pass tests and inspections will be considered defective.
 - 5. Factory Test Reports: Prepare and submit factory test and inspection reports.

PART 3 - EXECUTION

3.1 WIRING METHODS

- A. Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters[**and except in accessible ceiling spaces, attics, and gypsum board partitions where unenclosed wiring method may be used**]. Conceal raceway and cables except in unfinished spaces.
 - 1. Install plenum cable in environmental air spaces, including plenum ceilings.
 - 2. Comply with requirements for pathways specified in Section 270528 "Pathways for Communications Systems."

- B. Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.2 INSTALLATION OF HYBRID CABLES

- A. Comply with NECA 1, NECA 301, and BICSI N1.
- B. General Requirements for Cabling:
 - 1. Comply with TIA-568 Series of standards.
 - 2. Terminate all conductors; no cable may contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
 - 3. Cables may not be spliced.
 - 4. Secure and support cables at intervals not exceeding **30 inch (760 mm)** and not more than **6 inch (150 mm)** from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
 - 5. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
 - 6. Bundle, lace, and train cable to terminal points without exceeding manufacturer's limitations on bending radii. Use lacing bars and distribution spools.
 - 7. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
 - 8. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps may not be used for heating.
 - 9. In the communications equipment room, provide a **10 ft (3 m)** long service loop on each end of cable.
 - 10. Pulling Cable: Monitor cable pull tensions.
 - 11. Cable may be terminated on connecting hardware that is rack or cabinet mounted.
- C. Open-Cable Installation:
 - 1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
 - 2. Cable may not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.
- D. Installation of Cable Routed Exposed under Raised Floors:
 - 1. Install plenum-rated cable only.
 - 2. Install cabling after the flooring system has been installed in raised floor areas.
 - 3. Coil cable [**6 ft (2 m)**]**<Insert size>** long not less than [**12 inch (300 mm)**]**<Insert size>** in diameter below each feed point.
- E. Group connecting hardware for cables into separate logical fields.

3.3 FIRESTOPPING

- A. Comply with requirements in Section 078413 "Penetration Firestopping."
- B. Comply with TIA-569, Annex A, "Firestopping."

3.4 GROUNDING

- A. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems" for grounding conductors and connectors.
- B. Comply with TIA-607 and NECA/BICSI 607.
- C. Locate telecommunications grounding bus bar to minimize the length of bonding conductors. Fasten to wall, allowing at least **2 inch (50 mm)** clearance behind the grounding bus bar. Connect grounding bus bar with a minimum 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground. Connect rack grounding bus bar to the telecommunications ground bus bar or the telecommunications main ground bus bar.
 - 1. Bond the shield of shielded cable to patch panel and bond patch panel to SBB or PBB.

3.5 IDENTIFICATION

- A. Comply with TIA-606 and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.
- B. Identify system components, wiring, and cabling. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
 - 1. Administration Class: **[Class 1][Class 2][Class 3][Class 4]**.
 - 2. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.
- C. Comply with requirements in Section 099123 "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.
- D. Paint and label colors for equipment identification must comply with TIA-606 for **[Class 2][Class 3][Class 4]** level of administration[, **including optional identification requirements of this standard**].
- E. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect schedule with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.
- F. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, **[horizontal pathways and cables],[entrance pathways and cables,]** terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.
- G. Cable and Wire Identification:
 - 1. Label each cable within **4 inch (100 mm)** of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
 - 2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
 - 3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding **15 ft (4.5 m)**.
 - 4. Label each unit and field within distribution racks and frames.
 - 5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and -connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for

jacks and plugs of each service.

- H. Labels must be machine printed. Type must be [1/8 inch (3 mm)][3/16 inch (5 mm)][1/4 inch (6 mm)] in height.

3.6 FIELD QUALITY CONTROL

- A. Acceptance Testing Preparation:

- 1. <Insert requirements>.

- B. Field tests and inspections must be witnessed by [Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>.

- C. Tests and Inspections:

- 1. Visually inspect jacket materials for qualified electrical testing laboratory certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA-568.1.
 - 2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
 - 3. Optical Fiber Cable Tests:
 - a. Test instruments must comply with or exceed applicable requirements in TIA-568.1. Use only test cords and adapters that are recommended by test equipment manufacturer for channel or link test configuration.
 - b. Link End-to-End Attenuation Tests:
 - 1) Horizontal and Multimode Horizontal Link Measurements: Test at 850 or 1300 nm in one direction in accordance with TIA-526-14, Method B, One Reference Jumper.
 - 2) Attenuation test results for horizontal links must be less than 2.0 dB. Attenuation test results must be less than those calculated in accordance with equation in TIA-568.1.

- D. Data for each measurement must be documented. Data for submittals must be printed in a summary report, or transferred from the instrument to the computer, saved as text files, and printed and submitted.

- E. Nonconforming Work:

- 1. End-to-end cabling will be considered defective if it does not pass tests and inspections.
 - 2. Remove and replace cabling where test results indicate that it does not comply with specified requirements.

- F. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

- G. Manufacturer Services: Engage factory-authorized service representative to [support][supervise] field tests and inspections.

- 1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at Project site.



3.7 PROTECTION

- A. After installation, protect cables and cable hardware from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 27 16 00 00



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Task	Specification	Specification Description
27 16 16 00	27 13 23 00	Communications Optical Fiber Backbone Cabling
27 16 16 00	27 16 00 00	Communications Hybrid Cabling
27 16 19 00	26 05 19 00	Low-Voltage Electrical Power Conductors and Cables
27 16 19 00	27 13 23 00	Communications Optical Fiber Backbone Cabling
27 16 19 00	27 16 00 00	Communications Hybrid Cabling
27 21 16 00	27 13 23 00	Communications Optical Fiber Backbone Cabling
27 32 13 00	26 27 26 00	Wiring Devices



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SECTION 27 41 23 00 - EDUCATIONAL INTERCOMMUNICATIONS AND PROGRAM SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. The Work of this Section includes microprocessor-switched intercommunications microprocessor-switched, IP-based telephone/intercommunications and program systems with the following components:
 - 1. Administrative console for microprocessor-switched systems.
 - 2. Call control console.
 - 3. Staff and classroom telephone stations.
 - 4. Speaker-microphone stations.
 - 5. Call-switch unit.
 - 6. All-call amplifier.
 - 7. Intercommunication amplifier.
 - 8. Paging amplifier.
 - 9. Cone-type loudspeakers/speaker microphones.
 - 10. Horn-type loudspeakers/speaker microphones.
 - 11. Local Area Network: **[Expansion of existing system][Dedicated new system]**.
- B. Related Requirements:
 - 1. Section 260523 "Control-Voltage Electrical Power Cables" for control systems communications cables and Classes 1, 2 and 3 control cables.
 - 2. Section 271513 "Communications Horizontal Cabling" for cabling used for voice and data circuits.

1.2 DEFINITIONS

- A. DHCP: Dynamic Host Configuration Protocol.
- B. FXO: Foreign eXchange Office.
- C. H.323: Audio and Video Protocol.
- D. SIP: Session Initiation Protocol.

1.3 ACTION SUBMITTALS

- A. Product Data:
 - 1. Administrative console for microprocessor-switched systems.
 - 2. Call control console.
 - 3. Staff and classroom telephone stations.
 - 4. Speaker-microphone stations.
 - 5. Call-switch unit.
 - 6. All-call amplifier.
 - 7. Intercommunication amplifier.
 - 8. Paging amplifier.

9. Cone-type loudspeakers/speaker microphones.
10. Horn-type loudspeakers/speaker microphones.
11. Local Area Network: **[Expansion of existing system][Dedicated new system]**.

B. Shop Drawings: For educational intercommunications and program systems.

1. Include plans, elevations, sections, and **[mounting][attachment]** details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include scaled drawings for **[administrative console][and][speaker-microphone station]** station arrangement of built-in equipment.
4. Include diagrams for power, signal, and control wiring.
 - a. Identify terminals to facilitate installation, operation, and maintenance.
 - b. Single-line diagram showing interconnection of components.
 - c. Cabling diagram showing cable routing.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings:

1. Reflected ceiling plans, drawn to scale, on which ceiling-mounted items including luminaires, diffusers, grilles, speakers, sprinklers, access panels, and special moldings are shown and coordinated with each other, using input from installers of the items involved.
2. Elevation drawings, drawn to scale, on which wall-mounted items including luminaires, intercommunications components, windows, doors, access panels, wall finishes, trims, piping, and conduit are shown and coordinated with each other, using input from installers of the items involved.

B. Qualification Data: For **[Installer][and][testing agency]**.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For educational intercommunications and program systems to include in operation and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. A record of final matching transformer-tap settings and signal ground-resistance measurement certified by Installer.
2. A record of Owner's equipment-programming option decisions.
3. Plans, drawn to scale, indicating location, designation, and connection of intercommunications system components.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On USB media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.



1.6 QUALITY ASSURANCE

- A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.
- B. Testing Agency Qualifications: Qualified agency, with the experience and capability to conduct testing indicated.
 - 1. Testing Agency's Field Supervisor:
 - a. Certified by NICET as Audio Systems **[Level II][Level III]** Technician.
 - b. **<Insert qualification>**.

1.7 COORDINATION

- A. Coordinate layout and installation of ceiling-mounted speaker microphones and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.1 EDUCATIONAL INTERCOMMUNICATIONS AND PROGRAM SYSTEMS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Bogen Communications, Inc]**
 - 2. **[Code Blue Corporation]**
 - 3. **[Jeron Electronic Systems, Inc]**
 - 4. **[Rauland-Borg Corporation]**
 - 5. **[Valcom, Inc.]**
 - 6. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Bogen Communications, Inc]**
 - 2. **[Code Blue Corporation]**
 - 3. **[Jeron Electronic Systems, Inc]**
 - 4. **[Rauland-Borg Corporation]**
 - 5. **[Valcom, Inc.]**
 - 6. **<Insert manufacturer's name>**

2.2 SYSTEM DESCRIPTION

- A. Equipment: Modular type using solid-state components, fully rated for continuous duty unless otherwise indicated. Select equipment for normal operation on input power usually supplied at 110 to 130 V, 60 Hz in a satisfactory manner without the requirement of any external power conditioning equipment. Comply with UL 813.
- B. Expansion Capability: Increase number of stations in the future by **[25]<Insert number>** percent above

those indicated without adding any internal or external components or main trunk cable conductors.

- C. Integration: Coordinate features and select components to form an integrated system. Match components and interconnections for optimum performance of specified functions.
- D. Local Area Network: The system will utilize a LAN for the connectivity of all devices and components within the facility for the transmission of electronic data. The LAN will be an expansion to the existing or a separate standalone structure in support of the intercommunication system as dictated by the project design documents.
- E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for location and application.
- F. Weather-Resistant Equipment: Listed and labeled by an NRTL for duty outdoors or in damp locations.

2.3 FUNCTIONAL DESCRIPTION OF MICROPROCESSOR-SWITCHED SYSTEMS

A. Administrative Console:

- 1. Communicating selectively with other administrative and speaker-microphone stations by dialing station's number on a 12-digit keypad.
- 2. Communicating with individual stations in privacy.
- 3. Communicating on a minimum of three voice channels with up to two simultaneous conversations between administrative consoles and one conversation between an administrative console and a speaker-microphone station.
- 4. Increasing the number of conversation channels by adding a module in central-control cabinet.
- 5. Include up to three other station connections in a conference call.
- 6. Access separate paging speakers or groups of paging speakers by dialing designated numbers on a 12-digit keypad.
- 7. Display indicates selected station, originating station call, all-call, zone page, normal or emergency status of call(s), and time/date.
- 8. Communicating simultaneously with all other stations by dialing a designated number on a 12-digit keypad.
- 9. Automatic control of gain to ensure constant intercom speech level.
- 10. Controlling simultaneous distribution of program material to various combinations of speaker-microphone stations or groups over two program channels by using keypad to control sources and distribute programs.
- 11. Operating and controlling class-change signals to speakers and bells by using keypad.
- 12. User-programmable features include the following:
 - a. Station calling by room number.
 - b. Room station call-in priority levels.
 - c. Audible signal schedule functions.
 - d. Schedule characteristics of audible signals.
 - e. Call-in tone characteristic.
 - f. Grouping of rooms and speakers into zones for paging and program distribution purposes.

B. Speaker-Microphone Station:

- 1. Remote monitoring without a warning tone signal at monitored station. Designated speaker-microphone stations have a privacy switch to prevent another station from listening and to permit incoming calls.
- 2. Communicating hands free.
- 3. Calling administrative console by actuating call switch.

4. Returning a busy signal to indicate that station is already in use.
- C. Speakers: Free of noise and distortion during operation and when in standby mode.

2.4 FUNCTIONAL DESCRIPTION OF IP-BASED TELEPHONE/INTERCOMMUNICATION SYSTEMS

A. Integrated central system with the following:

1. Direct-dial, full duplex private telephone communications between all locations equipped with telephones **[and IP-addressable speaker-microphone]**. Call initiation among administrative consoles and between administrative consoles and remote stations by dialing station's number on a 12-digit keypad.
2. **[16]<Insert number>** channels for unrestricted simultaneous communications.
3. Initial system operation with **<Insert number>** administrative console and remote stations, expandable to 720 stations.
4. Direct-dial, two-way amplified voice intercommunication between administrative console telephones and remote stations without use of press-to-talk or talk-listen switches.
5. Automatic queuing for intercommunication channels, with automatic call waiting.
6. Call transfer among administrative consoles.
7. Display of selected station and answering calling station by pressing a single "response button."
8. Simultaneous communication with other stations on system by dialing a designated number on a 12-digit keypad.
9. Automatic gain control to ensure constant intercom speech level.
10. Simultaneous distribution of emergency announcements to all locations equipped with speakers by dialing a predetermined code number.
11. User-selectable facility for providing selected telephone stations with dial tone for external telephone calls.
12. Assignment of speaker locations within any one or more of eight zones for zone paging or time signal reception.
13. Digital readout displays on which up to three incoming calls are displayed with additional calls stored for subsequent display.
14. Off-site diagnostics to monitor system functions, operations, and faults through a serial data port on central-control station.
15. Control of simultaneous distribution of program material to various combinations of remote stations or groups by using keypad to control sources and distribute programs.
16. User-programmable features include the following:
 - a. Station calling by room number.
 - b. Room station call-in priority levels.
 - c. Audible signal schedule functions.
 - d. Schedule characteristics of audible signals.
 - e. Call-in tone characteristic.
 - f. Precedence among administrative consoles as destinations for incoming calls from room stations.
 - g. Grouping rooms and speakers into zones for paging and program distribution purposes.
17. Telephone interconnect shall be capable of accepting H.323, SIP, and FXO type protocols and include the following features:
 - a. Direct connection to central office trunk lines with initial system wiring for **<Insert number>** trunk lines.
 - b. Routing of outside trunk lines for "attendant answer incoming" and "direct inward line" functions.
 - c. Station programming for access to outside trunk lines to be any of the following:

- 1) Totally unrestricted access.
 - 2) Restricted access.
 - 3) No access.
- d. System programming to allow or disallow local prefixes, and to authorize access for as many as three area codes.
- e. Discriminating ringing for identifying internal and outside calls.
- f. Circular hunting for outside trunks to prevent excess usage of any one trunk.
- g. Direct connection of a single trunk to designated telephone with transfer to attendant if unanswered.
- h. Call parking allowing paged party to remotely pick up outside call from any station.
- i. Night-answer mode to allow one or all of the following:
 - 1) Incoming call transferred to predetermined extension.
 - 2) Tone transmitted to speakers to notify key personnel to answer telephone.
 - 3) Dial tone to remote stations to allow answering call from all locations.
- j. Call control console to perform as follows:
 - 1) Identify, answer, and route incoming outside calls, with reminder and recall features.
 - 2) Directly access outside trunk lines.
 - 3) Hold, park, and transfer calls.
 - 4) Screen outside calls.

B. Remote Stations:**1. Staff and Classroom Telephone Station:**

- a. Corded handset or hands-free speakerphone operation.
- b. Capable of placing outside call.
- c. Ability to transfer calls.
- d. Call forwarding functions.
- e. Paging and emergency call placement.
- f. Speed-dial programming.
- g. Programmable restrictive functions.

2. Speaker-Microphone Station:

- a. Having privacy from remote monitoring without a warning tone signal at monitored station. Designated speaker-microphone stations have a privacy switch to prevent another station from listening and to permit incoming calls.
- b. Communicating hands free.
- c. Calling administrative console by actuating call switch.
- d. Returning a busy signal to indicate that station is already in use.

C. Speakers: Free of noise and distortion during operation and when in standby mode.**2.5 ADMINISTRATIVE CONSOLE FOR MICROPROCESSOR-SWITCHED SYSTEMS**

- A. 12-Digit Keypad Selector: Transmits calls to other stations and initiates commands for programming and operation.
- B. Volume Control: Regulates incoming-call volume.

- C. Tone Annunciation: Momentary audible tone signal announces incoming calls.
- D. LED Annunciation: Identifies calling stations and stations in use. LED remains on until call is answered.
- E. Speaker Microphone: Transmits intercom voice signals when used via a voice-operated switch.
 - 1. Minimum Speaker Sensitivity: 91 dB at one meter, with 1-W input.
- F. Hard Buttons: To transfer and place calls on hold.
- G. Reset Control: Cancels call and resets system for next call.
- H. Digital Display: 16-digit alphanumeric LCD readout to register up to four three-digit station numbers.
- I. Central-Equipment Cabinet: Comply with EIA/ECA-310-E. Lockable, ventilated metal cabinet houses terminal strips, power supplies, amplifiers, system volume control, and other switching and control devices required for conversation channels and control functions.

2.6 CALL CONTROL CONSOLE

- A. Microprocessor-based instrument to process outside and internal calls with a 12-digit keypad selector.
- B. 20-character alphanumeric display for the following:
 - 1. Simultaneous display of up to three calling stations plus last station dialed.
 - 2. Display of calls in order received with emergency calls taking precedence on the display.
 - 3. Review of calls stored in groups of four.
 - 4. Display of prompt messages to assist in system operation.
- C. Programmable Keys: Minimum of 20 with LED indicators for ringing/busy status; programmable for trunk and operator functions.
- D. Transfer Button: Calls to busy extensions and unanswered calls automatically returned to call control console.
- E. Hold Button: With reminder feature every 30 seconds for parked calls or calls placed on hold.
- F. Release Button: For use with parked calls or calls placed on hold.
- G. Page Button: For engaging system paging functions.
- H. Programmable for night answer, remote answer, and remote pickup features.
- I. Programmable for distribution of emergency announcements, all-page announcements, zone-page announcements, and emergency/evacuation alert.
- J. Central-Control Cabinet Equipment: Central switching equipment, central office adapter module, line link modules, power supplies, chassis adapters, and other switching and control devices required for trunk and internal conversation channels and control functions.

2.7 STAFF AND CLASSROOM TELEPHONE STATIONS

- A. Faceplate: Stainless steel or anodized aluminum with tamperproof mounting screws.

- B. Enclosure: Galvanized steel with **2-1/2-inch (64-mm)** minimum depth.
- C. 12-Digit Keypad: Input device to initiate calls and commands.
- D. Volume Control: Regulates incoming-call volume.
- E. Tone Annunciation: Momentary audible tone signal announces incoming calls.
- F. LED Annunciation: Identifies calling stations and stations in use. Lamp remains on until call is answered.
- G. Speaker Microphone: Transmits intercom voice signals when used via a voice-operated switch.
 - 1. Minimum Speaker Sensitivity: 91 dB at one meter, with 1-W input.
- H. Handset with Hook Switch: Telephone type with **18-inch- (450-mm-)** long, permanently coiled cord. Arrange to disconnect speaker when handset is lifted.

2.8 SPEAKER-MICROPHONE STATIONS

- A. Mounting: Flush unless otherwise indicated, and suitable for mounting conditions indicated.
- B. Faceplate: Stainless steel or anodized aluminum with tamperproof mounting screws.
- C. Enclosure: Two-gang galvanized steel with **2-1/2-inch (64-mm)** minimum depth.
- D. Speaker: Minimum axial sensitivity shall be 91 dB at one meter, with 1-W input. Voice coil shall be not less than **3 inches (76 mm), 2.3 oz. (65 g)** minimum; permanent magnet.
- E. Tone Annunciation: Recurring momentary tone indicates incoming calls.
- F. Call Switch: Mount on faceplate. Permits calls to administrative console.
- G. Privacy Switch: Mount on faceplate. When in on position, switch prevents transmission of sound from remote station to system; when in off position, without further switch manipulation, response can be made to incoming calls.

2.9 CALL-SWITCH UNIT

- A. Mounting: Flush unless otherwise indicated, and suitable for mounting conditions indicated.
- B. Faceplate: Stainless steel or anodized aluminum with tamperproof mounting screws.
- C. Enclosure: Single-gang box with stainless-steel faceplate.
- D. Call Switch: Momentary contact signals system that a call has been placed.
- E. Privacy Switch: Prevents transmission of sound signals from station to system.
- F. Volume Control: Operated by screwdriver blade through a hole in faceplate to adjust output level of associated speaker.

2.10 ALL-CALL AMPLIFIER

- A. Output Power: 70-V balanced line. **[80 percent of the sum of wattage settings of connected]<Insert wattage>** for each station and speaker connected in all-call mode of operation, plus an allowance for future stations.
- B. Total Harmonic Distortion: Less than 5 percent at rated output power with load equivalent to quantity of stations connected in all-call mode of operation.
- C. Minimum Signal-to-Noise Ratio: 60 dB, at rated output.
- D. Frequency Response: Within plus or minus 2 dB from 50 to 12,000 Hz.
- E. Output Regulation: Maintains output level within 2 dB from full to no load.
- F. Input Sensitivity: Compatible with administrative console and central equipment so amplifier delivers full-rated output with sound-pressure level of less than 10 dynes/sq. cm impinging on administrative console, speaker microphones, or handset transmitters.
- G. Amplifier Protection: Prevents damage from shorted or open output.

2.11 INTERCOMMUNICATION AMPLIFIER

- A. Minimum Output Power: 15 W; adequate for all functions.
- B. Total Harmonic Distortion: Less than 5 percent at rated output power with load equivalent to one station connected to output terminals.
- C. Minimum Signal-to-Noise Ratio: 50 dB, at rated output.
- D. Frequency Response: Within plus or minus 3 dB from 70 to 10,000 Hz.
- E. Output Regulation: Maintains output level within 2 dB from full to no load.
- F. Input Sensitivity: Matched to input circuit and to provide full-rated output with sound-pressure level of less than 10 dynes/sq. cm impinging on microphones in administrative console, speaker microphones, or handset transmitters.
- G. Amplifier Protection: Prevents damage from shorted or open output.

2.12 PAGING AMPLIFIER

- A. Input Voltage: 120-V ac, 60 Hz.
- B. Frequency Response: Within plus or minus 3 dB from 60 to 10,000 Hz.
- C. Minimum Signal-to-Noise Ratio: 60 dB, at rated output.
- D. Total Harmonic Distortion: Less than 3 percent at rated output power from 70 to 12,000 Hz.
- E. Output Regulation: Less than 2 dB from full to no load.
- F. Controls: On-off, input levels, and low-cut filter.

- G. Input Sensitivity: Matched to input circuit and to provide full-rated output with sound-pressure level of less than 10 dynes/sq. cm impinging on speaker microphones or handset transmitters.
- H. Amplifier Protection: Prevents damage from shorted or open output.

2.13 CONE-TYPE LOUDSPEAKERS/SPEAKER MICROPHONES

- A. Minimum Axial Sensitivity: 91 dB at one meter, with 1-W input.
- B. Frequency Response: Within plus or minus 3 dB from 70 to 15,000 Hz.
- C. Minimum Dispersion Angle: 100 degrees.
- D. Line Transformer: Maximum insertion loss of 0.5 dB, power rating equal to speaker's, and at least four level taps.
- E. Enclosures: Steel housings or back boxes, acoustically dampened, with front face of at least **0.0478-inch (1.2-mm)** steel and whole assembly rust proofed and factory primed; complete with mounting assembly and suitable for surface ceiling, flush ceiling, pendant or wall mounting; with relief of back pressure.
- F. Baffle: For flush speakers, minimum thickness of **0.032-inch (0.8-mm)** aluminum [**brushed to a satin sheen and lacquered**][**with textured white finish**]**<Insert finish>**.
- G. Vandal-Proof, High-Strength Baffle: For [**flush**][**surface**]-mounted speakers, self-aging cast aluminum with tensile strength of **44,000 psi (303 MN/sq. m)**, **0.025-inch (0.65-mm)** minimum thickness; countersunk heat-treated alloy mounting screws; and textured white epoxy finish.
- H. Size: **8 inches (200 mm)** with **1-inch (25-mm)** voice coil and minimum **5-oz. (140-g)** ceramic magnet.

2.14 HORN-TYPE LOUDSPEAKERS/SPEAKER MICROPHONES

- A. Speakers shall be all-metal, weatherproof construction; complete with universal mounting brackets.
- B. Frequency Response: Within plus or minus 3 dB from 275 to 14,000 Hz.
- C. Minimum Power Rating of Driver: 15 W, continuous.
- D. Minimum Dispersion Angle: 110 degrees.
- E. Line Transformer: Maximum insertion loss of 0.5 dB, power rating equal to speaker's, and at least four level taps.

2.15 IP ADDRESSABLE MODULES

- A. Modules utilized for the operation of the intercommunication and paging functions.
 - 1. POE 802.3af compliant.
 - 2. Support DHCP.
 - 3. RJ45 connectivity.

B. Speaker Modules:

1. Interface with speaker and multiple call switches.
2. Capable of providing privacy function for speaker/microphone when activated.
3. Rated for installation within air plenum spaces.

PART 3 - EXECUTION

3.1 WIRING METHODS

- A. Wiring Method, Raceways: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters[, **and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used**]. Conceal raceway and cables except in unfinished spaces.
1. Install plenum cable in environmental air spaces, including plenum ceilings.
 2. Comply with requirements for raceways and boxes specified in Section 270528 "Pathways for Communications Systems."
- B. Wiring Method, Concealed: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- C. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

3.2 INSTALLATION OF CABLES

- A. Comply with NECA 1.
- B. General Requirements:
1. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at outlets and terminals.
 2. Splices, Taps, and Terminations: Arrange on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Cables may not be spliced.
 3. Secure and support cables at intervals not exceeding **30 inches (760 mm)** and not more than **6 inches (150 mm)** from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
 4. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
 5. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
 6. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used.
- C. Open-Cable Installation:
1. Install cabling with horizontal and vertical cable guides in telecommunication spaces with terminating hardware and interconnection equipment.
 2. Suspend cable not in a wireway or pathway a minimum of **8 inches (200 mm)** above ceiling by cable supports not more than **[60 inches (1524 mm)]<Insert dimension>** apart.
 3. Cable shall not be run through structural members or be in contact with pipes, ducts, or other potentially damaging items.



- D. Separation of Wires: Separate speaker-microphone, line-level, speaker-level, and power wiring runs. Install in separate raceways or, where exposed or in same enclosure, separate conductors at least **12 inches (300 mm)** apart for speaker microphones and adjacent parallel power and telephone wiring. Separate other intercommunication equipment conductors as recommended by equipment manufacturer.

3.3 INSTALLATION

- A. Match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.
- B. Identification of Conductors and Cables: Color-code conductors and apply wire and cable marking tape to designate wires and cables so they identify media in coordination with system wiring diagrams.
- C. Weatherproof Equipment: For units that are mounted outdoors, in damp locations, or where exposed to weather, install consistent with requirements of weatherproof rating.
- D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- E. Mounting of Stations: Surface mount at **54 inches (137.2 cm)** above finished floor to center of station unless otherwise indicated.

3.4 INSTALLATION OF GROUNDING

- A. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
- B. Signal Ground Terminal: Locate at main equipment cabinet. Isolate from power system and equipment grounding.
- C. Install grounding electrodes as specified in Section 260526 "Grounding and Bonding for Electrical Systems."

3.5 SYSTEM PROGRAMMING

- A. Programming: Fully brief Owner on available programming options. Record Owner's decisions and set up initial system program. Prepare a written record of decisions, implementation methodology, and final results.

3.6 FIELD QUALITY CONTROL

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

1. Schedule tests with at least seven days' advance notice of test performance.
 2. After installing educational intercommunications and program systems and after electrical circuitry has been energized, test for compliance with requirements.
 3. Operational Test: Test originating station-to-station[, **all-call, and page**] messages at each intercommunication station. Verify proper routing and volume levels and that system is free of noise and distortion. Test each available message path from each station on system.
 4. Frequency Response Test: Determine frequency response of two transmission paths[, **including all-call and paging,**] by transmitting and recording audio tones. Minimum acceptable performance is within 3 dB from 150 to 2500 Hz.
 5. Signal-to-Noise Ratio Test: Measure signal-to-noise ratio of complete system at normal gain settings as follows:
 - a. Disconnect speaker microphone and replace it in the circuit with a signal generator using a 1000-Hz signal. Measure signal-to-noise ratio at[**paging**] speakers.
 - b. Repeat test for three speaker microphones, [**and**]one administrative console microphone[, **and for each separately controlled zone of paging loudspeakers**].
 - c. Minimum acceptable ratio is 45 dB.
 6. Distortion Test: Measure distortion at normal gain settings and rated power. Feed signals at frequencies of 150, 200, 400, 1000, and 2500 Hz into each intercom[, **paging, and all-call amplifier**]. For each frequency, measure distortion in the paging and all-call amplifier outputs. Maximum acceptable distortion at any frequency is 5 percent total harmonics.
 7. **[Acoustic Coverage Test: Feed pink noise into system using octaves centered at 500 and 4000 Hz. Use sound-level meter with octave-band filters to measure level at five locations in each paging zone. Maximum permissible variation in level is plus or minus 3 dB; in levels between adjacent zones, plus or minus 5 dB.]**
 8. Power Output Test: Measure electrical power output of each paging amplifier at normal gain settings of 150, 1000, and 2500 Hz. Maximum variation in power output at these frequencies is plus or minus 3 dB.
 9. Signal Ground Test: Measure and report ground resistance at system signal ground. Comply with testing requirements in Section 260526 "Grounding and Bonding for Electrical Systems."
- E. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified. Prepare a list of final tap settings of paging and independent room speaker-line matching transformers.
- F. Educational intercommunications and program systems will be considered defective if they do not pass tests and inspections.
- G. Prepare test and inspection reports.

3.7 STARTUP SERVICE

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service and initial system programming.
1. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements.
 2. Complete installation and startup checks according to manufacturer's written instructions.

3.8 ADJUSTING

- A. On-Site Assistance: Engage a factory-authorized service representative to provide on-site assistance in adjusting sound levels, resetting transformer taps, and adjusting controls to meet occupancy conditions.



- B. Occupancy Adjustments: When requested within [12]<Insert number> months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to [two]<Insert number> visits to Project during other-than-normal occupancy hours for this purpose.

3.9 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain the educational intercommunications and program systems.
 - 1. Train Owner's maintenance personnel on programming equipment for starting up and shutting down, troubleshooting, servicing, and maintaining the system and equipment.

END OF SECTION 27 41 23 00



Task	Specification	Specification Description
27 41 23 00	26 33 43 00a	Public Address Systems



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SECTION 27 41 33 00 - MASTER ANTENNA TELEVISION SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. MATV equipment.
2. Off-air antennas.
3. MATV headend components.
4. Distribution components.

B. Related Sections:

1. Section 271313 "Communications Copper Backbone Cabling" for copper data cabling associated with system panels and devices.
2. Section 271323 "Communications Optical Fiber Backbone Cabling" for optical-fiber data cabling associated with system panels and devices.
3. Section 271333 "Communications Coaxial Backbone Cabling" for riser-rated coaxial data cabling associated with system panels and devices.
4. Section 271513 "Communications Copper Horizontal Cabling" for balanced twisted-pair optical-fiber cables and connectors.
5. Section 271523 "Communications Optical Fiber Horizontal Cabling" for optical-fiber cables and connectors.
6. Section 271533 "Communications Coaxial Horizontal Cabling" for coaxial cables and connectors.
7. Section 282000 "Video Surveillance" for cameras, monitors, computers, and cabling for video surveillance systems.

1.2 DEFINITIONS

- A. Agile Receiver:** A broadband receiver that can be tuned to any desired channel.
- B. A/V:** Audio/visual.
- C. Broadband:** For the purposes of this Section, wide bandwidth equipment or systems that can carry signals occupying in the frequency range of 54 to 1002 MHz. A broadband communication system can simultaneously accommodate television, voice, data, and many other services.
- D. Carrier:** A pure-frequency signal that is modulated to carry information. In the process of modulation, the signal is spread out over a wider band. The carrier frequency is the center frequency on any television channel.
- E. CATV:** Community antenna television. A communication system that simultaneously distributes several different channels of broadcast programs and other information to customers via a coaxial cable.
- F. CCTV:** Closed-circuit television.
- G. CEA:** Consumer Electronics Association.
- H. db mV:** Decibels relative to 1 mV across 75 ohms. $db\ mV = 20 \log 10(V(1)/V(2))$, where V(1) is the



measurement of voltage at a point having identical impedance to V(2) (0.001 V across 75 ohms).

- I. Headend: The control center of the MATV system, where incoming signals are amplified, converted, processed, and combined into a common cable along with any locally originated television signals, for transmission to user-interface points. It is also called the "central retransmission facility."
- J. I/O: Input/output.
- K. MATV: Master antenna television. A small television antenna distribution system usually restricted to one or two buildings.
- L. RF: Radio frequency.
- M. User Interface: End point of Contractor's responsibility for Work of this Section. User interfaces are the **[terminal blocks to which the end user may connect coaxial cabling][75-ohm terminals on device plates]<Define user-interface points>**.

1.3 ACTION SUBMITTALS

- A. Product Data:
 - 1. MATV equipment.
 - 2. Off-air antennas.
 - 3. MATV headend components.
 - 4. Distribution components.
- B. Shop Drawings: For headend and distribution system. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail fabrication and installation details for television equipment.
 - 2. Functional Block Diagram: Show single-line interconnections between components for headend and distribution system to user-interface points. Show cable types and sizes.
 - 3. Dimensioned Plan and Elevations of Headend Equipment: Show access and workspace requirements.
 - 4. Wiring Diagrams: For power, signal, and control wiring. Balanced twisted-pair or optical-fiber cable include cross connects, patch panels, and patch cords.
- C. Samples: Full size for each outlet device plate in required colors and textures.
- D. Design Calculations: Calculate signal attenuation budget and show calculated line and equipment losses for the system based on the functional block diagram, to show that proposed system layout can be expected to perform up to specification. Calculate signal strength from sources to headend input points for each antenna, satellite dish, and CATV grouping. Allowable losses between components and user interface shall be used to determine size and type of coaxial cable.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Include dimensioned plan and elevation views of components and enclosures. Show access and workspace requirements.
- B. Equipment List: Include each piece of equipment and include model number, manufacturer, serial number, location, and date of original installation. Insert testing record of each piece of adjustable

equipment, listing name of person testing, date of test, and description of as-left set points.

- C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For headend and distribution system to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents. Provide no fewer than one of each item listed below. Deliver extra materials to Owner.

1. Fuses: One for every [10]<Insert number> of each type and rating.
2. Splitters: One for every [10]<Insert number> installed.
3. MATV Distribution Power Amplifiers: One for every [10]<Insert number> of each type installed.
4. MATV Signal Traps: [One]<Insert number> for every [10]<Insert number> of each type used.
5. MATV Attenuators: [One]<Insert number> for every [10]<Insert number> of each type used.
6. Cable: 100 feet (30 m) of each type used.

1.7 PROJECT CONDITIONS

- A. Environmental Limitations: System components shall be equipped and rated for the environments in which they are installed.
- B. Environmental Conditions: Capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
1. Interior, Controlled Environment: System components, except central-station control unit, installed in [air-conditioned][temperature-controlled] interior environments shall be rated for continuous operation in ambient conditions of [36 to 122 deg F (2 to 50 deg C)]<Insert temperature range> dry bulb and 20 to 90 percent relative humidity, noncondensing.
 2. Interior, Uncontrolled Environment: System components installed in non-[air-conditioned][temperature-controlled] interior environments shall be rated for continuous operation in ambient conditions of [0 to 122 deg F (minus 18 to plus 50 deg C)]<Insert temperature range> dry bulb and 20 to 90 percent relative humidity, noncondensing.
 3. Exterior Environment: System components installed in locations exposed to weather shall be rated for continuous operation in ambient conditions of [minus 30 to plus 122 deg F (minus 34 to plus 50 deg C)]<Insert temperature range> dry bulb and 20 to 90 percent relative humidity, condensing. Rate for continuous operation when exposed to rain as specified in NEMA 250, winds up to [85 mph (137 km/h)]<Insert wind speed>[and snow cover up to 24 inches (610 mm) thick].

1.8 COORDINATION

- A. Coordinate size and location of raceway system and provisions for electrical power to equipment specified in this Section.
- B. Coordinate Work of this Section with requirements of [cable television service][direct broadcast



satellite service][an off-air antenna system][CCTV cameras and video recorders] service provider.

- C. Coordinate sizes and locations of concrete bases with actual equipment provided.
- D. Coordinate installation of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. System shall consist of **[cable television service][direct broadcast satellite service][an off-air antenna system][CCTV cameras and video recorders]** and a coaxial cable distribution system.
 - 1. Headend equipment shall consist of receiving antennas, satellites, and associated signal distribution amplification and equalization.
 - 2. Distribution of direct broadcast satellite-service signals, which includes coordinating with Owner's selected service provider for installation of its dish-type antennas and processing the signals as needed to provide specified services combined into a single-feed point ready for connection into the distribution system. Obtain signal levels and noise and distortion characteristics from service provider as the point of departure for system layout and final equipment selection.
 - 3. Distribution of cable television service signals, which includes coordinating with Owner's selected service provider for installation of cable to the service point ready for connection into the distribution system. Obtain signal levels and noise and distortion characteristics from service provider as the point of departure for system layout and final equipment selection.
 - 4. Cable distribution system consisting of coaxial cables, user interfaces, signal taps and splitters, RF amplifiers, signal equalizers, power supplies, and required hardware, complying with EIA/ECA 310-E and CTA-2032-B and resulting in performance parameters specified in this Section. System shall be capable of distributing television channels according to CTA-542-D.
- B. Hardware Requirements: Use plug-in, modular, solid-state electronic components. Mount amplifiers and other powered equipment in standard **19-inch (483-mm)** cabinet complying with EIA/ECA 310-E.
- C. Off-Air Stations: Install antennas for the reception and distribution of selected stations.

2.2 PERFORMANCE REQUIREMENTS

- A. Minimum acceptable performance of distribution system at all user-interface points shall be as follows:
 - 1. RF Video-Carrier Level: Between 3 and 12 db mV.
 - 2. Relative Video-Carrier Level: Within 3 db to adjacent channel.
 - 3. Carrier Level Stability, Short Term: Level shall not change more than 0.5 db during a 60-minute period.
 - 4. Carrier Level Stability, Long Term: Level shall not change more than 2 db during a 24-hour period.
 - 5. Channel Frequency Response: Across any 6-MHz channel in the 54- to 220-MHz frequency range, referenced to video; signal amplitude shall be plus or minus 1 db, maximum.
 - 6. Carrier-to-Noise Ratio: 45 db or more.
 - 7. RF Visual Signal-to-Noise Ratio: 43 db or more.
 - 8. Antenna Combiner Insertion Loss: 40 db maximum.
 - 9. Signal Power Splitter and Isolation Tap Return Loss: 17 db maximum.
 - 10. Cable Connectors Attenuation: Less than 0.1 db.

11. Cross Modulation: Less than minus 50 db.
12. Carrier-to-Echo Ratio: More than 40 db.
13. Composite Triple Beat: Less than minus 53 db.
14. Second Order Beat: Less than minus 60 db.
15. Terminal Isolation from Television to Television: 25 db, minimum.
16. Terminal Isolation between Television and FM: 35 db, minimum.
17. Hum Modulation: 2 percent, maximum.
18. RF FM Carrier Level: 13 to 17 db below video-carrier level.
19. FM Frequency Response: More than in the 88- to 108-MHz frequency range; signal amplitude is plus or minus 0.75 db, maximum.
20. FM Carrier-to-Noise Ratio: More than 24 db.

2.3 SYSTEM REQUIREMENTS

- A. Components: Plug-in, modular, heavy-duty, industrial- or commercial-grade units.
- B. Equipment: Silicon-based, solid-state, integrated circuit devices.
- C. Power Supply Characteristics: Devices shall be within specified parameters for ac supply voltages within the range of 105 to 130 V.
- D. Protect signal cables and connected components against transient-voltage surges by suppressors and absorbers designed specifically for that purpose. Comply with requirements in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."
- E. Provide ac-powered equipment with integral surge protection devices complying with UL 1449.
- F. RF and Video Impedance Matching: Signal-handling components, including connecting cable, shall have end-to-end impedance-matched signal paths. Match and balance devices used at connections where it is impossible to avoid impedance mismatch or mismatch of balanced circuits to unbalanced circuits.
- G. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.4 MATV EQUIPMENT

- A. Description: Signal-source components, signal-processing and amplifying equipment, distribution components, and interconnecting wiring. System shall receive, amplify, process, and distribute signals to outlets for receiving sets. Equipment shall translate UHF channels to VHF channels before distribution to outlets.
- B. Identification of Signal Sources Distributed:
 1. **<Insert signal sources and basic service selection>.**
- C. MATV System Qualitative and Quantitative Performance Requirements: Reception quality of color-television program transmissions at each system outlet from each service and source shall be equal to or superior than that obtained with performance checks specified in "Field Quality Control" Article, using standard, commercial, cable-ready, multiple A/V input color-television receivers.



2.5 OFF-AIR ANTENNAS

- A. Antennas shall be tested, marked, and packaged, according to CTA-774-A, CEA-2028-B, and CEA-2032-B. Antennas shall be labeled according to CEA antenna mapping program.
- B. Off-Air, Mast-Mounted Antennas: Weatherproof single-channel or broadband type, constructed of high-strength anodized aluminum and rated to survive in a **[100-mph (160-km/h)]<Insert speed>** wind, minimum.
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Channel Master]**
 - b. **[Winegard Company]**
 - c. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Channel Master]**
 - b. **[Winegard Company]**
 - c. **<Insert manufacturer's name>**
 - 3. Elements: Internally dampened against mechanical vibration that may occur in service.
 - 4. Ends of Crossarms and Elements: Sealed.
 - 5. Mounting and Connecting Hardware: Corrosion proof.
 - 6. Frequency Range: Matched to source frequencies.
 - 7. CEA Reception Patterns: **<Insert reception pattern and number of antennas>**.
 - 8. FM Antenna: Separate from the broadband antenna and the **[omnidirectional][directional]** antenna, with 2-db minimum gain.
- C. Antenna-Supporting Structures: Prefabricated, hot-dip galvanized-steel units.
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Channel Master]**
 - b. **[Winegard Company]**
 - c. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Channel Master]**
 - b. **[Winegard Company]**
 - c. **<Insert manufacturer's name>**
 - 3. Strength of Structure and Attachments: Adequate to withstand **[100-mph (160-km/h)]<Insert speed>** winds while supporting installed antennas.

4. Comply with 47 CFR 17 and TIA 222-G.
5. Comply with FAA AC 70/7460-1L.

2.6 MATV HEADEND COMPONENTS

A. Headend Equipment:

1. Components:

- a. Channel mixers.
- b. Processors.
- c. Broadband amplifier.
- d. Single-channel amplifiers.
- e. FM module.
- f. Combining networks.

2. Description: For receiving off-air television and FM signals and outputting the signals to cable distribution system. Equip coaxial down-leads of the off-air antennas with preamplifiers to send signals at strength required by headend. Headend component performance specified in this article is minimum acceptable; better performance may be required to comply with minimum acceptable system performance standard in "Performance Requirements" Article.

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

- a. **[ARRIS]**
- b. **[ATX Networks Inc.]**
- c. **[Blonder Tongue Laboratories, Inc]**
- d. **[Cisco Systems, Inc.]**
- e. **<Insert manufacturer's name>**

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

- a. **[ARRIS]**
- b. **[ATX Networks Inc.]**
- c. **[Blonder Tongue Laboratories, Inc]**
- d. **[Cisco Systems, Inc.]**
- e. **<Insert manufacturer's name>**

5. House units in standard **19-inch (483-mm)** electronic equipment cabinet complying with EIA/ECA 310-E.

B. Antenna Combiner: Directional coupler design network, combining up to eight antenna signals into a single output. Frequency response of the device shall be 5 to 400 MHz, and the insertion loss between input ports shall be not less than 40 db.

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

- a. **[ATX Networks Inc.]**



- b. **[Blonder Tongue Laboratories, Inc]**
 - c. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ATX Networks Inc.]**
 - b. **[Blonder Tongue Laboratories, Inc]**
 - c. **<Insert manufacturer's name>**
- C. Down-Lead Preamplifiers: Antenna mast-mounted preamplifier, designed to boost antenna signal and contained in weatherproof housing; single-channel or broadband type. Install power supplies indoors at headend equipment, connected through power inserters to provide power to preamplifiers through the coaxial down-lead cable.
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ARRIS]**
 - b. **[ATX Networks Inc.]**
 - c. **[Blonder Tongue Laboratories, Inc]**
 - d. **[Channel Master]**
 - e. **[Leviton Manufacturing Co., Inc.]**
 - f. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ARRIS]**
 - b. **[ATX Networks Inc.]**
 - c. **[Blonder Tongue Laboratories, Inc]**
 - d. **[Channel Master]**
 - e. **[Leviton Manufacturing Co., Inc.]**
 - f. **<Insert manufacturer's name>**
 3. Frequency Response: Plus or minus 0.75 db.
 4. Minimum Input: Minus 20 db mV.
 5. Return Loss: 14 db.
 6. I/O Impedance: 75 ohms.
- D. Channel Mixers: Use for nonadjacent channels only.
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ATX Networks Inc.]**
 - b. **[Blonder Tongue Laboratories, Inc]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ATX Networks Inc.]**
 - b. **[Blonder Tongue Laboratories, Inc]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **<Insert manufacturer's name>**
 3. Insertion Loss (Maximum 54 to 216 MHz): 2.5 db.
 4. Return Loss: 14 db.
 5. Out-of-Band Rejection: 12 db.
 6. I/O Impedance: 75 ohms.
- E. Processors: One for each channel to be translated.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ARRIS]**
 - b. **[ATX Networks Inc.]**
 - c. **[Blonder Tongue Laboratories, Inc]**
 - d. **[Cisco Systems, Inc.]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ARRIS]**
 - b. **[ATX Networks Inc.]**
 - c. **[Blonder Tongue Laboratories, Inc]**
 - d. **[Cisco Systems, Inc.]**
 - e. **<Insert manufacturer's name>**
 3. Bandwidth: 6 MHz.
 4. Return Loss: 16 db, within the 6-MHz bandwidth.
 5. Noise: Not more than 10 db at maximum gain.
 6. Input Level Range, VHF: Minus 20 to plus 30 db mV.
 7. Input Level Range, UHF: Minus 20 to plus 25 db mV.
 8. Output Level Range: 50 to 60 db mV.
 9. Carrier-to-Noise Ratio: Minus 57 db at plus 10-db mV input.
 10. Automatic Gain Control: Plus or minus 1-db output variation for rated input level range variation.
 11. Frequency Stability: Plus or minus 10 kHz over the operational temperature range.
 12. Spurious Output: 60 db below the video carrier with video-carrier output level at plus 60 db mV and audio-carrier level at plus 45 db mV.
 13. Adjacent Channel Rejection: Not less than 60 db.
 14. I/O Impedance: 75 ohms.
- F. Broadband Amplifier:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the**

following]:

- a. [ATX Networks Inc.]
- b. [Blonder Tongue Laboratories, Inc]
- c. [Leviton Manufacturing Co., Inc.]
- d. <Insert manufacturer's name>

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

- a. [ATX Networks Inc.]
- b. [Blonder Tongue Laboratories, Inc]
- c. [Leviton Manufacturing Co., Inc.]
- d. <Insert manufacturer's name>

- 3. Frequency Range: [54 to 108, 174 to 220][54 to 220] MHz.
- 4. Frequency Response: Plus or minus 1.0 db across passband.
- 5. Maximum Noise: 10 db.
- 6. Minimum Return Loss: 16 db.
- 7. I/O Impedance: 75 ohms.

G. Single-Channel Amplifiers:

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

- a. [ATX Networks Inc.]
- b. [Blonder Tongue Laboratories, Inc]
- c. [Cisco Systems, Inc.]
- d. [Leviton Manufacturing Co., Inc.]
- e. <Insert manufacturer's name>

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

- a. [ATX Networks Inc.]
- b. [Blonder Tongue Laboratories, Inc]
- c. [Cisco Systems, Inc.]
- d. [Leviton Manufacturing Co., Inc.]
- e. <Insert manufacturer's name>

- 3. Frequency: 6 MHz for specified channel.
- 4. Frequency Response: Plus or minus 0.5 db.
- 5. Maximum Noise: 10 db.
- 6. Minimum Return Loss: 14 db.
- 7. Automatic Gain Control: Plus or minus 1-db output variation for rated input level range variation.
- 8. Skirt Rejection: Minus 26 db at plus or minus 5 MHz from channel center.
- 9. Sound Trap: Adjustable to 10 Vdb of attenuation of the sound carrier.
- 10. I/O Impedance: 75 ohms.

H. FM Module: One RF processor module for each station listed.

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ATX Networks Inc.]**
 - b. **[Blonder Tongue Laboratories, Inc]**
 - c. **[Cisco Systems, Inc.]**
 - d. **[Leviton Manufacturing Co., Inc.]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ATX Networks Inc.]**
 - b. **[Blonder Tongue Laboratories, Inc]**
 - c. **[Cisco Systems, Inc.]**
 - d. **[Leviton Manufacturing Co., Inc.]**
 - e. **<Insert manufacturer's name>**
3. Frequency Range: Between 88 and 108 MHz.
4. Output Level: 52 db mV.
5. Output Level Control: Plus or minus 10 db.
6. Stability: 0.005 percent, crystal controlled.
7. Sensitivity: 3 mV for 30-db quieting.
8. Input Level: 60 mV, stereo.
9. Image Rejection: 901 db.
10. Passband: 200 kHz.
11. Selectivity: Plus or minus 150 kHz or less, at 30 db down. Plus or minus 250 kHz or less, at 50 db down.
- I. Combining Network (Mixer): Combines the off-air television **[FM][CCTV][and][CATV]** signals into a single-broadband output. An output test point, a 75-ohm television jack, a mixer output step attenuator dual-pilot insertion network, and a removable mixer-to-trunk jumper are included.
 1. Passband: As required by system performance.
 2. Distortion:
 - a. Not more than plus or minus 0.1 db over any 6-MHz segment.
 - b. Not more than plus or minus 0.5 db over the 54- to 216-MHz frequency range.
 3. Nominal Insertion Loss:
 - a. 15 db maximum, channel input to single-system output.
 - b. 13 db maximum, channel input to mixer output.
 - c. 20 db maximum at test point (e.g., loss from trunk output).
 4. Isolation between Any Two Inputs: 30 db.
 5. I/O Impedance: 70 ohms.

2.7 DISTRIBUTION COMPONENTS

- A. Signal Power Splitters and Isolation Taps: Metal-enclosed directional couplers with brass connector parts. Where installed in signal circuits used to supply cable-powered amplifiers, power throughput

capacity shall exceed load by at least 25 percent.

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ATX Networks Inc.]**
 - b. **[Leviton Manufacturing Co., Inc.]**
 - c. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ATX Networks Inc.]**
 - b. **[Leviton Manufacturing Co., Inc.]**
 - c. **<Insert manufacturer's name>**
 3. Return Loss: 17 db.
 4. RFI Shielding: 100 db.
 5. Isolation: 25 db.
 6. I/O Impedance: 75 ohms.
- B. Distribution System Amplifiers: Powered by coaxial cable system and equipped with surge protection device and external test points to allow convenient signal monitoring.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ARRIS]**
 - b. **[ATX Networks Inc.]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ARRIS]**
 - b. **[ATX Networks Inc.]**
 - c. **[Leviton Manufacturing Co., Inc.]**
 - d. **<Insert manufacturer's name>**
- C. Cable System Power Supplies: Plug-in, modular construction, with surge, short-circuit, and overload protection.
- D. Signal Traps: Packaged filters tuned to interference frequencies encountered in Project.
- E. Attenuators: Passive, of fixed value, and used to balance signal levels.
- F. Terminating Resistors: Enclosed units rated 0.5 W and matched for coaxial impedance.

- G. Jack: Flush, female-type outlets, designed to mimic power duplex outlet; for mounting in standard outlet box; with metallic parts of anodized brass, beryllium copper, or phosphor bronze. Cable connector mounting shall be semirecessed, so its protrusion is flush with the plane of device plate. **[Feed-through-type cable connection shall not be used][, except in area housing a single tenant][, except within a single-dwelling unit].**
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ARRIS]**
 - b. **[ATX Networks Inc.]**
 - c. **[Canare Corporation of America]**
 - d. **[Cisco Systems, Inc.]**
 - e. **[Leviton Manufacturing Co., Inc.]**
 - f. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ARRIS]**
 - b. **[ATX Networks Inc.]**
 - c. **[Canare Corporation of America]**
 - d. **[Cisco Systems, Inc.]**
 - e. **[Leviton Manufacturing Co., Inc.]**
 - f. **<Insert manufacturer's name>**
 3. Cable Connector: Female, Type F.
 4. Wall Plates: Match materials and finish of power outlets in same space.
 5. Attenuation: Less than 0.1 db.
 6. Voltage Standing-Wave Ratio: Less than 1.15 to 1.

2.8 ENCLOSURES

- A. Enclosures for Interior, Controlled Environments: NEMA 250, Type 1.
- B. Enclosures for Interior, Uncontrolled Environments: NEMA 250, **[Type 3R][Type 4][Type 12][Type 12K]**.
- C. Enclosures for Exterior Environments: NEMA 250, **[Type 3][Type 3R][Type 3S][Type 4][Type 4X]**.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for antenna to verify actual locations of cable connections before antenna installation.
- B. Examine walls, floors, roofs, equipment bases, and roof supports for suitable conditions where television equipment is to be installed.

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

3.2 INSTALLATION

- A. Install signal line surge suppressors on coaxial cables entering headend equipment space and at antenna-mounted amplifiers. Comply with requirements in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."
- B. Install antenna towers, masts, and mountings on concrete bases. Comply with requirements for concrete bases specified in Section 033000 "Cast-in-Place Concrete."
 - 1. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 2. Install anchor bolts to elevations required for proper attachment to supported equipment.

3.3 INSTALLATION OF ANTENNA AND HEADEND COMPONENTS

- A. Mount headend equipment in electronic equipment cabinets recommended by manufacturer. Group related items in methodical sequence.
- B. Arrange equipment to facilitate access for maintenance and to preserve headroom and passage space. Parts that require periodic service or maintenance shall be readily accessible. Headend components that require tuning adjustments shall be accessible from the front of equipment cabinets.
- C. Align antenna elements to achieve maximum signal level and quality.
- D. Antenna-Supporting Structure: Increase antenna height as required to obtain signal strength needed for specified system performance.
 - 1. Attachment to Building:
 - a. Use **0.375-inch- (10-mm-)** minimum expansion anchors for masonry, and place anchors clear of grout or mortar joints.
 - b. Use **0.375-inch- (10-mm-)** minimum lag bolts for attachment to wood.
 - 2. Lightning Protection: Comply with requirements in Section 264113 "Lightning Protection for Structures."
- E. Antenna Cable Entrance: Use weatherproof entrance fittings, and seal at penetrations of the building envelope.

3.4 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections:

1. Align and adjust system and pretest components, wiring, and functions to verify that they comply with specified requirements.
2. Replace malfunctioning or damaged items.
3. Retest until satisfactory performance and conditions are achieved.
4. Prepare television equipment for acceptance and operational testing.
5. Use an agile receiver and signal strength meter or spectrum analyzer for testing.
6. Off-Air, Mast-Mounted Antenna Sources: Connect receiver to the down-lead of a 10-element, single-channel antenna, tuned and oriented to optimize reception for the channel and placed at system antenna's location. Alternatively, connect receiver to a single-channel video amplifier connected to the down-lead of the above single-channel antenna.
7. CATV Sources: Connect receiver to an agile demodulator or CATV set-top converter at CATV service entrance to the facility.
8. Satellite Earth-Station System Sources: Adapt receiver to the output of satellite-television receiver.
9. CCTV Sources: Connect receiver to the output of each CCTV signal source or the distribution amplifier associated with it.
10. Test Schedule: Schedule tests after pretesting has successfully been completed and system has been in normal functional operation for at least 14 days. Provide a minimum of 10 days' notice of test schedule.
11. Operational Tests: Perform tests of operational system to verify that system complies with Specifications. Include all modes of system operation. Test equipment for proper operation in all functional modes.
12. Distribution System Acceptance Tests:
 - a. Field-Strength Instrument: Rated for minus 40-db mV measuring sensitivity and a frequency range of 54 to 812 MHz, minimum. Provide documentation of recent calibration against recognized standards.
 - b. Signal Level and Picture Quality: Use a field-strength meter or spectrum analyzer, and a standard television receiver to measure signal levels and check picture quality at **[all][25 percent of]<Insert number or percentage>** user-interface outlets.
 - 1) Test the signal strength in db mV at 55[, **151, 547,**] and 750 MHz.
 - 2) Minimum acceptable signal level is 0 db mV (1000 mV).
 - 3) Maximum acceptable signal level over the entire bandwidth is 15 db mV.
 - 4) Television receiver shall show no evidence of cross-channel intermodulation, ghost images, or beat interference.
13. Signal-to-Noise-Ratio Test: Use a field-strength meter to make a sequence of measurements at the output of the last distribution amplifier or of another agreed-on location in system. With system operating at normal levels, tune meter to the picture carrier frequency of each of the designated channels in turn, and record the level. With signal removed and input to corresponding headend amplifier terminated at 75 ohms, measure the level of noise at same tuning settings. With meter correction factor added to last readings, differences from first set must not be less than 45 db.
14. Qualitative and Quantitative Performance Tests: Demonstrate reception quality of color-television program transmissions at each user interface from each designated channel and source. Quality shall be equal to or superior than that obtained with performance checks specified below, using a standard, commercial, cable-ready, color-television receiver. Level and quality of signal at each outlet and from each service and source shall comply with the following Specifications when tested according to 47 CFR 76:
 - a. RF video-carrier level.
 - b. Relative video-carrier level.
 - c. Carrier level stability, during 60-minute and 24-hour periods.

- d. Broadband frequency response.
- e. Channel frequency response.
- f. Carrier-to-noise ratio.
- g. RF visual signal-to-noise ratio.
- h. Antenna combiner insertion loss.
- i. Signal power splitter loss.
- j. Cable connector attenuation.
- k. Cross modulation.
- l. Carrier-to-echo ratio.
- m. Composite triple beat.
- n. Second order beat.
- o. Terminal isolation.
- p. Terminal isolation between television and FM.
- q. Hum modulation.
- r. RF FM carrier level.
- s. FM frequency response.
- t. FM carrier-to-noise ratio.

- C. Headend and distribution system will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.
- E. Cap all unused connectors and seal weathertight.

3.6 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain MATV equipment.
 - 1. Train Owner's maintenance personnel on procedures and schedules for troubleshooting, servicing, and maintaining equipment.
 - 2. Demonstrate methods of determining optimum alignment and adjustment of components and settings for system controls.
 - 3. Demonstrate programming and tuning of satellite receivers.

END OF SECTION 27 41 33 00

SECTION 27 51 19 00 - SOUND MASKING SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Networked sound masking systems.
2. Standalone sound masking systems.

B. Products Installed, but Not Furnished, under This Section:

1. **<Insert products identified in "Existing Products to be Modified" Article or "Existing Products to be Removed and Re-Installed" Article>.**

C. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. **[Section 013100 "Project Management and Coordination"]<Insert Section number and title>** for preinstallation conference procedures.
5. Section 260533.13 "Conduit for Electrical Systems" specifies raceways installed by this Section.
6. Section 260533.16 "Boxes and Covers for Electrical Systems" specifies boxes installed by this Section.
7. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs installed by this Section.
8. Section 270528 "Pathways for Communications Systems"[**and Section 271100 "Communications Equipment Room Fittings"**] specifies additional requirements for raceway materials, routing, locations, and identification of communications equipment and cabling.
9. Section 271513 "Communications Copper Horizontal Cabling" specifies network cabling, loudspeaker cabling, and Class 2 control cabling installed by this Section.
10. **[Section 284600 "Fire Detection and Alarm"]&[Section 284700 "Mass Notification"]** specify coordination of sound masking systems with emergency alarms and paging.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at **[the Project site]<Insert location>**.

B. Preinstallation Coordination Meeting(s): For sound masking systems. Conduct meeting(s) **[as videoconference]&[or][at the Project site]<Insert location>** before **<Insert construction activity>**.

1. Attendees: Installers, fabricators, representatives of manufacturers, and administrators for field tests and inspections. Notify Architect[, **Construction Manager**][, **and Owner's Commissioning Authority**] of scheduled meeting dates.



1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing agency, certifying product's compliance with specified listing criteria.
 - a. If listed manufacturer differs from selling manufacturer, indicate relationship between entities on submittal. Clearly indicate which entity warrants product performance and fitness for purpose.
 - b. Listing criteria identified in approval letter must match specified listing criteria. UL label indicating approval of equipment's enclosure is not considered approval of equipment for intended application.
 - c. Product identification in approval letter must match product branding and model numbers in submittal. Approval letters for discontinued or superseded products are not acceptable for submitted product.
 - 2. Include manufacturer's sample extended warranty language.
- B. Shop Drawings: Prepare and submit the following:
 - 1. Include plans, elevations, sections, details, and attachments to other work.
 - 2. Include schematic of system and floor plan indicating quantity, type, and location of components.
 - 3. Include diagrams for power, signal, and control wiring.
 - 4. Include details supplementing assembly and installation instructions with dimensions, weights, loads, required clearances, methods of field assembly, components, and location and rating of each field connection.
 - 5. Shop drawings for installation of loudspeakers and cabling connecting to fire-alarm EVACS or mass notification systems must be prepared and signed by certified NICET FAS Senior Engineering Technician or NICET IBPSC Design Technician.
 - 6. **<Insert additional requirements for drawing content or format>.**
- C. Sustainable Design Submittals:
 - 1. Collect, assemble, and submit testing documentation indicating that sound masking system levels achieve sound isolation ratings for adjacent spaces required for LEED credit.
 - 2. Collect, assemble, and submit design documentation, indicating that sound-masking system levels that will be followed for installation and setup were set by acoustic professional and comply with specified limits and uniformity required for LEED credit.
- D. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

- A. Manufacturer's published instructions.
- B. Field Reports:
 - 1. Manufacturer's field reports for field quality-control support.
 - 2. Manufacturer's field reports for system startup support.
 - 3. Field reports for software and firmware upgrades.

1.5 CLOSEOUT SUBMITTALS

- A. Warranty documentation.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Spare parts.
- B. Extra stock material.
- C. Special tools.

1.7 REGULATORY AGENCY APPROVALS

- A. Submittals for sound masking systems connected to **[fire alarm][and][mass notification]** require approval by authorities having jurisdiction and must be signed and sealed by qualified life safety professional engineer responsible for their preparation. **[Obtain approval by authorities having jurisdiction prior to submitting for action by Architect.][Submit for action by Architect prior to submitting for approval by authorities having jurisdiction.]**
- B. Submittals for sound masking systems connected to **[fire alarm][and][mass notification]** require action by Architect prior to submitting for approval by authorities having jurisdiction.

1.8 QUALIFICATIONS

- A. Communications Cable Installer: Entity possessing active qualifications specified in Section 014000 "Quality Requirements" and the following:
 - 1. Training and manufacturer certification to install, splice, and terminate communications cabling.
 - 2. Installation Supervisor: Active BICSI Technician (TECH) certification.
 - 3. Copper Installers: **[30 percent]<Insert quantity>** of employees possess BICSI Copper Installer 2 (INSTC) certification. Remaining employees possess BICSI Installer 1 (INST1) certification.
- B. Communications Testing and Inspecting Agency: Entity possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
 - 1. On-site communications testing supervisor must have **[BICSI Technician (TECH)]<Insert certification program>** certification and documented training, and be experienced with testing communications equipment in accordance with **[BICSI]<Insert code enforced by authorities having jurisdiction>** testing standards.

1.9 WARRANTY FOR SOUND MASKING SYSTEMS

- A. Special Installer Extended Warranty: Installer warrants that fabricated and installed sound masking systems perform in accordance with specified requirements and agrees to repair or replace components or products that fail to perform as specified within extended-warranty period.
 - 1. Extended-Warranty Period: **[Two][Three][Four]<Insert number>** years from date of Substantial Completion; full coverage for labor, materials, and equipment.
- B. Special Manufacturer Extended Warranty: Manufacturer warrants that sound masking systems perform



in accordance with specified requirements and agrees to repair or replace components or products that fail to perform as specified within extended-warranty period.

1. Extended-Warranty Period: **[Ten]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for materials only, free on board **[origin][destination]**, freight prepaid.

1.10 WARRANTY FOR BATTERIES

- A. Special Manufacturer Extended Warranty for Batteries: Manufacturer warrants that batteries perform in accordance with specified requirements and agrees to repair or replace batteries that fail to perform as specified within extended-warranty period.
 1. Initial Extended-Warranty Period for Li-ion Batteries: **[Three][Four][Five]<Insert number>** years from date of Substantial Completion; full coverage for materials only, free on board **[origin][destination]**, freight prepaid.
 2. Follow-On Extended-Warranty Period for Li-ion Batteries: **[Ten]<Insert number>** years from date of Substantial Completion; prorated coverage for materials only, free on board **[origin][destination]**, freight prepaid.
 3. Extended-Warranty Period for Ni-MH Batteries: **[Three]<Insert number>** years from date of Substantial Completion; prorated coverage for materials only, free on board **[origin][destination]**, freight prepaid.
 4. Extended-Warranty Period for Ni-Cd Batteries: **[Five]<Insert number>** years from date of Substantial Completion; prorated coverage for materials only, free on board **[origin][destination]**, freight prepaid.

PART 2 - PRODUCTS

2.1 EXISTING PRODUCTS TO BE MODIFIED

- A. Basis for Pricing: **<Insert name of manufacturer; model number or series for existing product>**.
- B. Description: **<Insert description of existing product, including special features, options, and finishes that may impact the Work>**.
 1. Sustainable Design Features:
 - a. Material Reuse: Product is salvaged, refurbished, or reused.
- C. Accessories: **<Insert accessories included with existing product>**.

2.2 EXISTING PRODUCTS TO BE REMOVED AND RE-INSTALLED

- A. Basis for Pricing: **<Insert name of manufacturer; model number or series for existing product>**.
- B. Description: **<Insert description of existing product, including special features, options, and finishes that may impact the Work>**.
 1. Sustainable Design Features:
 - a. Material Reuse: Product is salvaged, refurbished, or reused.

- C. Accessories: **<Insert accessories included with existing product>**.

2.3 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- B. Seismic and Wind Performance: Installed product must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:
1. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events[**and unit must be fully operational after seismic events**]."
 2. Component Importance Factor (Ip): **[1.0][1.5]**.
 3. Component Amplification Factor (ap): **[1.0][2.5]<Insert value>**.
 4. Component Response Modification Factor (Rp): **[1.5][2.5]<Insert value>**.
 5. Component Overstrength Factor (Ω_o): **[1.5][2.5]<Insert value>**.

2.4 NETWORKED SOUND MASKING SYSTEMS

- A. Description: Electronic noise generators and associated controls for simultaneously operating multiple loudspeakers throughout facility.
- B. UL AZOT - Multi-Room Sound Masking System :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Biamp]**
 - b. **[K. R. Moeller Associates Ltd]**
 - c. **[Lencore Acoustics Corp.; business of Emmis Communications Corp.]**
 - d. **[Soft dB, Inc.]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Biamp]**
 - b. **[K. R. Moeller Associates Ltd]**
 - c. **[Lencore Acoustics Corp.; business of Emmis Communications Corp.]**
 - d. **[Soft dB, Inc.]**
 - e. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria:
 - a. Audio Equipment: Comply with one of the following:
 - 1) UL CCN AZOT; including UL 62368-1.
 - 2) UL CCN AZSQ; including UL 60065 or UL 6500.

- 3) UL CCN AZJX; including UL 813.
- b. Suitable for Installation in Air-Handling Spaces: UL CCN BHZF; including UL 2043.
5. Standard Features:
 - a. Reference Standards: Complies with principles and recommended test methods described in ASTM E1374.
 - b. **<Insert characteristics>.**
6. Other Available Features Required by the Project:
 - a. Loudspeaker Mounting: **[Duct][Ceiling][Wall][Furniture]<Insert mounting option>.**
 - b. Loudspeaker Controller Mounting: **[Wall][Furniture]<Insert mounting option>.**
 - c. Network Control Panel Mounting: **[Wall][Rack]<Insert mounting option>.**
 - d. Provide input for connection to supervised fire-alarm N.O. contact that when closed causes network controller to mute sound masking equipment **[that includes paging, background music, and other audio programming].**
 - e. Masking Sound Frequency Range: **[20 Hz to 20 kHz][125 Hz to 8 kHz]<Insert frequencies>**, with equalizers for adjusting the masking sound spectrum at third-octave resolution.
 - f. Masking Sound Volume Adjustment: Digital control, adjustable in **[0.5 dB][1.5 dB][5 dB]<Insert step>** increments over the range of **[34 to 82.5 dB(A-weighted)][35 to 85 dB(A-weighted)]<Insert range>**, or a continuous adjustment within that range.
 - g. Masking Preset Contour Options: **[50][28].**
 - h. Paging Inputs: Provision for connecting **[microphone],[telephone],[and][auxiliary audio device]** with analog-to-digital conversion of audio signals.
 - i. Remote central volume control.
- C. UL AZOT - Single-Room Sound Masking System :
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Biamp]**
 - b. **[K. R. Moeller Associates Ltd]**
 - c. **[Lencore Acoustics Corp.; business of Emmis Communications Corp.]**
 - d. **[Soft dB, Inc.]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Biamp]**
 - b. **[K. R. Moeller Associates Ltd]**
 - c. **[Lencore Acoustics Corp.; business of Emmis Communications Corp.]**
 - d. **[Soft dB, Inc.]**
 - e. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria:

- a. Audio Equipment: Comply with one of the following:
 - 1) UL CCN AZOT; including UL 62368-1.
 - 2) UL CCN AZSQ; including UL 60065 or UL 6500.
 - 3) UL CCN AZJX; including UL 813.
- b. Suitable for Installation in Air-Handling Spaces: UL CCN BHZF; including UL 2043.
- 5. Standard Features:
 - a. Reference Standards: Complies with principles and recommended test methods described in ASTM E1374.
 - b. **<Insert characteristics>**.
- 6. Other Available Features Required by the Project:
 - a. Loudspeaker Mounting: **[Duct][Ceiling][Wall][Television][Furniture]<Insert mounting option>**.
 - b. Loudspeaker Controller Mounting: **[Wall][Furniture][Tabletop]<Insert mounting option>**.
 - c. Provide input for connection to supervised fire-alarm N.O. contact that, when closed, mutes sound masking equipment **[that includes paging, background music, and other audio programming]**.

2.5 STANDALONE SOUND MASKING SYSTEMS

- A. Description: Self-contained loudspeaker with electronic noise generator and associated controls.
- B. UL UEAY - Standalone Sound Masking Loudspeakers :
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Atlas Sound LP]**
 - b. **[Biamp]**
 - c. **[Lencore Acoustics Corp.; business of Emmis Communications Corp.]**
 - d. **[Lowell Manufacturing Co.]**
 - e. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Atlas Sound LP]**
 - b. **[Biamp]**
 - c. **[Lencore Acoustics Corp.; business of Emmis Communications Corp.]**
 - d. **[Lowell Manufacturing Co.]**
 - e. **<Insert manufacturer's name>**
 - 3. Source Limitations: Obtain products from single manufacturer.
 - 4. Listing Criteria:
 - a. Sound Masking Loudspeakers: UL CCN UEAY; including UL 1480A.
 - b. Suitable for Installation in Air-Handling Spaces: UL CCN BHZF; including UL 2043.



5. Standard Features:
 - a. Reference Standards: Complies with principles and recommended test methods described in ASTM E1374.
 - b. **<Insert characteristics>.**
6. Other Available Features Required by the Project:
 - a. Loudspeaker Mounting: **[Duct][Ceiling][Wall]<Insert mounting option>.**
 - b. Loudspeaker Controller Mounting: **[Wall]<Insert mounting option>.**
 - c. Provide input for connection to supervised fire-alarm N.O. contact that when closed mutes loudspeaker.

2.6 MAINTENANCE MATERIAL ITEMS

- A. Spare Parts: Furnish to Owner spare parts, for repairing sound masking equipment, that are packaged with protective covering for storage on-site and identified with labels describing contents. **[Include the following:]**
 1. **<Insert item>: <Insert quantity>.**
- B. Extra Stock Material: Furnish to Owner extra materials[, **from same production run,**] that match products installed and that are packaged with protective covering for storage and identified with labels describing contents. **[Include the following:]**
 1. **<Insert item>: [One]<Insert quantity>[of each type].**
- C. Special Tools: Furnish to Owner proprietary equipment, keys, and software required to operate, maintain, repair, adjust, or implement future changes to sound masking equipment, that are packaged with protective covering for storage on-site and identified with labels describing contents. **[Include the following:]**
 1. **<Insert name of special tool>.**

PART 3 - EXECUTION

3.1 INSTALLATION OF SOUND MASKING SYSTEMS

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation:
 1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
 2. Fire Alarm and Premises Security Work: NFPA 72 and NECA NEIS 305.
 3. Communications Work: BICSI N1.
 4. Life Safety and Means of Egress Work: NFPA 101.
 5. Audio Equipment and Wiring Methods: Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with Article 640 of NFPA 70.
 6. Consult Architect for resolution of conflicting requirements.

C. Special Installation Techniques:

1. Loudspeaker Installation above Ceiling: Suspend with chains from building structure above ceilings, so bottom of assembly is **6 to 8 inch (150 to 200 mm)** above upper plane of finished ceiling material. Use eyebolts on speaker assemblies for attachment. Suspend independently from structure, not to supports for components of other building systems.
2. Zoned Loudspeaker Connections: For two- or three-channel systems, connect loudspeaker assemblies alternatively, so masking sound is redundant throughout coverage zones.
3. Wiring Methods:
 - a. Cable in Raceway: Install cables in raceways and cable trays, except within consoles, cabinets, desks, and counters and unless otherwise indicated.
 - 1) Except raceways are not required in accessible indoor ceiling spaces and attics.
 - 2) Except raceways are not required in hollow gypsum board partitions.
 - 3) Conceal raceways and wiring, except in unfinished spaces.
 - b. Concealed Cable: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
 - c. Exposed Cable: Install parallel to building lines, follow surface contours, and support as recommended by manufacturer.
 - 1) Install plenum cable in environmental air-handling spaces, including plenum ceilings.
 - d. Within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.
4. Grounding: As recommended by manufacturers unless more stringent requirements are indicated. Ground equipment and conductors to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments with a maximum of 5 Ω to ground at main equipment location. **[Measure, record, and report ground resistance.]**
5. Impedance Matching: For system components, including connecting cable, provide end-to-end level and impedance-matched signal paths. Use matching networks and balancing devices at connections where necessary to avoid mismatches.
6. Splices, Taps, and Terminations: Make splices, taps, and terminations on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.
7. Identification: Provide labels for vehicle charging equipment and associated electrical equipment.
 - a. Use color-coded conductors, and apply wire- and cable-marking tape to designate wires and cables, so media are identified in coordination with system wiring diagrams.
 - b. Label loudspeakers as to channel, zone, and address.
 - c. Identify field-installed conductors, interconnecting wiring, and components.
 - d. Provide warning signs.
 - e. Label each enclosure with engraved metal or laminated-plastic nameplate.
8. **<Insert more stringent installation requirements that supplement or supersede listed standards and manufacturers' published instructions>.**

D. Interfaces with Other Work:

1. Coordinate installation of new products for **<Insert system or product family/category>** with existing conditions.
 - a. **<Insert requirements for transition between new and existing>.**

2. Coordinate quantity and arrangement of sound masking system components with ceiling space configuration and with components occupying ceiling space, including structural members, pipes, air-distribution components, raceways, cable trays, luminaires, and other items.
3. Coordinate installation of raceways and boxes with installation of cabling for sound masking system.
4. Coordinate installation of network cabling, loudspeaker cabling, and Class 2 control cabling with installation of sound masking equipment.

E. Systems Integration:

1. Integrate sound masking system with **[fire-alarm system][and][mass notification system]** for muting non-emergency audio broadcast in event of fire or other emergency.
2. Final connection to FACU will be completed by fire-alarm system Installer.

3.2 FIELD QUALITY CONTROL OF SOUND MASKING SYSTEMS

A. Adminstrant for Communications Tests and Inspections:

1. **[Owner][Tenant]** will engage qualified communications testing and inspecting agency to administer and perform tests and inspections.
2. Engage qualified communications testing and inspecting agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].

B. Acceptance Testing Preparation:

1. Pretesting: Tune, align, and adjust system, and pretest components, wiring, and functions to verify compliance with specified material, installation, and performance requirements. Correct deficiencies and retest until satisfactory performance and conditions are achieved.

C. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.

D. Tests and Inspections:

1. Perform manufacturer's recommended tests and inspections.
2. Operational Test: Start system to confirm proper operation. Remove malfunctioning units, replace with new units, and retest. Make initial sound-spectrum and -level adjustments for each zone.
3. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.
4. Masking Sound Power Level Adjustments: Adjust independently for each space to minimum level between **[40][47]** and 50 dB(A-weighted) that will provide speech privacy between adjacent workstations while complying with other system requirements.

E. Final Acceptance Testing: Provide a minimum of 10 days' notice of acceptance test performance schedule. Schedule tests after pretesting has been successfully completed.

1. Perform sound masking evaluation tests in accordance with **[ASTM E1130][ASTM E1573]**, with measurements and calculations in accordance with ASA S3.5.
2. Tests and Calibration Conditions: Spaces are to be completely furnished, but unoccupied; lights and HVAC systems must be on; HVAC system testing and balancing are to be completed; and

- electronic ballasts, lighting relay panels, and low-voltage transformers must be in place.
3. Test Conditions: Complying with ASTM E1130 and calculated in accordance with ASA S3.5.
4. Instrumentation: Use a professional-quality, sound-level meter with octave-band filters and documentation of recent calibration against recognized standards. Comply with ASA S1.4 Part 1.
5. System Tests: Include the following for each system zone:
 - a. Loudspeaker Circuit Impedance Test: Measure impedance at 1000 Hz with amplifier disconnected, using a professional impedance meter or bridge. Locate and correct faults denoted by abnormal readings.
 - b. Ambient Sound-Level Tests: With system off, measure ambient sound level in one-third octave bands. Also measure ambient sound level as a single, wide-band, A-weighted reading.
 - c. System Noise Test: With masking-noise signal on and amplifiers adjusted at a working level 10 dB above ambient sound level, check for hum, buzz, rattle, or other operating deficiencies.
 - d. Spatial Uniformity Test: Measure sound level at locations no greater than **15 ft (4.6 m)** on center throughout covered spaces to determine compliance with specified performance level.
 - e. Frequency Response Adjustment and Test: Adjust one-third octave frequency bands and other unit filters to provide response. Adjust to meet requirement of space speech intelligibility and quality of background sound. Comply with ASA S3.2, CTA-426, and ASTM E1110.
6. Adjust level of masking sound that is appropriate for area and overall volume.
7. Adjust level of masking sound for each space, so one-third octave band centered at 500 Hz has final selected sound-power level for that space. Measure deviation from listed values in one-third octave bands from 100 to 1000 Hz. Measured values must not deviate from those listed by more than 4 dB for open-plan areas and 8 dB for enclosed offices. The total of individual band deviations in eight bands must not exceed 16 dB for open-plan areas and 30 dB for enclosed offices.
8. Walk-Through Test: People in covered spaces cannot discern loudspeaker locations.
- F. Record test observations, readings, and corrective actions. Report test results in accordance with **[ASTM E1130][ASTM E1573]**.
- G. Record final control settings and programming, and final tap setting of loudspeaker-matching transformers. Record final sound-level measurements and observations.
- H. Nonconforming Work:
 1. Units will be considered defective if they do not pass tests and inspections.
 2. Remove and replace defective units and retest.
- I. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.
- J. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.
 1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.

3.3 SYSTEM STARTUP

- A. Perform startup service.

1. Complete installation and startup checks in accordance with manufacturer's published instructions.
 2. **<Insert startup steps if any>.**
- B. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** system startup.
1. Manufacturer's Field Reports for System Startup Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.

3.4 ADJUSTING

- A. Sound Masking Adjustments: Adjust sound masking devices to suit actual occupied conditions.

3.5 CLOSEOUT ACTIVITIES

- A. Training:
1. **[With assistance from factory-authorized service representatives, train][Train]** Owner's maintenance personnel on the following topics:
 - a. How to adjust, operate, and maintain sound masking system equipment specified in this Section.

3.6 PROTECTION

- A. After installation, protect sound masking equipment from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

3.7 MAINTENANCE

- A. Sound Masking Readjustments: When requested within **[12]<Insert number>** months from date of Substantial Completion, provide on-site assistance in readjusting system to suit actual occupied conditions. Provide up to **[two]<Insert number>** visits to the Project site during other-than-normal occupancy hours for this purpose.
- B. Software and Firmware Service Agreement:
1. Technical Support: Beginning at Substantial Completion, verify that software and firmware service agreement includes software and firmware support for **[two]<Insert number>** years.
 2. Upgrade Service: At Substantial Completion, update software and firmware to latest version. Install and program software and firmware upgrades that become available within **[two]<Insert number>** years from date of Substantial Completion. **[Verify that upgrading software includes operating system and new or revised licenses for using software.]**
 - a. Upgrade Notice: No fewer than **[30]<Insert number>** days to allow Owner to schedule and access the system **[and to upgrade computer equipment if necessary.]**



3. Field Reports for Software and Firmware Upgrades: Prepare and submit report after each update, documenting upgrades installed.

END OF SECTION 27 51 19 00



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Task	Specification	Specification Description
27 51 43 00	26 33 43 00a	Public Address Systems
27 51 43 00	27 41 23 00	Educational Intercommunications and Program Systems



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SECTION 27 52 23 00 - NURSE CALL CODE BLUE SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Visual/tone nurse-call system.
2. Audiovisual/voice nurse-call system.

1.2 ACTION SUBMITTALS

A. Product Data:

1. Visual/tone nurse-call system.
2. Audiovisual/voice nurse-call system.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment cabinets and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Cabling Diagrams: Single-line block diagrams showing cabling interconnection of all components for this specific equipment. Include cable type for each interconnection.
3. Station Installation Details: For built-in equipment, dimensioned and to scale.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Field quality-control reports.

C. Warranty: Sample of special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For nurse-call equipment to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps: All colors for corridor dome lights and zone lights equal to [20]<Insert number> percent of amount installed.
2. Fuses: One for every 10 of each type and rating, but no fewer than <Insert quantity> of each.
3. Printed Circuit Boards: Each kind, equal to [10]<Insert number> percent of amount installed, but

- no fewer than one unit.
- 4. Master-Station Privacy Handset: **[One]<Insert number>**.
- 5. System program backup software.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
- B. Compatibility: System shall be capable of integration with any brand of phone system (wired or wireless), staff locating system, CCTV, and fire-alarm system.
- C. Electrical Components, Devices, and Accessories: Listed and labeled according to UL 1069 as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.7 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace batteries that fail in materials or workmanship within specified warranty period. Special warranty for batteries applies to materials only, on a prorated basis for specified period.
 - 1. Warranty Period: Include the following warranty periods, from date of Substantial Completion:
 - a. Nickel-Cadmium Batteries, Lithium Batteries, and Wet-Cell Batteries:
 - 1) Full Warranty: **[Five]<Insert number>** years.
 - 2) Pro Rata: **[15]<Insert number>** years.

1.8 SOFTWARE SERVICE AGREEMENT

- A. Technical Support: Beginning with Substantial Completion, provide software support for **[two]<Insert number>** years.
- B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within **[two]<Insert number>** years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.
 - 1. Provide **[30]<Insert number>** days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

PART 2 - PRODUCTS

2.1 NURSE-CALL SYSTEM GENERAL REQUIREMENTS

- A. Station Zones: Able to program **[256]<Insert number>** station zones for each master station in the network with **[eight]<Insert number>** priority levels and addressable visual and audible annunciation of audible devices such as smoke detectors and door contacts.

- B. System shall provide integrated and centralized "Code Blue" and "Staff Emergency" calls.
- C. Expansion Capability: Equipment ratings, housing volume, spare keys, switches, relays, annunciator modules, terminals, and cable conductor quantities adequate to increase the number of stations in the future by **[25]<Insert number>** percent above those indicated without adding internal or external components or main trunk cable conductors.
- D. Existing System Compatibility: Functionally and electrically compatible with existing system so components and wiring operate as an extension or upgrade of the existing system and existing or upgraded functional performance of the existing system applies to the entire final system. Colors, tones, types, and durations of signal manifestation shall be common among new and existing systems.
- E. Resistance to Electrostatic Discharge: System, components, and cabling, and the selection, arrangement, and connection of materials and circuits, shall be protected against damage or diminished performance when subjected to electrostatic discharges of up to 25,000 V in an environment with a relative humidity of 20 percent or less.
- F. Equipment: Microprocessor, electronic, modular.
- G. Master Nurse-Call Station: Programmed via a PC.
- H. Wall-Mounted Component Connection Method: Components connect to system wiring in back boxes with factory-wired plug connectors.
- I. Telephone Interface: Permit use of wired and wireless telephones to execute nurse-call master station functions.
- J. Third-Party Pager Interface: Programmable to send tone, numeric, and alphanumeric message to pocket pagers or personal digital assistants and to use industry standard-protocol, RS-485 interface.

2.2 VISUAL/TONE NURSE-CALL SYSTEM

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Aiphone Corporation]**
 - 2. **[Alpha Communications]**
 - 3. **[Ascom North America]**
 - 4. **[Cornell Communications, Inc]**
 - 5. **[Intego Systems, Inc.]**
 - 6. **[Intercall Systems, Inc]**
 - 7. **[Jeron Electronic Systems, Inc]**
 - 8. **[Rauland-Borg Corporation]**
 - 9. **[Simplex; brand of Johnson Controls International plc, Building Solutions North America]**
 - 10. **[TekTone Sound & Signal Mfg., Inc.]**
 - 11. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Aiphone Corporation]**
 - 2. **[Alpha Communications]**
 - 3. **[Ascom North America]**
 - 4. **[Cornell Communications, Inc]**



5. [Intego Systems, Inc.]
6. [Intercall Systems, Inc]
7. [Jeron Electronic Systems, Inc]
8. [Rauland-Borg Corporation]
9. [Simplex; brand of Johnson Controls International plc, Building Solutions North America]
10. [TekTone Sound & Signal Mfg., Inc.]
11. <Insert manufacturer's name>

C. Operational Requirements:

1. Patient Station Call: Lights a steady call-placed lamp on the station, steady lamps in the zone light and corridor dome light associated with the patient's room, and steady lamps at the central annunciator and other system display devices and displays message on master and staff/duty stations. At the same time, it sounds a programmed tone at intervals, at the respective annunciator and master and staff/duty stations. Legends at the central annunciator and master station identify the calling station.
2. Pull-Cord-Call Station Call: Flashes a call-placed lamp on the station and distinctive-color lamps in the zone light and corridor dome light and at the central annunciator and staff/duty stations. At the same time, it sounds a programmed tone at intervals, at the central annunciator and master and staff/duty stations. A legend at the master station identifies the calling station, priority as programmed, and bed identification.
3. Emergency-Call Station Call: Produces the same responses as pull-cord-call station calls except rapidly flashing red emergency digital display and tone repetition rates are more frequent, tone frequency is higher, and lamps in the zone light and corridor dome light are a different color. Indicator lamps may be extinguished and the system reset only at the calling station. Displays message on pocket pagers, sounds programmed tone on phones, and displays message on display equipped phones.
4. System Reset: Operating reset button at the originating station cancels signals associated with the call. Illuminates a green digital display on the patient station and log presence on the master station.
5. Cord-Set Removal: Initiates a patient station call when the cord set is removed from the jack in the patient station faceplate. Displays location and "cord removed" message on master station, pocket pagers, and display equipped phones. Inserting a cord-set plug or a dummy plug into the jack and operating the station reset button resets the call.
6. Patient Control Unit: Controls entertainment volume and channel selection. Nurse button on the unit initiates a patient station call. Integral speaker reproduces entertainment sound.
7. Emergency Bath Station Call: Illuminates the digital display on the emergency bath station; rapidly flashes white dome lamp; displays location, priority, and bath on master station; and sounds programmed tone on master station display equipped phones and pocket pagers.
8. Staff/Duty Station Operation: Operation shall be identified to patient station except the message staff shall display on all devices when the staff call button is activated.
9. Privacy Key Activation: When privacy key is activated on patient station, the system shall disconnect the patient station microphone and slowly flash yellow privacy digital display on the patient station. Displays "privacy" on master station when selecting this room/bed.

D. Central Annunciator:

1. Lamp type.
2. Lamp Legends: Machine lettered and legible from a distance of at least **48 inches (1200 mm)** when a call is present. Legend shall identify initiating station and priority of call.
3. Power-on Indicator: Digital, or push-to-test switch.
4. Audible Signal: Electronic tone.

E. Central Equipment Cabinet:

1. Lockable metal.
 2. Houses power supplies, controls, terminal strips, and other components.
 3. Power-on indicator lamp.
 4. Battery Backup Unit: Sealed [nickel-cadmium, wet-cell]<Insert type> battery supplies power through an automatic switch when normal power fails, for a period of not less than [six]<Insert number> minutes at rated output. System shall lose no unanswered calls or calls in progress during the transfer operation.
 - a. Automatic retransfer to normal power, after a [15]<Insert number>-minute time delay.
 - b. Two-rate battery charger with an automatic trickle rate and a recharge rate.
- F. Single-Patient Station: Call-placed lamp, reset push button, and polarized receptacle matching cord-set plug; mounted in a single faceplate.
- G. Dual-Patient Station: Single call-placed lamp, single reset push button, and two polarized receptacles matching cord-set plug; mounted in a single faceplate.
- H. Ambulatory-Patient Station: Call push-button switch, call-placed lamp, and reset push button; mounted in a single faceplate.
- I. Staff/Duty Stations: A minimum of two call lamps, one for routine calls and one for emergency calls; and an audible tone signal device.

2.3 AUDIOVISUAL/VOICE NURSE-CALL SYSTEM

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
1. [Aiphone Corporation]
 2. [Alpha Communications]
 3. [Ascom North America]
 4. [BEST HEALTHCARE COMMUNICATIONS]
 5. [Cornell Communications, Inc]
 6. [Intego Systems, Inc.]
 7. [Intercall Systems, Inc]
 8. [Jeron Electronic Systems, Inc]
 9. [Rauland-Borg Corporation]
 10. [Simplex; brand of Johnson Controls International plc, Building Solutions North America]
 11. [TekTone Sound & Signal Mfg., Inc.]
 12. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [Aiphone Corporation]
 2. [Alpha Communications]
 3. [Ascom North America]
 4. [BEST HEALTHCARE COMMUNICATIONS]
 5. [Cornell Communications, Inc]
 6. [Intego Systems, Inc.]
 7. [Intercall Systems, Inc]
 8. [Jeron Electronic Systems, Inc]
 9. [Rauland-Borg Corporation]
 10. [Simplex; brand of Johnson Controls International plc, Building Solutions North America]

11. [TekTone Sound & Signal Mfg., Inc.]
12. <Insert manufacturer's name>

C. Operational Requirements:

1. Station Selection from Master Station: Capable of selectively communicating with other stations or groups of stations on its system by touch screen, mouse click, or manual switch; and capable of programming up to [256]<Insert number> stations for each master station in the network.
2. Master Station Privacy: Capable of conversing with individual stations in complete privacy.
3. Called Station:
 - a. Capable of hands-free and two-way conversation.
 - b. Pressing "talk/listen" key shall cause the annunciation tone to cease.
 - c. Pressing "cancel" key terminates normal calls and conversations.
 - d. Terminating of high-priority level [1][2][3][or][4] shall not be allowed except at calling station location and shall send "remind" message if the call is not acknowledged at point of origin in programmed time frame.
4. Annunciation:
 - a. At the master station, a programmable tone announces an incoming call; an annunciator light or digital display identifies the calling station and indicates the priority of the call.
 - b. Call type indications include alarm assist, bath, bed, code, communication fault, cord out, door, emergency, and fire.
 - c. Memory lamps or lighted displays identify stations selected for outgoing calls.
5. System Reset at Master Station: A normal, incoming call can be canceled, associated lights and audible tones extinguished, and the system reset when the station switch is returned to the normal position.
6. Patient Station Calls:
 - a. Lights the call-placed lamp at patient station, zone, and corridor dome lights.
 - b. Sounds a tone and lights the call lights at staff/duty stations and actuates annunciation at the master station.
 - c. When the calling station is selected at the master station, the patient can converse with the master station without moving and without raising or directing the voice.
 - d. During voice communications, entertainment audio at the calling station is automatically muted.
7. Pull-Cord-Call Station Calls and Emergency-Call Station Calls:
 - a. Lights call-placed lamp and corridor dome light and flashes zone light.
 - b. Master station tone pulses and annunciator light for that room flashes.
 - c. When master station acknowledges the call by touch screen or switch, the tone stops but lights continue to flash until the call is canceled at the initiating point.
8. Code Blue and Staff/Duty Station Calls:
 - a. Lights the call-placed lamp at the station and actuates annunciation at the master station.
 - b. When the called station is selected at the master station, the caller and the master station operator can converse.
 - c. Code Blue: Unique sound and light pattern indicating the highest priority emergency.
 - d. Staff Station: Unique sound and light pattern indicating an emergency.
 - e. Duty Station: Sound and light pattern indicating a call to the nurse station.

9. Handset Operation: Lifting the handset on master station disconnects speaker/microphone and transfers conversation to the handset.
10. Station Privacy: No patient or staff/duty station can be remotely monitored without lighting a warning lamp at the monitored station.
11. Patient Station Cord-Set Removal:
 - a. A patient station call is initiated as described above when a patient station cord-set plug is removed from the jack in the station faceplate.
 - b. Tone stops but lights continue to flash until the call is canceled at the initiating point or the plug is reinserted or replaced with a dummy plug when the master station call button for the station is pressed.
12. Patient Control Unit:
 - a. Controls entertainment volume and channel selection.
 - b. Speaker is used for both nurse communication and entertainment sound.
 - c. Entertainment sound is automatically muted when station is communicating with master station.
 - d. Nurse button on the unit initiates a patient station call.
13. Selective Paging: Master station is capable of initiating a message to selected groups of stations or speakers simultaneously by using station group switches.
14. Staff Reminder:
 - a. Master station can initiate a staff reminder that a patient requires direct staff response by operating a reminder control while in contact with the patient station.
 - b. This reminder will light a distinctive-color lamp in the corridor dome light at the patient's room and in the appropriate zone lights.
 - c. Reminder calls are canceled by operating a staff reminder cancel switch in the patient's room.
15. Call Priority Indication:
 - a. Capable of **[eight]<Insert number>** call priority levels in addition to normal.
 - b. Call priority switch near each patient station, or integral with the master station, shall control priority status of the call transmitted by individual stations.
 - c. Switch selects one of the following status levels:
 - 1) Normal: No change to the normal call initiation and canceling sequence.
 - 2) Emergency: Call initiation produces signals and indications identical to those of emergency-call stations. Indicator lamps are extinguished and the system is reset only at the originating station.
 - 3) Priority: System response is the same for emergency status except voice communication between the master station and the calling station is locked in from the time of call initiation until the system is reset at the originating station.
16. Additional Call:
 - a. Waiting display window on the master station similar to current call window displays incoming calls.
 - b. Master station shall have a call-overflow indicator when incoming calls exceed **<Insert number>** calls.
 - c. System shall store unlimited number of incoming calls.
 - d. System shall be capable of automatically answering incoming calls in order of priority.
17. Calling Intercom Stations:



- a. Master station shall be capable of calling any intercom station using the handset or the hands-free speaker/microphone.
 - b. Receipt of a call at the intercom station shall be preceded by an optional pre-announce tone.
 - c. If there is a call in process, system shall place the active call on automatic hold while the new call is placed, then reestablish the previous call when the new call has ended.
18. Privacy Override:
- a. Temporarily deactivates the "Privacy" mode of a called station by calling the station and instructing the called party to press the call-cord button.
 - b. On completion of the conversation, the called station shall automatically return to the "Privacy" mode.
 - c. When in "Privacy" mode, a called station shall be capable of hearing the master station; however, the master station shall not be capable of hearing the called station; a privacy message shall be indicated on the master station display.
19. Master-Station-to-Master-Station Calls:
- a. Master stations shall be capable of calling other master stations using the handset.
 - b. Calls from master stations shall be answered using the handset only.
 - c. Busy master stations shall be indicated by a master station intercom busy tone.
20. Voice Paging:
- a. Capable of voice paging to all stations using a single "All Call" key. [**The page shall be preceded by an optional pre-announce tone.**]
 - b. Capable of voice paging to eight user-defined groups of stations by selecting the group and then the "All Call" key. [**The page shall be preceded by a pre-announce tone.**]
 - c. Capable of voice paging to all staff/duty stations and all patient stations where staff has registered presence using a single "Public Address (PA)/Staff" key. [**The page shall be preceded by a pre-announce tone.**]
 - d. Capable of voice paging through a third-party PA system.
 - e. Capable of including or excluding any station from the voice paging function(s).
 - f. Automatically places an active station call on hold during any page and reestablishes the connection at the end of the page.
 - g. Automatically cancels a page if the talk mode is inactive for more than 15 seconds.
21. Station Monitor:
- a. An audio monitor feature shall allow a user to sequentially or simultaneously listen to one or all stations that are included in the user-created list.
 - b. Master station display shall indicate which station is being monitored when in sequential mode.
 - c. The dwell time each station is monitored shall be user programmable.
 - d. The user shall be able to stop the monitoring sequence by activating a "pause" key.
 - e. The user shall be able to manually sequence through stations using a "next" key.
22. Night Service:
- a. Functions shall be adaptable for nighttime staffing levels, patient traffic, and day/night operations.
 - b. Staff Follow:
 - 1) Capable of locating roving staff; forwarding visual and audible annunciation of

- incoming calls to station(s) where personnel have registered presence.
- 2) Master station shall display locations where staff have registered presence.
- 3) Incorporates a programmable timer that automatically cancels a forgotten staff presence registration.

c. Tones:

- 1) Deactivates audio signals from a duty station and mini-master display telephones.
- 2) Capable of changing the tone volume at the master and duty stations.
- 3) Satellite function shall permit the user to deactivate audio signals from duty stations and other remote annunciator devices.

d. Day/Night Transfer:

- 1) Permits one nurse station to take control of all or individually selected bed call cords from another nurse station. It shall be possible to view transfer status of a nurse station.
- 2) Transfer Modes: As a minimum, include the following three transfer modes to allow one nurse station to take control or share calls and operations from another nurse station:
 - a) Parallel Transfer Mode: Permits both nurse stations to share all calls and operations.
 - b) Supervised Transfer Mode: Permits the transferred nurse station to share all calls and operations with the controlling nurse station; however, the controlling nurse station calls are not shared with the transferring station.
 - c) Capture Transfer Mode: Transfers all calls and operations from the transferred nurse station to the controlling nurse station.
 - d) Transferred station shall have no control over calls, and its display shall indicate calls have been transferred to another station.
- 3) Patient Swing Modes: As a minimum, include the following two patient swing modes to allow one nurse station to take control or share calls from one or many calls from another nurse station:
 - a) Supervised Transfer Mode: Permits the transferred calls to be shared with the controlling nurse station.
 - b) Capture Transfer Mode: Transfers all calls from the call cord from the transferred nurse station to the controlling nurse station.
 - c) Transferred station has no control over those transferred calls.

23. Service Request:

- a. Permits users to assign a service request to a substation, at programmable priority level.
- b. Displays service request on the nurse station display and light the green flashing corridor lamp at the respective substation and automatically generate a service reminder request.
- c. Cancels service requests only at the initiating point.
- d. Recall calls shall sound and be displayed at the master station if the service request has not been cancelled at the initiating point within the programmed period of time.

24. Call Reminder Function:

- a. Automatically generates a reminder call for a patient- or staff-initiated, high-priority [2][3][or][4] request that has had the call tones silenced, allowing time to physically attend to the request and cancel the call at the initiating point.
- b. Regenerated calls shall display the same tones and visual indications and priority as the

- original call and shall also display a "regenerated call" message.
 - c. Capable of manually adding low-priority calls to the reminder list.
 - d. "Call Reminder" function and reminder timer shall be programmable by call priority.
- 25. Hide Function: Prevents a selected station from displaying calls or generating tones on the nurse station.
- 26. Door Control Function: Capable of being programmed to enable the user to remotely activate electric door locks.
- 27. Test and Diagnostics Feature:
 - a. Able to automatically diagnose system faults and categorize them as warnings, communication errors, or fatal errors.
 - b. Warnings shall indicate possible system problems.
 - c. Communication errors shall indicate the inability of the master station to communicate with a substation or another nurse-call station.
 - d. Fatal errors shall indicate a major hardware or software failure.
- 28. User-Configured System Programming - Access Code Not Required:
 - a. Patient call-cord priority levels.
 - b. Monitor list.
 - c. "All Call" list.
 - d. Master station communication parameters (volume, filtering, talk/listen, sensitivity).
 - e. Master and duty station call annunciation tone volume.
 - f. Date/time.
 - g. Staff-follow operating mode.
 - h. Transfer type.
 - i. Pocket pager list assignment.
 - j. Presence mode.
- 29. User-Configured System Programming - Access Code Required:
 - a. Master station number.
 - b. Room device type.
 - c. Room number.
 - d. Bed number.
 - e. Bed alpha or numeric.
 - f. Reminder duration.
 - g. Staff presence registration cancel duration.
 - h. Display language.
 - i. Paging group assignment(s).
 - j. Zone group assignments.
 - k. Monitoring duration.
 - l. Pocket pager number.
 - m. Call tone assignment by priority.
 - n. Pretone activation.
 - o. Call tones minimum volume.
 - p. Clock mode (12 h/24 h).
- D. Master Station:
 - 1. Speaker/microphone unit with operating controls.
 - 2. Indicator lamps with legends or by digital display designate identification and priority of calling stations and called stations.
 - 3. Pulse rate of incoming-call lights denotes priority of calls awaiting response.

4. Station Selection Controls: Touchpad select stations for two-way voice communications.
5. Signal Tones: Programmable to announce incoming calls.
6. Pulse rate and frequency of tone identify the highest priority call awaiting response at one time.
7. Volume Control: Regulates incoming-call volume.
8. Privacy Handset with Hook Switch: Of the type that does not require push-to-talk switch attached to each station unless otherwise indicated.
9. Staff Reminder Control: Initiates flashing of corresponding corridor dome lights for patients requiring service. Permits scanning equipment to indicate which patients are currently in reminder status.
10. Call Priority Selection: Controls associated with patient-station selection switches determine the priority displayed when a call is initiated at a patient station.

E. Central Equipment Cabinet:

1. Lockable metal.
2. Houses amplifiers, tone generators, power supplies, controls, terminal strips, and other components.
3. Amplifier: With fidelity and overall gain necessary to achieve the sound-transmission and reproduction characteristics specified, considering interoperability with the installed speakers/microphones and wiring.
 - a. Power Output: Not less than 3 W at a total harmonic distortion not exceeding 5 percent.
 - b. Hum and Noise: 60 dB below full output with normal input open.
 - c. Volume Control: Concealed within the amplifier unit to control the volume of sound reproduced at all stations.
 - d. Protection: Circuit to prevent damage to the amplifier in case of shorted or open circuit.
4. Selective Paging Amplifiers: Plug-in card mounted in central equipment cabinet, rated 15 W.
5. System Power Supply:
 - a. 24-V dc for operation of the call system.
 - b. Equipment Rating: Suitable for continuous operation between **32 and 120 deg F (0 and 49 deg C)**, from a primary line voltage between 105- to 125-V ac, 60 Hz.
 - c. Output: Regulated 24-V dc with protection against overloads. Line-to-load regulation shall not exceed 2-1/2 percent with ripple and noise remaining below the 10-mV, rms level.
 - d. Overload Protection: Electronic fold-back circuit set to limit the volt-ampere output to less than 100 VA during overloaded or shorted output. Restore power output automatically on removal of overload without resetting circuit breakers or replacing fuses.
6. Power-on indicator lamp.
7. Surge Protector Device: Comply with Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits" for auxiliary panel suppressors, with **[digital indicator lights for power and protection status]<Insert accessories>**.
8. Battery Backup Unit: Sealed **[nickel-cadmium, wet-cell]<Insert type>** battery supplies power through an automatic switch when normal power fails, for a period of not less than **[six]<Insert number>** minutes at rated output.
 - a. Automatic retransfer to normal power, after a **[15]<Insert number>**-minute time delay.
 - b. Two-rate battery charger with an automatic trickle rate and a recharge rate.

F. Speaker/Microphones:

1. Type: Permanent-magnet, dynamic or ceramic, protected against dust and humidity.
2. Sound Reproduction: Sound level of 90 dB plus or minus 3 dB at a distance of **48 inches (1220 mm)** on the axis without overdriving or distorting any frequencies between 300 and 3000 Hz when installed in an enclosure or in the pillow speaker.

3. Power Handling Capacity: Not susceptible to damage from overdriving within the range of power available from the amplifier.
 4. Impedance Matching: Coordinated and matched to the input and output circuits of the amplifier, both for single connection and for group monitoring, to provide the sound reproduction specified. Subsystems or components shall not be combined, which could cause unacceptable distortion such as feedback between pillow speakers and unmuted room speaker/microphone combinations. This protection shall extend throughout the entire range of operation (volume control) of all components.
- G. Single-Patient Station: Speaker/microphone with **2-inch (50-mm)** dynamic cone, a polarized receptacle to match the cord-set plug, monitor lamp, reset switch, and call-placed lamp; assembled under a single faceplate.
- H. Dual-Patient Station:
1. Speaker/microphone with **2-inch (50-mm)** dynamic cone, two polarized receptacles to match cord-set plugs, monitor lamp, and reset switch; assembled under a single faceplate.
 2. Single call-placed lamp serves both beds.
 3. Dual call-placed lamps, one for each bed.
- I. Staff/Duty Stations: Audible call-tone signal device, speaker/microphone with **2-inch (50-mm)** dynamic cone, monitor lamp, reset switch, routine-call lamp, emergency-call lamp, and call push button; assembled under a single faceplate.
- J. Code Blue Station: Audible call-tone signal device, speaker/microphone with **2-inch (50-mm)** dynamic cone, monitor lamp, reset switch, Code Blue emergency-call lamp, and call push button; assembled under a single faceplate.
- K. Ambulatory-Patient Station: Speaker/microphone with **2-inch (50-mm)** dynamic cone, monitor lamp, reset switch, call-placed lamp, and call push button; assembled under a single faceplate.
- L. Selective Paging Speakers: **8-inch (200-mm)** cone type with **1-inch (25-mm)** voice coil and minimum **5-oz. (140-g)** ceramic magnet, multitap matching transformer, flush-mounted steel back-box, and white enamel-finished metal ceiling grille.
- M. Call Priority Switch Station: Three-position, tamper-resistant priority selection switch. Positions designated by labeling "Normal," "Emergency," and "Priority."
- N. Staff Reminder Cancel Switch Station: Momentary contact.

2.4 SYSTEM COMPONENTS

- A. Emergency-Call Station: Locking-type push button, labeled "Push to Call Help"; reset trigger to release push button and cancel call; and call-placed lamp, mounted in a single faceplate.
- B. Emergency-Bath Station:
1. Consists of a sliding, chemical-resistant, ABS red fascia marked with the word "URGENT" in bold letters.
 2. Capable of being activated with nylon pull cord or by sliding the face of the unit downwards.
 3. Activation of the station shall illuminate a reassurance digital display on the face of the unit in addition to notifying the master station.
 4. Water resistant and able to withstand routine cleaning and chemical disinfectants.
 5. Uses magnetic reed switch technology for reliability and corrosion resistance.

6. Mounts on a single-gang electrical box wire to the respective patient station or input controller.

C. Code Blue Station:

1. Consists of a sliding, chemical-resistant, ABS blue fascia marked with the word "CODE" in bold letters.
2. Capable of being activated with nylon pull cord or by sliding the face of the unit downwards.
3. Activation of the station shall illuminate a reassurance digital display on the face of the unit in addition to notifying the master station.
4. Water resistant and able to withstand routine cleaning and chemical disinfectants.
5. Uses magnetic reed switch technology for reliability and corrosion resistance.
6. Mounts on a single-gang electrical box wire to the respective patient station or input controller.

D. Staff, Emergency Station:

1. Consists of a sliding, chemical-resistant, ABS red fascia marked with the word "EMERGENCY" in bold letters.
2. Capable of being activated with nylon pull cord or by sliding the face of the unit downwards.
3. Activation of the station shall illuminate a reassurance digital display on the face of the unit in addition to notifying the master station.
4. Mounts on a single-gang electrical box wire to the input controller.

E. Pull-Cord-Call Station:

1. Pull-Down Switch: Lever-locking type, labeled "Pull Down to Call Help."
2. Reset trigger.
3. Call-placed lamp.
4. Water-resistant construction.

F. Patient Control Unit:

1. Equipped with plug and **96-inch- (2400-mm-)** long white cord.
2. Ethylene oxide, sterilizable.
3. Light-Control Switch: Arranged for independent on-off control of patient's up and down light.
4. Integral Speaker: **2 inches (50 mm)**, with **0.35-oz. (9.9-g)** magnet, rated 0.2 W.
5. Controls: Speaker volume, TV control, and nurse call.
6. Housing: High-impact white plastic.
7. Attachment: Stainless steel bed clamp with permanently attached polyester film strap.
8. Quantity: 12 units for every 10 patient beds.

G. Call-Button Cord Set:

1. Plug and **72-inch (1800-mm)** white cord; cord set shall be resistant to medical gas environment equipped with momentary-action, call-button switch.
2. Ethylene oxide, sterilizable.
3. Washable cord.
4. Palladium switch contacts in high-impact white housing with cord-set strain relief.
5. Attachment: Stainless steel bed clamp with permanently attached polyester film strap.
6. Quantity: Three cord sets for every 10 patient beds.

H. Geriatric Call-Button Cord Set:

1. Plug and **72-inch (1800-mm)** white cord.
2. Resistant to medical gas environment equipped with momentary-action, light-pressure switch in soft outer jacket.
3. Ethylene oxide, sterilizable.

4. Washable cord.
5. Palladium switch contacts in high-impact white housing with cord-set strain relief.
6. Attachment: Stainless steel bed clamp with permanently attached polyester film strap.
7. Quantity: Two cord sets for every 10 patient beds.

I. Squeeze-Bulb Switch Cord Set:

1. Plug and **72-inch (1800-mm)** washable tube with white cord set.
2. Resistant to medical gas environment; washable; equipped with neoprene squeeze-bulb activator, and plug-mounted, momentary contact switch.
3. Ethylene oxide, sterilizable.
4. Attachment: Stainless steel bed clamp with permanently attached polyester film strap.
5. Quantity: Two cord sets for every 10 patient beds.

J. Breath Call Cord:

1. Flexible PVC jacketed cable and a momentary contact air-pressure sensitive switch.
2. Cord: **108 inches (2700 mm)** long.
3. Include an adjustable arm for clamping and suitable for use in oxygen atmospheres.
4. Include 12 replacement straws.

K. Pillow Speakers:

1. Eight-conductor, DIN, flexible PVC jacketed cable.
2. Contain nurse-call button, volume control, speaker, and channel control in molded flame-retardant ABS housing.
3. Cord: **96 inches (2400 mm)** long with sheet clip.

L. Call-Button Plug:

1. Designed to plug into patient station cord-set receptacle.
2. Button switches call circuit.
3. Two plugs for every 10 patient beds.

M. Dummy Plugs:

1. Designed to plug into patient station cord-set receptacle when call-button plug or patient cord set is not used.
2. Three plugs for every 10 patient beds.

N. Indicator Lamps: Digital type with rated life of 20 years unless otherwise indicated.

O. Station Faceplates, Stainless Steel:

1. Minimum of **0.0375 inch (0.95 mm)** thick.
2. Finish: Brushed.
3. Machine-engraved labeling identifies indicator lamps and controls.

P. Station Faceplates, High-Impact Plastic:

1. Color: **[Beige]<Insert color>**.
2. Molded or machine-engraved labeling identifies indicator lamps and controls.

Q. Corridor Dome Lights and Zone Lights:

1. Three-lamp signal lights.
2. Lamps: **[LED.]**Front replaceable without tools, low voltage with rated life of 7500 hours. Barriers are such that only one color is displayed at a time.
3. Lenses: Heat-resistant, shatterproof, translucent polymer that will not deform, discolor, or craze when exposed to hospital cleaning agents.
4. Filters: Two per unit, amber and red.

R. Cable:

1. Conductors: Jacketed single and multiple, twisted-pair copper cables.
2. Sizes and Types: As recommended by equipment manufacturer.
3. Cable for Use in Plenums: Listed and labeled for plenum installation.

S. Grounding Components: Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

2.5 SOFTWARE REQUIREMENTS

A. Telephone System Interface:

1. Permits use of wired and/or wireless telephones to execute nurse-call master station.
2. Two-way communication with patient and staff stations.
3. Two-way communication with the master nurse station.
4. "All Call," group call, and staff call paging.
5. Capable of being programmed to forward calls destined for a master nurse station to any connected telephone.
6. Telephones connected to the telephone interface shall have the same call tone ring patterns as those generated at the master nurse station.
7. Telephones having a display shall indicate the call type, priority code, and the calling station number of incoming calls.
8. Telephones shall be capable of initiating a service request for a particular patient station, logging calls on the master station's reminder list, and activating door lock mechanisms associated with a call station.
9. Capable of routine setup and configuration changes using the keypads on display telephone and/or the master station.

B. Display Telephones:

1. Digital telephones for use as mini-master nurse-call stations.
2. Digital display shall indicate the call type, priority code, and calling station number of incoming calls.
3. Ring patterns shall be identical to those generated at the master station.
4. Capable of two-way communication with patient and staff stations and the master station, and other telephones interfaced with the system.
5. Capable of placing or answering outside calls when interfaced with the facility telephone system.
6. Capable of "All Call," group call, and staff call paging and of initiating service requests, logging calls to the reminder list, and activating optional door controls.

C. Third-Party Pocket Pager Interface:

1. Equipped with a standalone pocket pager interface.
2. Connects with the facility paging system and transmit alphanumeric messages to the pocket pagers as preprogrammed in the system.

D. Statistical Software:

1. Includes a data statistical software package that stores, sorts, and analyzes activities occurring on the nurse-call system network.
2. Windows based and operated on a PC that is connected to the nurse-call system network.
3. Stores events on the PC's hard disk. Accumulation of these stored events shall make up the database that is used to generate reports and statistics.
4. Events stored by the software shall include date, day of week, time, ward, priority, and room number.
5. Capable of assigning a patient name to bed number.
6. Stored events shall include, but not be limited to, calls placed, call priority, calls cancelled at the nurse station, calls cancelled at the point of origin, regenerated calls, calls answered, calls sent to pager interface, staff presence registration, staff presence cancellation, service request, service cancellation, and system and network error messages.

E. Data Analysis Software:

1. Capable of analyzing the stored information and generating computed analysis.
2. Analysis of the database can be conducted by specifying one, many, or all of the following parameters of the database: date, day of week, time, wards, priority, and room number.
3. Analysis shall include, but not be limited to, total number of calls placed, average call response time (from call placed to call cancellation), total number of presence registrations, average presence time in a room, total number of service requests, average response time (from audio answer to call cancellation), and average ring time (from call placed to audio answer).

F. Statistical Software Package:

1. Capable of displaying multiple calls/events on a PC monitor or on a RS-485 data-bus-driven digital display panel.
2. Calls from patient or staff stations and associated devices shall be displayed by priority. Display shall be customizable as follows:
 - a. Choice of color by type of call.
 - b. Choice of display size (character size).
 - c. Choice of priority levels, type of events, points of origin.
 - d. Identification of facility.
 - e. Identification of ward.
 - f. Identification of patient with specific patient information.

2.6 CONDUCTORS AND CABLES

A. Audio Cables:

1. Conductors: Jacketed, twisted-pair and twisted-multipair, untinned solid copper. Sizes as recommended by system manufacturer, but no smaller than No. 22 AWG.
2. Insulation: Thermoplastic, not less than **1/32 inch (0.8 mm)** thick.
3. Shielding: For speaker/microphone leads and elsewhere where recommended by manufacturer; No. 34 AWG, tinned, soft-copper strands formed into a braid or equivalent foil.
4. Minimum Shielding Coverage on Conductors: 60 percent.
5. Plenum Cable: Listed and labeled for plenum installation.

B. Data Cable and Hardware: **[Category 5e][Category 6]** balanced twisted-pair cabling and hardware. Comply with requirements in Section 271513 "Communications Copper Horizontal Cabling."

C. Power Conductors and Cables: Copper, solid, No. 20 AWG. Comply with requirements in **[Section 260519 "Low-Voltage Electrical Power Conductors and Cables."]****[Section 260523 "Control**

Voltage Electrical Power Conductors and Cables."]

- D. Grounding Conductors and Cables: Copper, stranded, No. 16 AWG. Comply with requirements in **[Section 260519 "Low-Voltage Electrical Power Conductors and Cables."][Section 260523 "Control Voltage Electrical Power Conductors and Cables."]**

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Wiring Method:
1. Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters[**and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used**].
 - a. Install plenum cable in environmental air spaces, including plenum ceilings.
 - b. Conceal raceway and cables except in unfinished spaces.
 2. Cable Trays: Comply with requirements in Section 260536 "Cable Trays for Electrical Systems."
 3. Conduit and Boxes: Comply with requirements in Section 270528 "Pathways for Communications Systems." **[Flexible metal conduit shall not be used.]**
 - a. Outlet boxes shall be no smaller than **2 inches (50 mm)** wide, **3 inches (75 mm)** high, and **2-1/2 inches (64 mm)** deep.
- B. Install cables without damaging conductors, shield, or jacket.
- C. Do not bend cables, while handling or installing, to radii smaller than as recommended by manufacturer.
- D. Pull cables without exceeding cable manufacturer's recommended pulling tensions.
 1. Pull cables simultaneously if more than one is being installed in same raceway.
 2. Use pulling compound or lubricant if necessary. Use compounds that will not damage conductor or insulation.
 3. Use pulling means, including fish tape, cable, rope, and basket-weave wire or cable grips, that will not damage media or raceway.
- E. Install exposed raceways and cables parallel and perpendicular to surfaces or exposed structural members, and follow surface contours. Secure and support cables by straps, staples, or similar fittings designed and installed so as not to damage cables. Secure cable at intervals not exceeding **30 inches (760 mm)** and not more than **6 inches (150 mm)** from cabinets, boxes, or fittings.
- F. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.
- G. Separation of Wires: Separate speaker/microphone, line-level, speaker-level, and power-wiring runs. Run in separate raceways or, if exposed or in same enclosure, provide **12-inch (300-mm)** minimum separation between conductors to speaker/microphones and adjacent parallel power and telephone wiring. Provide separation as recommended by equipment manufacturer for other conductors.
- H. Splices, Taps, and Terminations: Make splices, taps, and terminations on numbered terminal strips in

junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Install terminal cabinets where there are splices, taps, or terminations for eight or more conductors.

- I. Impedance and Level Matching: Carefully match input and output impedances and signal levels at signal interfaces. Provide matching networks if required.
- J. Identification of Conductors and Cables: Comply with requirements in Section 260553 "Identification for Electrical Systems" for cable administration, cable schedule, and cable and wire identification.
- K. Equipment Identification:
 - 1. Comply with requirements in Section 260553 "Identification for Electrical Systems" for equipment labels and signs and labeling installation requirements.
 - 2. Label stations, controls, and indications using approved consistent nomenclature.

3.2 EXISTING SYSTEMS

- A. Examine existing systems for proper operation, compatibility with new equipment, and deficiencies. If discrepancies or impairments to successful connection and operation of interconnected equipment are found, report them and do not proceed with installation until directed. Schedule existing systems' examination so there is reasonable time to resolve problems without delaying construction.

3.3 GROUNDING

- A. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other signal impairments.
- B. Signal Ground Terminal: Locate at main equipment cabinet. Isolate from power system and equipment grounding except at connection to main building ground bus.
- C. Grounding Provisions: Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- B. Perform tests and inspections.
 - 1. Manufacturer's Field Service Assistance: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- C. Tests and Inspections:
 - 1. Schedule tests a minimum of seven days in advance.
 - 2. Report: Submit a written record of test results.
 - 3. Operational Test: Perform an operational system test and demonstrate proper operations, adjustment, and sensitivity of each station. Perform tests that include originating station-to-station and "All Call" messages and pages at each nurse-call station. Verify proper routing, volume

levels, and freedom from noise and distortion. Test each available message path from each station on the system. Meet the following criteria:

- a. Speaker Output: 90 dB plus or minus 3 dB, 300 to 3000 Hz, reference level threshold of audibility 0 dB at 0.02 mPa of sound pressure.
 - b. Gain from patient's bedside station to nurse station, with distortion less than 65 dB (plus or minus 3 dB, 300 to 3000 Hz).
 - c. Signal-to-Noise Ratio: Hum and noise level at least 45 dB below full output.
4. Test Procedure:
- a. Frequency Response: Determine frequency response of two transmission paths by transmitting and recording audio tones.
 - b. Signal-to-Noise Ratio: Measure the ratio of signal to noise of the complete system at normal gain settings using the following procedure: Disconnect a speaker/microphone and replace it in the circuit with a signal generator using a 1000-Hz signal. Measure the ratio of signal to noise and repeat the test for four speaker microphones.
 - c. Distortion Test: Measure distortion at normal gain settings and rated power. Feed signals at frequencies of 300, 400, 1000, and 3000 Hz into each nurse-call equipment amplifier, and measure the distortion in the amplifier output.
- D. Retesting: Rectify deficiencies indicated by tests and completely retest work affected by such deficiencies at Contractor's expense. Verify, by the system test, that the total system meets these Specifications and complies with applicable standards. Report results in writing.
- E. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.
- F. Prepare test and inspection reports.
- 3.5 ADJUSTING
- A. Occupancy Adjustments: When requested within [12]<Insert number> months of date of Substantial Completion, provide on-site assistance in adjusting sound levels and controls to suit actual occupied conditions. Provide up to [three]<Insert number> visits to Project during other-than-normal operating hours for this purpose.
- 3.6 DEMONSTRATION
- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel and caregiver staff to adjust, operate, and maintain nurse-call equipment.

END OF SECTION 27 52 23 00



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SECTION 27 53 13 00 - CLOCK SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Master and secondary clock system.
2. Master clock.
3. Secondary indicating clocks.
4. Program signal devices.
5. Clock circuit power booster.
6. Back boxes for secondary indicating clocks and program devices.
7. Guards.
8. Rack-mounting provision for master clock.
9. Conductors and cables.
10. Pathways.

1.2 DEFINITIONS

- A. NIST: The National Institute of Science and Technology.
- B. PC: Personal computer.
- C. UTC: Universal time coordinated. The precisely measured time at zero degrees longitude; a worldwide standard for time synchronization.

1.3 ACTION SUBMITTALS

A. Product Data:

1. Master and secondary clock system.
2. Master clock.
3. Secondary indicating clocks.
4. Program signal devices.
5. Clock circuit power booster.
6. Back boxes for secondary indicating clocks and program devices.
7. Guards.
8. Rack-mounting provision for master clock.
9. Conductors and cables.
10. Pathways.

- B. Product Data Submittals: For each product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes (including available colors) for each product indicated and describe features and operating sequences, both automatic and manual, for the following:

1. Master unit.
2. Indicating clocks.

3. Signal equipment.
4. Equipment enclosures and back boxes.
5. Accessory components.

C. Shop Drawings: For clock systems. Include plans, elevations, sections, details, and attachments to other work.

1. Wiring Diagrams: For power, signal, and control wiring and correction circuits.
 - a. Identify terminals and wiring color codes to facilitate installation, operation, and maintenance.
 - b. Indicate recommended wire types and sizes, and circuiting arrangements for field-installed system wiring. Show protection from overcurrent, static discharge, and voltage surge.
2. Details of seismic restraints including mounting, anchoring, and fastening devices for the following system components:
 - a. Surface-mounted and semirecessed secondary indicating clocks.
 - b. Master clock **[enclosures][mounting racks]**.
 - c. Clock circuit power boosters.
3. Details of seismic strengthening of master clock **[enclosures][mounting racks]**.
4. Dimensioned Outline Drawings of the Mounting Rack for the Master Clock: Show internal seismic bracing, and locate center of gravity of fully equipped and assembled unit. Locate and describe mounting and anchorage provisions.

D. Samples for Initial Selection:

1. Manufacturer's color photographs or color chips showing the full range of colors available for clocks, signal equipment, and control panels.
2. Representative operating models of clock type **<Insert designations of clocks for which Samples are required>**.

E. Delegated Design Submittals: For the master clock and housing indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of the master clock and housing.
2. Design Calculations: Calculate requirements for selecting seismic restraints.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for the master clock, accessories, and components, from manufacturer.

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

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For clock and program control to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Master clock and housing shall withstand the effects of earthquake motions determined according to **[ASCE/SEI 7]<Insert requirement>**.
1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified **and the unit will be fully operational after the seismic event**]."

2.2 MASTER AND SECONDARY CLOCK SYSTEM

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[American Time & Signal Co]**
 2. **[Dukane Communication Systems]**
 3. **[Faraday]**
 4. **[Lathem Time]**
 5. **[Midwest Time Control, Inc.]**
 6. **[National Time & Signal Corporation]**
 7. **[Primex, Inc.]**
 8. **[Rauland-Borg Corporation]**
 9. **[Sapling, Inc.]**
 10. **[Simplex; brand of Johnson Controls International plc, Building Solutions North America]**
 11. **[Telecor Inc]**
 12. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[American Time & Signal Co]**
 2. **[Dukane Communication Systems]**
 3. **[Faraday]**
 4. **[Lathem Time]**
 5. **[Midwest Time Control, Inc.]**
 6. **[National Time & Signal Corporation]**

7. [Primex, Inc.]
8. [Rauland-Borg Corporation]
9. [Sapling, Inc.]
10. [Simplex; brand of Johnson Controls International plc, Building Solutions North America]
11. [Telecor Inc.]
12. <Insert manufacturer's name>

C. System Functions and Features:

1. Supply power to remote indicating clocks[**except those indicated to have correction signals applied through a data circuit**].
2. Maintain correct synchronized time and transmit time-correction signals over dedicated system wiring from a master clock to any [one][two]<Insert number> type(s) of secondary indicating clocks, including the following:
 - a. Analog Synchronous Clocks: Correct for minute- and second-hand synchronization at least once each hour and for hour-hand synchronization at least once each day.
 - b. Digital Clocks: Test clocks automatically for synchronization with master time control at least once every hour and automatically correct those not synchronized with the time reference unit.[**Automatically correct clocks immediately when power is restored after an outage of power to the master clock.**]
3. Initiate and execute programs for scheduled automatic operation of remote devices. Include **[audible signal devices][and][visual signal devices][and on and off switching of equipment and circuits]**.
4. Provide for manual control of programmed signal and equipment-switching circuits.
5. Communicate with remote PC **[for access to UTC time base][and][to permit programming from remote location]**.
6. Maintain system access security with a minimum of [one level][two levels][three levels] of user-access control to restrict use of system controls to authorized personnel.[**Levels of access apply to both local access and access from a remote computer.**] Access to user programming and control functions is accomplished by entering a minimum three-digit code. Access levels include the following:
 - a. Access to review existing programs only.
 - b. Access to normal system operating controls.
 - c. Access to all user-programming and control functions.
7. Regulate system timing functions using power-line frequency, backed up for power outages by an internal battery-powered, crystal-controlled oscillator.
8. Regulate system timing functions using power-line frequency, backed up for power outages by an internal battery-powered, crystal-controlled oscillator, and automated periodic reference to NIST or UTC time signals via **[internal telephone modem and automatic dialup connection][internal modem and network or microcomputer Internet access][dedicated internal radio receiver tuned to NIST time signal broadcasts]**. Reference time signals shall be automatically accessed at programmable intervals.
9. Provide for programming multiple independent event schedules into memory and running them simultaneously for different output circuits.
 - a. Quantity of Programmable Schedules: **[Three][Four][Eight][18][250]**, minimum.
 - b. Number of Weekly Events That Can Be Programmed for Each Schedule: **[64][128][300][600][2500]**, minimum.
 - c. Simultaneous operation of independent schedules shall be limited only by the number of signal-device and equipment-switching output circuits.
 - d. Advance Programming for Automatic Holiday Schedule Changes: Number of schedule

changes that can be programmed to suit holidays and vacations shall be [10][16][50][100], and each change may be programmed up to a year in advance to occur on any day of the calendar year.

10. Automatically check functioning of LEDs, switches, input keys, central processor, read-only memory, random access memory, and output circuits. A display on the control panel[**or a remote computer with the proper access code**] shall indicate failure by identifying faulty component or circuit and shall recommend corrective action.
11. Provide [manually initiated][programming for automatic] daylight savings time correction.
12. Provide for adjustments to master clock output signals. Duration of momentary signal shall be individually programmable for each signal and equipment-control output circuit from 1 to 99 seconds. Signals shall be programmable for either on or off switching to suit equipment-operation scheduling.

2.3 MASTER CLOCK

- A. Description: Microprocessor-based, software-controlled unit complying with Class A device requirements in 47 CFR 15.
 1. Programming and control switches.
 2. Informational Display: LED or backlit LCD type.
 - a. Normally shows current time[, **date, and day of week**] display.
 - b. Provides programming cues when system is being programmed.
 3. Output Circuits for Power and Correction of Secondary Indicating Clocks:
 - a. Wired Synchronous Clock Power-and-Correction Circuits: For [analog][and][digital] clocks; a minimum of [one][two]<Insert number> required. Relay controlled.
 - b. Wired Synchronous Digital Clock Power-and-Correction Circuits: [One]<Insert number> required.
 - c. Existing Clock Power-and-Correction Circuit: An output circuit suitable for <Insert **description of type of existing power-and-correction circuit and number of clocks to be connected**>.
 4. Data Output Port for Secondary Clock Correction Circuit: [Digital,]RS485 or similar circuit for scheduled periodic correction signals.
 5. Modem and PC interface software suitable for [remote programming][and][automatic NIST or UTC synchronization].
 6. Circuits for Audible Signal Devices: Relay controlled, manually switchable, using controls on the master clock. Rated 120-V ac, [five][10] A minimum. A minimum of [two][four][six][eight]<Insert number> circuits.
 7. Circuits for Visual Signal Devices: Relay controlled, manually switchable, using controls on the master clock. Rated 120-V ac, [five][10] A minimum. A minimum of [two][four][six][eight]<Insert number> circuits.
 8. Circuits for Programmable Switching of Remote Equipment and Circuits: Relay controlled, manually switchable, using controls on the master clock. Rated 120-V ac, [5][10] A minimum. A minimum of [two][four][six][eight]<Insert number> circuits.
 9. Power Supplies: Capacity for internal loads and power-and correction circuits of connected clocks.
 10. Enclosure: Metal cabinet with locking front panel. When cabinet is locked, display indication shall be visible on or through front panel face. Arrange cabinet for surface, semirecessed, or flush mounting as indicated.
 11. Housing: Rack-mounting metal enclosure with display indication visible on front panel face.



- a. Reinforce mounting and attachment capable of resisting seismic forces described in Section 260548.16 "Seismic Controls for Electrical Systems."
12. Battery Backup for Time Base: Lithium battery to maintain the timekeeping function and retain the programs in memory during outage of normal ac power supply for up to 10 years.
13. Electrostatic Discharge Resistance: Master clock[**and secondary indicating clocks**] shall be tested and certified according to IEC 61000-4-2 in both human-discharge and direct-injection modes.

2.4 SECONDARY INDICATING CLOCKS

- A. Analog Clock: Equipped with a sweep second hand. Movement shall be driven by self-starting, permanently lubricated, sealed synchronous motor equipped with a correcting solenoid actuator, or be a microprocessor-based, second impulse unit, compatible with the master clock.
- B. Digital Clock: Microprocessor-controlled unit complying with Class A device requirements in 47 CFR 15, with red LED digital time display of hours [**and minutes**][, **minutes, and seconds**].
 1. Display Height, 2-1/2-Inch (64-mm) Clock: Hour and minute numerals readable at **50 feet (15 m)**.
 2. Display Height, 4-Inch (102-mm) Clock: Hour and minute numerals readable at **100 feet (30 m)**.
 3. Display Format: Selectable between 12-hour with "PM" LED display and 24-hour formats.
 4. Connections for Power and Correction:
 - a. Wired synchronous connection to the master clock for both operating power and correction.
 - 1) Time-Base Backup, Internal Alkaline Battery: Backs up internal time base to maintain timekeeping during power outages of up to six days' duration.
 - 2) Time-Base Backup, Internal Capacitor: Back up internal time base to maintain timekeeping during power outages of up to 12 hours' duration.
 - b. Correction by RS485, Ethernet, or similar data line with operating power supplied over a separate connection.
 - c. Power Connection for Secondary Indicating Clocks: [**Plug connector**][**Wire pigtail or compression splice**].
- C. Interval-Timer Clock: Digital microprocessor-controlled, **4-inch (102-mm)** unit with **2-1/2-inch (64-mm)**, red LED digital display for hours and minutes and **1-5/16-inch (33-mm)** display for seconds; a separately mounted, mode-control switch; and the following features:
 1. Display Visibility: Hour and minute numerals readable at [**30 feet (10 m)**]**<Insert dimension>** in normal ambient light.
 2. Operating Modes:
 - a. Normal: Clock operates as a regular secondary system clock, displaying corrected time in normal display configuration, selectable between 12- and 24-hour formats, with "PM" digital display for 12-hour format.
 - b. Count-Down or Count-Up Timer: Selected by mode-control switch count-up and count-down positions, and capable of being preset at the mode-control station.
 - c. Code Blue: Automatically selected by a signal through a wiring connection from [**the code-blue system**]**<Insert source for the initiating signal>**. This signal captures control of the clock regardless of current mode or correction status and instantly initiates count-up operation, starting at time 00:00:00. While in this mode, other clock functions, including correction, shall run in the background. Clock shall revert to normal operating mode when

the initiating-signal system is reset.

3. Mode-Selector Switch: Push-button or rotary, multiposition type, flush mounted; with start, stop, and reset capability in both count-up and count-down modes.
 4. Audible tone signal: Housed in clock or mode-selector-switch box. Sounds at end of preset up or down count.
- D. Provision for Modular Panel Installation: Equip designated clock for panel mounting. Mount flush or semirecessed with arrangement and trim as indicated. Coordinate wiring with other modular panel components, including **[room lighting switches][intercom devices][convenience outlets][data outlets][speaker]** and other similar devices.
- E. Provision for Time-Tone-Unit Installation: Equip indicated clocks for housing or mounting in an acoustically treated and baffled speaker compartment specified in Section 275116 "Public Address and Mass Notification Systems."
- F. Secondary Indicating Clock Characteristics:
1. Clock Type: **[Analog][Digital]**.
 2. Face Configuration: **[Single][Double]**.
 3. Mounting: **[Recessed][Semirecessed][Pendant][Surface][Suspended][Within time-tone unit][Within modular panel]**<Insert mounting height of pendant, wall, and suspended clocks>.
 4. Nominal Dimensions: <Insert depth and nominal diameter or height and width in inches (mm)>.
 5. Casing Finish: <Insert description, including types and colors>.
 6. Special Environmental Conditions: <Describe conditions such as corrosive, damp, or wet locations>.
 7. Dial Face Color: <Insert color>.
 8. Analog Clock Crystal: Clear **[glass][acrylic][polycarbonate]**.
 9. Face Color: <Insert color>.
 10. Display Height: <Insert inches (mm)>.
 11. Seconds Display: **[Yes][No]**.
 12. Digital Clock Lens: Antiglare acrylic material.
 13. Battery Backup: **[Yes][No]**.
 14. Interval-Timer Display: **[Yes][No]**.

2.5 PROGRAM SIGNAL DEVICES

- A. Bells: Heavy-duty, modular, vibrating type with the following sound-output ratings measured at **10 feet (3 m)**:
1. 4-Inch (100-mm) Bell: 90 dB.
 2. 6-Inch (150-mm) Bell: 95 dB.
 3. 10-Inch (250-mm) Bell: 104 dB.
- B. Chimes: Heavy-duty, modular, vibrating chimes with polished-chrome tone bar and enamel-finished housing. Minimum sound-output rating measured at **10 feet (3 m)** shall be 75 dB.
- C. Clock Buzzers: Adjustable output signal device designed for mounting within clock housing or outlet box.
1. Sound-Output Rating Measured at 3 Feet (1 m): 75 dB.
 2. Audible Tone Frequency: Manufacturer's standard between 120 Hz and 2 kHz.

- D. Horns: Modular, adjustable-output, vibrating type with minimum full-intensity-rated sound output of 103 dB measured at **10 feet (3 m)**.
- E. Projector Horns: Adjustable-output, vibrating type with **[single][double]** projector arranged to channel sound in the direction of the projector axis, and with minimum full-intensity-rated sound output of 104 dB measured at **10 feet (3 m)**.
- F. Loudspeakers for Audible Tones: See Section 275116 "Public Address and Mass Notification Systems."
- G. Visible Signal Devices: Strobe lights with **[blue][yellow]** polycarbonate lens and xenon flash tube, with lens mounted on an aluminum faceplate and the word "Program" engraved in letters at least **1 inch (25 mm)** high on lens. Lamp unit shall have a minimum rated light output of 75 candela.
- H. Combination Audible and Visible Signal Devices: Factory-integrated horn and strobe light in a single mounting assembly.
- I. Outdoor Signal Equipment: Weatherproof models listed for outdoor use.
- J. Mounting Arrangement for Signal Devices: Designed for attachment with screws on the mounting plate of a flush-mounted back box unless otherwise indicated.
- K. Enclosures for Flush-Mounting Bells and Horns: Enclosure, mounting plate, and grille assembly shall be furnished by device manufacturer to match features of the device to be mounted. Enclosure shall be recessed in wall, completely enclosing the device, with grille mounting over the open side of the enclosure and flush with the wall.
- L. Connection Provision for Signal-Indicating Devices: **[Plug connector][Wire pigtail or compression splice]**.

2.6 CLOCK CIRCUIT POWER BOOSTER

- A. Description: Transformer power supply, mounted in steel cabinet with hinged door, and having fuse-protected input and output circuits.

2.7 BACK BOXES FOR SECONDARY INDICATING CLOCKS AND PROGRAM DEVICES

- A. Description: Box and cover-plate assembly shall be furnished by device manufacturer and be suitable for device to be mounted. Back boxes shall be equipped with knockouts and hanger straps or mounting adapters arranged for flush mounting the device unless otherwise indicated.

2.8 GUARDS

- A. Description: Formed-steel wire, shaped to fit around guarded device, with **1-inch (25-mm)** maximum clearance.
 - 1. Mounting Provisions: Fixed tabs, welded to guard and arranged for screw attachment to mounting surface.
 - 2. Finish for Indoor Devices: **[Clear]<Insert finish color>** epoxy lacquer over zinc plating.
 - 3. Finish for Outdoor Devices: **[Black]<Insert finish color>** powder coat over zinc plating and primer.

2.9 RACK-MOUNTING PROVISION FOR MASTER CLOCK

- A. Equipment Cabinet: **[Floor][Wall]**-mounted, rack type. Comply with EIA-310-D and the following:
1. Cabinet Housing: Constructed of steel, with front **[and rear]** doors; with manufacturer's standard tumbler locks, keyed alike.
 - a. Front door shall have a clear panel in front of the master clock display.
 - b. Housing shall enclose master clock and auxiliary clock system components, plus a minimum of **[20]<Insert number>** percent spare capacity for future equipment.
 2. Forced Ventilation: Internal low-noise fan with a filtered intake vent, connected to operate from 105- to 130-V ac, 60 Hz; separately fused and switchable and arranged to be powered when main cabinet power switch is on.
 3. Natural Ventilation: Ventilated rear and sides with louvers and solid top.
 4. Arrange inputs, outputs, interconnections, and test points so they are accessible at rear of rack for maintenance and testing, with each item removable from rack without disturbing other items or connections.
 5. Blank Panels: Cover empty space in equipment racks so entire front of rack is occupied by equipment or panels.
 6. Finish: Uniform, baked-enamel, **[manufacturer's standard color]<Insert color>** finish over rust-inhibiting primer.
 7. Power-Control Panel: On front of equipment housing; with master power on-off switch and pilot light, and socket for a 5-A, indicating, cartridge fuse for rack equipment power.
 8. Vertical Plug Strip: Grounded receptacles, **12 inches (300 mm)** o.c. the full height of rack, to supply rack-mounting equipment.
 9. Maintenance Receptacles: Duplex convenience outlet with supply terminals separate from equipment plug strip and located in front of rack.

2.10 CONDUCTORS AND CABLES

- A. Conductors: Jacketed, twisted pair and twisted multipair, untinned solid copper. Sizes as recommended by system manufacturer, but not smaller than No. 22 AWG. Voltage drop for signal, control, and clock correction circuits shall not exceed 10 percent under peak load conditions.
- B. 120-V AC and Class 1 Signal and Control Circuits: Stranded, single conductors of size and type recommended by system manufacturer. Materials and installation requirements are specified in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Class 2 and Class 3 Signal and Control Circuits: Single conductor or twisted-pair cable, unshielded, unless manufacturer recommends shielded cable. Materials and installation requirements are specified in Section 260523 "Control-Voltage Electrical Power Conductors and Cables."
- D. Data Circuits: Category 6 minimum, unshielded, twisted-pair cable, unless manufacturer recommends shielded cable.
- E. Insulation: Thermoplastic, not less than **1/32 inch (0.8 mm)** thick.
- F. Plenum Cable: Listed and labeled for plenum installation.
- G. Conductor Color-Coding: Uniformly identified and coordinated with wiring diagrams.
- H. Shielding: For speaker-microphone leads and at other locations recommended by manufacturer; No. 34 AWG tinned, soft-copper strands formed into a braid or equivalent foil.

1. Minimum Shielding Coverage on Conductors: 60 percent.

2.11 PATHWAYS

- A. Intercommunication and Program System Raceways and Boxes: Comply with requirements in Section 270528 "Pathways for Communications Systems."
 1. Raceway Type: **[Optical fiber/communications raceway and fittings][Metal wireways][Nonmetal wireways][Surface metal raceways][Surface nonmetal raceways]**.
- B. Outlet boxes shall be no smaller than **2 inches (50 mm)** wide, **3 inches (75 mm)** high, and **2-1/2 inches (64 mm)** deep.
- C. Flexible metal conduit is prohibited.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Mount system components with fastening methods and devices designed to resist the seismic forces indicated in Section 260548.16 "Seismic Controls for Electrical Systems."

3.2 WIRING METHODS

- A. Wiring in Raceways and Trays: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters[**and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used**]. Conceal raceway and cables except in unfinished spaces.
 1. Install plenum cable in environmental air spaces, including plenum ceilings.
 2. Comply with requirements for raceways and boxes specified in Section 270528 "Pathways for Communications Systems."
- B. Wiring in Ceilings, Walls, and Floors: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- C. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.
- D. Support cables not enclosed in raceways on J-Hooks. Install, size, and space J-Hooks to comply with TIA-568-C.

3.3 ELECTRICAL CONNECTIONS

- A. Make splices, taps, and terminations on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.
- B. Use **[plug connectors][splices]** for connections to clocks and signal devices.

- C. Ground clocks, programming equipment, and conductor and cable shields to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

3.4 IDENTIFICATION

- A. Comply with Section 260553 "Identification for Electrical Systems."
- B. Color-code wires, and apply wire and cable marking tape to designate wires and cables so they are uniformly identified and coordinated with wiring diagrams throughout the system.

3.5 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installation, including connections.
- B. Perform tests and inspections.
 - 1. Manufacturer's Field Service Assistance: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- C. Tests and Inspections:
 - 1. Perform operational-system tests to verify compliance with the Specifications and make adjustments to bring system into compliance. Include operation of all modes of clock correction and all programming and manually programmed signal and relay operating functions.
 - 2. Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.
- D. Clock system will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

3.6 ADJUSTING

- A. Program system according to Owner's requirements. Set system so signal devices operate on Owner-required schedules and are activated for durations selected by Owner. Program equipment-control output circuits to suit Owner's operating schedule for equipment controlled.
- B. Adjust sound-output level of adjustable signal devices to suit Owner's requirements.
- C. Occupancy Adjustments: When requested within [12]<Insert number> months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to [two]<Insert number> visits to Project during other-than-normal occupancy hours for this purpose.

3.7 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain clock-and-program-control system components.



27 - Communications

END OF SECTION 27 53 13 00



Task	Specification	Specification Description
27 53 13 13	27 53 13 00	Clock Systems
27 53 13 16	27 53 13 00	Clock Systems



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SECTION 28 08 00 00 - ACCESS CONTROL SOFTWARE AND DATABASE MANAGEMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Software for access control system units.
2. Software for access control system supplementary computer equipment.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. Section 281400 "Access Control System Hardware" for hardware required to run software specified in this Section.
5. Section 281500 "Integrated Access Control Hardware Devices" for access control field devices controlled by software specified in this Section.

1.2 DEFINITIONS

- ##### A. RAM: Random-access memory.

1.3 ACTION SUBMITTALS

A. Product Data:

1. For each type of product.

B. Certificates:

1. **<Insert certificate requirement>.**

C. Field Quality-Control Submittals:

1. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

- ##### A. Manufacturers' Published Instructions: Record copy of official installation[**and**][testing][and][troubleshooting] instructions issued to Installer by manufacturer for the following:

1. Installation and programming instructions for operating system software, including all applicable



- software add-ons.
- 2. Manufacturer's recommended setup and testing procedure for operating system software and applicable software add-ons.
- 3. Troubleshooting instructions for operating system software and applicable software add-ons.
- 4. Installation and programming instructions for antivirus and security protection software.
- 5. Manufacturer's recommended setup and testing procedure for antivirus and security protection software.
- 6. Troubleshooting instructions for antivirus and security protection software.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Contracts:

- 1. Software and firmware service agreement.

1.6 QUALIFICATIONS

- A. Security Design Professional: Design professional with active Physical Security Professional (PSP) certification issued by American Society for Industrial Security (ASIS) and with documented experience managing installation of security systems in similar size and complexity.
- B. Security Testing and Inspecting Agency: Entity possessing active credentials from qualified electrical testing laboratory recognized by authorities having jurisdiction.
 - 1. On-site security testing supervisor must have **[ASIS][PSP]<Insert organization>** certification and documented training and experience with testing security equipment in accordance with **[ASIS]<Insert organization>** testing standards.

PART 2 - PRODUCTS

2.1 SOFTWARE FOR ACCESS CONTROL SYSTEM UNITS

- A. Description: This category covers software products intended for installation on access control system units.
- B. Performance Criteria:
 - 1. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70 and NFPA 72, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - b. Comply with NFPA 1, NFPA 730, NFPA 731, and ICC IBC.
 - c. **<Insert requirements>**.
 - 2. Listing Criteria:
 - a. Cybersecurity: UL CCN CYBR; including UL 2900-1 and UL 2900-2-3.
 - b. Access Control System Functionality: UL CCN ALVY; including UL 294.
 - c. Hardware that Interfaces with Fire Alarm or Mass Notification: UL CCN UOJK; including UL

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C. Access Control System Unit Operating System Software:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Cansec Systems Ltd.]**
 - b. **[HID Global; ASSA ABLOY]**
 - c. **[Honeywell Commercial Security; Honeywell International, Inc.]**
 - d. **[LenelS2; Carrier Global Corporation]**
 - e. **[Tyco Software House; Tyco International, Ltd.]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Cansec Systems Ltd.]**
 - b. **[HID Global; ASSA ABLOY]**
 - c. **[Honeywell Commercial Security; Honeywell International, Inc.]**
 - d. **[LenelS2; Carrier Global Corporation]**
 - e. **[Tyco Software House; Tyco International, Ltd.]**
 - f. **<Insert manufacturer's name>**
3. Additional Characteristics:
 - a. Provides event logging, notification, and escalation.
 - b. Provides threat-level management and response actions.
 - c. Provides dashboard view of system health and status.
 - d. Maintains credential-driven user records and access history.
 - e. Supports network-connected credential readers and controlled doors.
 - f. Supports add-on software.
 - g. Supports video-surveillance system integration.
 - h. Provides email **[and text message]** alerts.
 - i. **<Insert characteristics>**.
4. Options:
 - a. Operating System: **[Windows 7][Windows 10]<Insert operating system>**.
 - b. User Interface: **[Web browser][and][mobile app]**.
 - c. Web Browser: **[Microsoft Edge (Chromium)][or][Google Chrome]<Insert web browser>**.
 - d. Drive Space: **[32 GB][100 GB][500 GB]<Insert size>**.
 - e. Memory: **[1 GB][4 GB][8 GB]<Insert size>** RAM.
 - f. Screen Resolution: **[1280×720][1920×1080]<Insert resolution>**.
 - g. Number of Cardholders: Up to **[1000][10,000][50,000][150,000]<Insert number>**.
 - h. Number of Supported Readers: Up to **[100][500][1000]<Insert number>**.
 - i. Number of Inputs: **[128][256][1024]<Insert number>**.
 - j. Number of Outputs: **[128][256][1024]<Insert number>**.
 - k. Simultaneous Users: **[Five][25][35]<Insert number>**.

D. Access Control System Unit Antivirus and Security Protection Software:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Avast Software s.r.o.]**
 - b. **[McAfee, LLC]**
 - c. **[Microsoft Corporation]**
 - d. **[S.C. Bitdefender S.R.L.]**
 - e. **[Sophos Ltd.; Sophos Group plc]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Avast Software s.r.o.]**
 - b. **[McAfee, LLC]**
 - c. **[Microsoft Corporation]**
 - d. **[S.C. Bitdefender S.R.L.]**
 - e. **[Sophos Ltd.; Sophos Group plc]**
 - f. **<Insert manufacturer's name>**
3. Additional Characteristics:
 - a. Endpoint detection and response.
 - b. Anti-ransomware.
 - c. Managed threat response.
 - d. Exploit prevention.
 - e. Active adversary mitigations.
 - f. Email alerts.
 - g. **<Insert characteristics>**.
4. Options:
 - a. Operating System: **[Windows 7][Windows 10]<Insert operating system>**.
 - b. User Interface: **[Web browser][and][mobile app]**.
 - c. Web Browser: **[Microsoft Edge (Chromium)][or][Google Chrome]<Insert web browser>**.
 - d. Drive Space: **[1 GB][4 GB][8 GB]<Insert size>**.
 - e. Memory: **[1 MB][100 MB][1 GB]<Insert size>** RAM.

E. Visitor Management Database Software:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[BluBØX Security, Inc.]**
 - b. **[HID Global; ASSA ABLOY]**
 - c. **[Splan Inc.]**
 - d. **[Traction Guest]**
 - e. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[BluBØX Security, Inc.]**
 - b. **[HID Global; ASSA ABLOY]**
 - c. **[Splan Inc.]**
 - d. **[Traction Guest]**
 - e. **<Insert manufacturer's name>**
3. Additional Characteristics:
 - a. Visitor registration.
 - b. Visitor audit trails and reporting.
 - c. Badge printing.
 - d. Unassisted visitor registration and badging.
 - e. Preconfigured security levels of users.
 - f. Filters out unsolicited visitors.
 - g. Supports integrated credential readers.
 - h. **<Insert characteristics>**.
4. Options:
 - a. Operating System: **[Windows 7][Windows 10]<Insert operating system>**.
 - b. User Interface: **[Web browser][and][mobile app]**.
 - c. Web Browser: **[Microsoft Edge (Chromium)][or][Google Chrome]<Insert web browser>**.
 - d. Drive Space: **[100 MB][500 MB][1 GB]<Insert size>**.
 - e. Memory: **[500 MB][1 GB][4 GB]<Insert size>** RAM.
 - f. Automated Alerts:
 - 1) Visitor check-in.
 - 2) Package check-in.
 - 3) Watch list alert.
 - 4) Expired badges.
 - 5) Panic message.
 - 6) Current visitor.
 - 7) Maximum visitor.
 - 8) Frequent visitor.
 - 9) Time based.

F. Mobile Credential Validation Database Software:

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



- b. <Insert manufacturer's name>
- 3. Additional Characteristics:
 - a. Mobile Validator and Mobile Registration engines.
 - b. Network-based functionality and database synchronization.
 - c. Credential audit trail exporting.
 - d. Contact or contactless verification.
 - e. Integrated card reader.
 - f. Biometric finger scanner.
 - g. <Insert characteristics>.
- 4. Options:
 - a. Operating System: [Windows CE 5.0][Windows Mobile 6]<Insert operating system>.
 - b. Multi-Factor Authentication: [One][Two][Three] factor authentication.
 - c. Drive Space: [100 MB][500 MB][1 GB]<Insert size>.
 - d. Memory: [32 MB][100 MB][1 GB]<Insert size> RAM.
 - e. Credentials:
 - 1) PIV.
 - 2) PIV-1.
 - 3) TWIC.
 - 4) FRAC.
 - 5) CAC.
 - 6) CIV.
 - 7) Prox.
 - 8) DESFire.

2.2 SOFTWARE FOR ACCESS CONTROL SYSTEM SUPPLEMENTARY COMPUTER EQUIPMENT

- A. Description: This category covers software products for installation on access control system supplementary computer equipment that do not inhibit safety or intended operation of access control system hardware devices when they are shut off, lose power, or otherwise fail.
- B. Performance Criteria:
 - 1. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70 and NFPA 72, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - b. <Insert requirements>.
 - 2. Listing Criteria:
 - a. Cybersecurity: UL CCN CYBR; including UL 2900-1 and UL 2900-2-3.
- C. Access Control System Supplementary Computer Equipment Operating System Software:
 - 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

- a. [Cansec Systems Ltd.]
 - b. [HID Global; ASSA ABLOY]
 - c. [Honeywell Commercial Security; Honeywell International, Inc.]
 - d. [LenelS2; Carrier Global Corporation]
 - e. [Tyco Software House; Tyco International, Ltd.]
 - f. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Cansec Systems Ltd.]
 - b. [HID Global; ASSA ABLOY]
 - c. [Honeywell Commercial Security; Honeywell International, Inc.]
 - d. [LenelS2; Carrier Global Corporation]
 - e. [Tyco Software House; Tyco International, Ltd.]
 - f. <Insert manufacturer's name>
 3. Additional Characteristics:
 - a. Provides event logging, notification, and escalation.
 - b. Provides threat-level management and response actions.
 - c. Provides dashboard view of system health and status.
 - d. Maintains credential-driven user records and access history.
 - e. Supports network-connected credential readers and controlled doors.
 - f. Supports add-on software.
 - g. Supports video-surveillance system integration.
 - h. <Insert characteristics>.
 4. Options:
 - a. Operating System: [Windows 7][Windows 10]<Insert operating system>.
 - b. User Interface: [Web browser][and][mobile app].
 - c. Web Browser: [Microsoft Edge (Chromium)][or][Google Chrome]<Insert web browser>.
 - d. Drive Space: [32 GB][100 GB][500 GB]<Insert size>.
 - e. Memory: [1 GB][4 GB][8 GB]<Insert size> RAM.
 - f. Screen Resolution: [1280×720][1920×1080]<Insert resolution>.
 - g. Number of Cardholders: Up to [1000][10,000][50,000][150,000]<Insert number>.
 - h. Number of Supported Readers: Up to [100][500][1000]<Insert number>.
 - i. Number of Inputs: [128][256][1024]<Insert number>.
 - j. Number of Outputs: [128][256][1024]<Insert number>.
 - k. Simultaneous Users: [Five][25][35]<Insert number>.
- D. Access Control System Supplementary Computer Equipment Antivirus and Security Protection Software:
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Avast Software s.r.o.]
 - b. [McAfee, LLC]
 - c. [Microsoft Corporation]
 - d. [S.C. Bitdefender S.R.L.]

- e. [Sophos Ltd.; Sophos Group plc]
 - f. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Avast Software s.r.o.]
 - b. [McAfee, LLC]
 - c. [Microsoft Corporation]
 - d. [S.C. Bitdefender S.R.L.]
 - e. [Sophos Ltd.; Sophos Group plc]
 - f. <Insert manufacturer's name>
 3. Additional Characteristics:
 - a. Endpoint detection and response.
 - b. Anti-ransomware.
 - c. Managed threat response.
 - d. Exploit prevention.
 - e. Active adversary mitigations.
 - f. Email alerts.
 - g. <Insert characteristics>.
 4. Options:
 - a. Operating System: [Windows 7][Windows 10]<Insert operating system>.
 - b. User Interface: [Web browser][and][mobile app].
 - c. Web Browser: [Microsoft Internet Explorer][Microsoft Edge (Chromium)][or][Google Chrome]<Insert web browser>.
 - d. Drive Space: [1 GB][4 GB][8 GB]<Insert size>.
 - e. Memory: [1 MB][100 MB][1 GB]<Insert size> RAM.
- E. Credential Card Personalization Software:
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [CardLogix Corporation]
 - b. [HID Global; ASSA ABLOY]
 - c. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [CardLogix Corporation]
 - b. [HID Global; ASSA ABLOY]
 - c. <Insert manufacturer's name>
 3. Additional Characteristics:
 - a. Credential card design and data-entry customization.

- b. Card data fields populated directly from internal or networked database.
 - c. User-defined privileges.
 - d. Quick filter for searching internal database.
 - e. Global find for searching all networked databases.
 - f. Customized reporting.
 - g. **<Insert characteristics>**.
 - 4. Options:
 - a. Operating System: **[Windows 7][Windows 10]<Insert operating system>**.
 - b. User Interface: **[Web browser][and][mobile app]**.
 - c. Web Browser: **[Microsoft Edge (Chromium)][or][Google Chrome]<Insert web browser>**.
 - d. Drive Space: **[1 GB][5 GB][10 GB]<Insert size>**.
 - e. Memory: **[1 GB][4 GB][8 GB]<Insert size>** RAM.
- F. Credential Card Printer and Encoder Software:
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[CardLogix Corporation]**
 - b. **[HID Global; ASSA ABLOY]**
 - c. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[CardLogix Corporation]**
 - b. **[HID Global; ASSA ABLOY]**
 - c. **<Insert manufacturer's name>**
 - 3. Additional Characteristics:
 - a. Printer status and diagnostics information.
 - b. Diagnostics information.
 - c. Printer integration enables control of printing and encoding through software APIs.
 - d. Integrates with credential management systems through standard application programming interfaces (APIs).
 - e. Supports Standard Development Languages:
 - 1) Microsoft Visual Basic.NET.
 - 2) Visual C++.
 - 3) Visual C#.
 - 4) Oracle Java.
 - f. **<Insert characteristics>**.
 - 4. Options:
 - a. Operating System: **[Windows 7][Windows 10]<Insert operating system>**.
 - b. User Interface: **[Web browser][and][mobile app]**.
 - c. Web Browser: **[Microsoft Edge (Chromium)][or][Google Chrome]<Insert web**

- browser>.**
- d. Drive Space: [1 GB][5 GB][10 GB]<Insert size>.
- e. Memory: [1 GB][4 GB][8 GB]<Insert size> RAM.

PART 3 - EXECUTION

3.1 INSTALLATION OF ACCESS CONTROL SOFTWARE

- A. Comply with manufacturer's published instructions.
- B. Reference Standards:
 - 1. Installation of Access Control Software: Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with requirements in guide information for UL CCN ALVY, UL CCN CYBR, and UL CCN UOJK.
 - 2. Consult Architect for resolution of conflicting requirements.
- C. Special Techniques:
 - 1. **<Insert more stringent installation requirements that supplement or supersede listed standards and manufacturers' published instructions>.**
- D. Interfaces with Other Work:
 - 1. Coordinate installation of new access control software with existing equipment and network conditions.
 - a. **<Insert requirements for transition between new and existing>.**
 - 2. Coordinate with Section 281000 "Access Control" for physical and functional interfaces with access control system and for compliance with system-wide performance requirements.
 - 3. Coordinate with Section 281400 "Access Control System Hardware" for products that require access control software specified in this Section for operation and compliance with system-wide performance requirements.
 - 4. Coordinate with Section 284600 "Fire Detection and Alarm" for interfacing access control system inputs/outputs with fire-alarm system inputs/outputs.
- E. Systems Integration:
 - 1. **<Insert requirements for integration with other systems>.**

3.2 FIELD QUALITY CONTROL OF ACCESS CONTROL SOFTWARE

- A. Administrant for Security Tests and Inspections:
 - 1. **[Owner][Tenant]** will engage qualified security testing and inspecting agency to administer and perform tests and inspections.
 - 2. Engage qualified security testing and inspecting agency to administer and perform tests and inspections.
 - 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.

4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].
- B. Acceptance Testing Preparation:
 1. **<Insert requirements>**.
- C. Field tests and inspections must be witnessed by [Architect][Tenant][authorities having jurisdiction]**<Insert names or titles of witnesses>**.
- D. Tests and Inspections:
 1. Perform manufacturer's recommended tests and inspections.
- E. Nonconforming Work:
 1. Software will be considered defective if it does not pass tests and inspections.
 2. Remove and replace defective software and retest.
- F. Collect, assemble, and submit test and inspection reports.
- G. Manufacturer Services:
 1. Engage factory-authorized service representative to [support][supervise] field tests and inspections.

3.3 SYSTEM STARTUP

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.
 1. Complete software installation and startup checks in accordance with manufacturer's published instructions.
 2. **<Insert startup steps>**.

3.4 MAINTENANCE

- A. Software and Firmware Service Agreement:
 1. Technical Support: Beginning at Substantial Completion, verify that software and firmware service agreement includes software and firmware support for [two]**<Insert number>** years.
 2. Upgrade Service: At Substantial Completion, update software and firmware to latest version. Install and program software and firmware upgrades that become available within [two]**<Insert number>** years from date of Substantial Completion.[**Verify that upgrading software includes operating system and new or revised licenses for using software.**]
 - a. Upgrade Notice: No fewer than [30]**<Insert number>** days to allow Owner to schedule and access the system[**and to upgrade computer equipment if necessary**].
 3. Upgrade Reports: Prepare report after each update, documenting upgrades installed.

END OF SECTION 28 08 00 00



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SECTION 28 10 00 00 - ACCESS CONTROL

PART 1 - GENERAL

1.1 SUMMARY

A. The Work of this Section Includes:

1. Access control system.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. **[Section 013100 "Project Management and Coordination"]<Insert Section number and title>** specifies preinstallation conference procedures.
5. **[Section 087100 "Door Hardware"]****[Section 087111 "Door Hardware (Descriptive Specification)"]** specifies the following:
 - a. Electric strike(s).
 - b. Electromagnetic lock(s).
 - c. Delayed-egress electromagnetic lock(s).
 - d. Electromechanical lock(s).
 - e. Self-contained electronic lock(s).
 - f. Exit lock(s) and alarm(s).
 - g. Auxiliary electrified door hardware.
6. Section 087113 "Power Door Operators" specifies the following:
 - a. Door operator controls.
 - b. Panic exit device(s).
 - c. Electric strike(s).
 - d. Auxiliary electrified door hardware.
7. Section 281300 "Access Control Software and Database Management" specifies the following:
 - a. Access control system unit operating system software.
 - b. Access control system unit antivirus and security protection software.
 - c. Visitor management database software.
 - d. Mobile credential validation database software.
 - e. Access control system supplementary computer equipment operating system software.
 - f. Access control system supplementary computer equipment antivirus and security protection software.
 - g. Credential card personalization software.
 - h. Credential card printer and encoder software.

8. Section 281400 "Access Control System Hardware" specifies the following:

- a. Access control system server(s).
 - b. Access control system DGP(s).
 - c. Access control system door controller(s).
 - d. Access control system input/output interface(s).
 - e. Access control system power supply and battery charger(s).
 - f. Access control system [terminal(s)][workstation(s)].
 - g. Access control system printer(s) and encoder(s).
9. Section 281500 "Integrated Access Control Hardware Devices" specifies the following:
- a. Swipe card reader(s).
 - b. Proximity reader(s) for card, fob, or smartphone.
 - c. Door lock keypad(s).
 - d. Scramble keypad(s).
 - e. Combination card reader(s) and keypad(s).
 - f. Access control cards.
 - g. Electrically controlled single-point latch(es).
 - h. Electrically controlled three-point latch(es).
 - i. Type 1 high-security electronic lock(s).
 - j. Type 1F high-security combination lock(s).
 - k. REX motion sensor(s).
 - l. REX push-button(s).
 - m. Magnetic lock hardware with special locking arrangement for fire-rated door(s).
 - n. Panic hardware with special locking arrangement for fire-rated door(s).
 - o. NFC access control device(s).
 - p. Electronic key management system unit(s).
10. Section 281511 "Integrated Credential Readers and Entry Management" specifies the following:
- a. Swipe card reader(s).
 - b. Chip card reader(s).
 - c. Proximity reader(s) for card, fob, or smartphone.
 - d. Proximity card reader(s) for hazardous (classified) location.
 - e. Door lock keypad(s).
 - f. LCD alarm keypad(s).
 - g. Scramble keypad(s).
 - h. Single finger scanner(s).
 - i. Palm scanner(s).
 - j. Iris scanner(s).
 - k. Facial scanner(s).
 - l. Combination card reader(s) and keypad(s).
 - m. Combination card reader(s)/keypad(s) and biometrics scanner(s).
11. Section 281513 "Access Control Credentials" specifies the following:
- a. Access control cards.
 - b. Wireless key fobs.
12. Section 281515 "Electrified Locking Devices and Accessories" specifies the following:
- a. Electrically controlled single-point latch(es).
 - b. Electrically controlled two-point latch(es).
 - c. Electrically controlled three-point latch(es).
 - d. Type 1 high-security electronic lock(s).
 - e. Type 1F high-security combination lock(s).

- f. Type 2 high-security combination lock(s).
 - g. REX motion sensor(s).
 - h. REX push-button(s).
- 13. Section 281517 "Egress Management Devices" specifies the following:
 - a. Magnetic lock hardware with special locking arrangement.
 - b. Panic hardware with special locking arrangement.
- 14. Section 281519 "Access Control Remote Devices" specifies the following:
 - a. NFC access control device(s).
 - b. Bluetooth communications access control device(s).
 - c. Wireless communications access control device(s).
- 15. Section 281521 "Telephone Entry Systems" specifies the following:
 - a. Analog audio telephone entry system(s).
 - b. Digital audio-video telephone entry system(s).
- 16. Section 281523 "Intercom Entry Systems" specifies the following:
 - a. Digital audio intercom entry system(s).
 - b. Digital audio-video intercom entry system(s).
- 17. Section 281525 "Electronic Key Management Systems" specifies the following:
 - a. Electronic key management system unit(s).
 - b. Mechanical key management system unit(s).
- 18. Section 281527 "Access Control Electronic Turnstiles and Mobility Systems" specifies turnstile operator(s) with access control devices.

1.2 DEFINITIONS

- A. DGP: Data gathering panel.
- B. NFC: Near field communications.
- C. REX: Request-to-exit.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at **[Project site]<Insert location>**.
- B. Preinstallation Coordination Meeting(s): For access control. Conduct meeting(s) **[as videoconference][or][at Project site]<Insert location> before <Insert construction activity>**.
 - 1. Attendees: Installers, fabricators, representatives of manufacturers, and administrants for field tests and inspections. Notify Architect[, **Construction Manager**][, and **Owner's Commissioning Authority**] of scheduled meeting dates.

1.4 ACTION SUBMITTALS

- A. Shop Drawings:
 - 1. Project general notes.
 - 2. Head-end hardware, equipment, and device locations.
 - 3. Block diagram and cable/conduit routing illustrating end-to-end system wiring.
 - 4. End-to-end system communications details.
 - 5. Secondary power calculations
 - 6. **<Insert requirements>**.
- B. Field quality-control reports.

1.5 INFORMATIONAL SUBMITTALS

- A. Sample warranties.

1.6 CLOSEOUT SUBMITTALS

- A. Manufacturers' Published Instructions: Record copy of official installation[**and testing**] instructions issued to Installer by manufacturer for the following:
 - 1. Installation and programming instructions for operating system software, including all applicable software add-ons.
 - 2. Installation and programming instructions for antivirus and security protection software.
 - 3. Manufacturer's recommended setup and testing procedure for operating system software and applicable software add-ons.
 - 4. Troubleshooting instructions for operating system software and applicable software add-ons.
 - 5. Manufacturer's recommended setup and testing procedure for antivirus and security protection software.
 - 6. Troubleshooting instructions for antivirus and security protection software.
 - 7. Installation instructions for access control system servers.
 - 8. Installation instructions for access control system DGPs.
 - 9. Installation instructions for access control system input/output interface.
 - 10. Installation instructions for access control system door controllers.
 - 11. Installation instructions for access control system workstation.
 - 12. Installation instructions for access control system power supplies and battery chargers.
 - 13. Installation instructions for access control system printers.
 - 14. Manufacturer's recommended testing and inspection procedure for operation of access control system servers, panels, input/output interfaces, door controllers, and workstations.
 - 15. Manufacturer's recommended testing and inspection procedure for operation of access control system power supplies and battery chargers.
 - 16. Manufacturer's recommended testing and inspection procedure for operation of access control system printers.
 - 17. Installation instructions for integrated credential readers and entry management devices.
 - 18. Printing, programming, and handling instructions for access control credentials.
 - 19. Installation instructions for electrified locking devices and accessories.
 - 20. Installation instructions for egress management devices.
 - 21. Installation instructions for access control remote devices.
 - 22. Installation instructions for telephone entry systems.
 - 23. Installation instructions for intercom entry systems.
 - 24. Installation instructions for electronic key management systems.
 - 25. Installation instructions for access control electronic turnstiles and mobility systems.

26. Manufacturer's recommended tests and inspections for integrated credential readers and entry management devices.
27. Manufacturer's recommended tests and inspections for electrified locking devices and accessories.
28. Manufacturer's recommended tests and inspections for egress management devices.
29. Manufacturer's recommended tests and inspections for access control remote devices.
30. Manufacturer's recommended tests and inspections for telephone entry systems.
31. Manufacturer's recommended tests and inspections for intercom entry systems.
32. Manufacturer's recommended tests and inspections for electronic key management systems.
33. Manufacturer's recommended tests and inspections for access control electronic turnstiles and mobility systems.
34. Manufacturer's recommended testing and inspection procedure for end-to-end operation of access control system software, hardware, and integrated hardware devices.

B. Warranty documentation.

1.7 REGULATORY AGENCY APPROVALS

- A. Submittals for access control system requiring approval by authorities having jurisdiction must be signed and sealed by qualified life safety professional engineer responsible for their preparation. **[Obtain approval by authorities having jurisdiction prior to submitting for action by Architect.][Submit for action by Architect prior to submitting for approval by authorities having jurisdiction.]**
- B. Submittals for access control system require action by Architect prior to submitting for approval by authorities having jurisdiction.

1.8 QUALIFICATIONS

- A. Security Design Professional: Design professional with active Physical Security Professional (PSP) certification issued by American Society for Industrial Security (ASIS) and with documented experience managing installation of security systems in similar size and complexity.
- B. Security Testing and Inspecting Agency: Entity possessing active credentials from qualified electrical testing laboratory recognized by authorities having jurisdiction.
 1. On-site security testing supervisor must have **[ASIS][PSP]<Insert organization>** certification and documented training and experience with testing security equipment in accordance with **[ASIS]<Insert organization>** testing standards.

1.9 WARRANTY FOR ACCESS CONTROL SYSTEM

- A. Special Installer Extended Warranty: Installer warrants that fabricated and installed access control system performs in accordance with specified requirements and agrees to repair or replace components that fail to perform as specified within extended-warranty period.
 1. Extended-Warranty Period: **[Two][Three][Four]<Insert number>** years from date of Substantial Completion; full coverage for labor, materials, and equipment.
- B. Special Manufacturer Extended Warranty: Manufacturer warrants that components of access control system perform in accordance with specified requirements and agrees to provide repair or replacement of components that fail to perform as specified within extended-warranty period.
 1. Initial Extended-Warranty Period: **[Three][Four][Five]<Insert number>** years from date of



2. Substantial Completion; **[full][prorated]** coverage for labor, materials, and equipment. Follow-On Extended-Warranty Period: **[Eight]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for components **that failed because of transient voltage surges** only, free on board **[origin][destination]**, freight prepaid.

1.10 WARRANTY FOR BATTERIES

- A. Special Manufacturer Extended Warranty for Batteries: Manufacturer warrants that batteries perform in accordance with specified requirements and agrees to provide repair or replacement of batteries that fail to perform as specified within warranted cycle life.
 1. Initial Extended-Warranty Period for Li-ion Batteries: **[Three][Four][Five]<Insert number>** years from date of Substantial Completion; full coverage for materials only, free on board **[origin][destination]**, freight prepaid.
 2. Follow-On Extended-Warranty Period for Li-ion Batteries: **[Ten]<Insert number>** years from date of Substantial Completion; prorated coverage for materials only, free on board **[origin][destination]**, freight prepaid.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 INSTALLATION OF ACCESS CONTROL SYSTEM

- A. Description: Access control system provides a means of regulating or controlling physical entry into an area, or access to or use of a device by electrical, electronic, and/or mechanical means. Typical access control system includes a card reader at a controlled door, which reads a user credential and sends the collected data to a centrally located DGP over the cabling infrastructure. DGP may hold a user database onboard or may communicate with a user database over the network. If user is authorized for access at a controlled door, DGP signals the electronic lock at the door to unlock. If user credential is not authorized according to user database, the door remains locked and access is denied. In addition to card readers and electronic locks, access control systems may include various other connected devices programmed for a desired function.
- B. Performance Criteria:
 1. Regulatory Requirements:
 - a. Components listed and labeled in accordance with NFPA 70 and NFPA 72, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - b. Comply with NFPA 1, NFPA 730, NFPA 731, and ICC IBC.
 - c. Certification: Provide certificate, authorized under UL Certification Service, that access control system installation complies with installation requirements of UL CCN ALOV.
 2. Listing Criteria: UL CCN ALOV and UL CCN ALVY; including UL 294.
 3. Consult Architect for resolution of conflicting requirements.
- C. Selection of Access Control System Components:
 1. Source Limitations: Obtain components for access control system from sources approved by **[manufacturer][fabricator][Installer]** warranting performance of entire system.
 2. Provide the following specified products with the access control system:

a. Access Control Software and Database Management:

- 1) Access control system unit operating system software.
- 2) Access control system unit antivirus and security protection software.
- 3) Visitor management database software.
- 4) Mobile credential validation database software.
- 5) Access control system supplementary computer equipment operating system software.
- 6) Access control system supplementary computer equipment antivirus and security protection software.
- 7) Credential card personalization software.
- 8) Credential card printer and encoder software.

b. Access Control System Hardware:

- 1) [Quantity as indicated on Drawings of][One]<Insert quantity> access control system server(s) <Insert drawing designation>.
- 2) [Quantity as indicated on Drawings of][One]<Insert quantity> access control system DGP(s) <Insert drawing designation>.
- 3) [Quantity as indicated on Drawings of][One]<Insert quantity> access control system door controller(s) <Insert drawing designation>.
- 4) [Quantity as indicated on Drawings of][One]<Insert quantity> access control system input/output interface(s) <Insert drawing designation>.
- 5) [Quantity as indicated on Drawings of][One]<Insert quantity> access control system power supply and battery charger(s) <Insert drawing designation>.
- 6) [Quantity as indicated on Drawings of][One]<Insert quantity> access control system [terminal(s)][workstation(s)]<Insert drawing designation>.
- 7) [Quantity as indicated on Drawings of][One]<Insert quantity> access control system printer(s) and encoder(s) <Insert drawing designation>.

c. Security Door Hardware:

- 1) [Quantity as indicated on Drawings of][One]<Insert quantity> electric strike(s) <Insert drawing designation>.
- 2) [Quantity as indicated on Drawings of][One]<Insert quantity> electromagnetic lock(s) <Insert drawing designation>.
- 3) [Quantity as indicated on Drawings of][One]<Insert quantity> delayed-egress electromagnetic lock(s) <Insert drawing designation>.
- 4) [Quantity as indicated on Drawings of][One]<Insert quantity> electromechanical lock(s) <Insert drawing designation>.
- 5) [Quantity as indicated on Drawings of][One]<Insert quantity> self-contained electronic lock(s) <Insert drawing designation>.
- 6) [Quantity as indicated on Drawings of][One]<Insert quantity> exit lock(s) and alarm(s) <Insert drawing designation>.
- 7) [Quantity as indicated on Drawings of][One]<Insert quantity> auxiliary electrified door hardware <Insert drawing designation>.
- 8) [Quantity as indicated on Drawings of][One]<Insert quantity> door operator controls <Insert drawing designation>.
- 9) [Quantity as indicated on Drawings of][One]<Insert quantity> panic exit device(s) with electric strike <Insert drawing designation>.

d. Integrated Credential Readers and Entry Management:

- 1) [Quantity as indicated on Drawings of][One]<Insert quantity> swipe card reader(s) <Insert drawing designation>.
- 2) [Quantity as indicated on Drawings of][One]<Insert quantity> chip card reader(s)

- 3) **<Insert drawing designation>.**
[Quantity as indicated on Drawings of][One]<Insert quantity> proximity reader(s) for card, fob, or smartphone **<Insert drawing designation>.**
 - 4) [Quantity as indicated on Drawings of][One]<Insert quantity> proximity card reader(s) for hazardous (classified) location **<Insert drawing designation>.**
 - 5) [Quantity as indicated on Drawings of][One]<Insert quantity> door lock keypad(s) **<Insert drawing designation>.**
 - 6) [Quantity as indicated on Drawings of][One]<Insert quantity> LCD alarm keypad(s) **<Insert drawing designation>.**
 - 7) [Quantity as indicated on Drawings of][One]<Insert quantity> scramble keypad(s) **<Insert drawing designation>.**
 - 8) [Quantity as indicated on Drawings of][One]<Insert quantity> single finger scanner(s) **<Insert drawing designation>.**
 - 9) [Quantity as indicated on Drawings of][One]<Insert quantity> palm scanner(s) **<Insert drawing designation>.**
 - 10) [Quantity as indicated on Drawings of][One]<Insert quantity> iris scanner(s) **<Insert drawing designation>.**
 - 11) [Quantity as indicated on Drawings of][One]<Insert quantity> facial scanner(s) **<Insert drawing designation>.**
 - 12) [Quantity as indicated on Drawings of][One]<Insert quantity> combination card reader(s) and keypad(s) **<Insert drawing designation>.**
 - 13) [Quantity as indicated on Drawings of][One]<Insert quantity> combination card reader(s)/keypad(s) and biometrics scanner(s) **<Insert drawing designation>.**
- e. Access Control Credentials:
- 1) [Quantity as indicated on Drawings of][25][50][100]<Insert quantity> access control cards **<Insert drawing designation>.**
 - 2) [Quantity as indicated on Drawings of][25][50][100]<Insert quantity> wireless key fobs **<Insert drawing designation>.**
- f. Electrified Locking Devices and Accessories:
- 1) [Quantity as indicated on Drawings of][One]<Insert quantity> electrically controlled single-point latch(es) **<Insert drawing designation>.**
 - 2) [Quantity as indicated on Drawings of][One]<Insert quantity> electrically controlled two-point latch(es) **<Insert drawing designation>.**
 - 3) [Quantity as indicated on Drawings of][One]<Insert quantity> electrically controlled three-point latch(es) **<Insert drawing designation>.**
 - 4) [Quantity as indicated on Drawings of][One]<Insert quantity> Type 1 high-security electronic lock(s) **<Insert drawing designation>.**
 - 5) [Quantity as indicated on Drawings of][One]<Insert quantity> Type 1F high-security combination lock(s) **<Insert drawing designation>.**
 - 6) [Quantity as indicated on Drawings of][One]<Insert quantity> Type 2 high-security combination lock(s) **<Insert drawing designation>.**
 - 7) [Quantity as indicated on Drawings of][One]<Insert quantity> REX motion sensor(s) **<Insert drawing designation>.**
 - 8) [Quantity as indicated on Drawings of][One]<Insert quantity> REX push-button(s) **<Insert drawing designation>.**
- g. Egress Management Devices:
- 1) [Quantity as indicated on Drawings of][One]<Insert quantity> magnetic lock hardware with special locking arrangement **<Insert drawing designation>.**
 - 2) [Quantity as indicated on Drawings of][One]<Insert quantity> panic hardware

with special locking arrangement <Insert drawing designation>.

h. Access Control Remote Devices:

- 1) [Quantity as indicated on Drawings of][One]<Insert quantity> NFC access control device(s) <Insert drawing designation>.
- 2) [Quantity as indicated on Drawings of][One]<Insert quantity> Bluetooth communications access control device(s) <Insert drawing designation>.
- 3) [Quantity as indicated on Drawings of][One]<Insert quantity> wireless communications access control device(s) <Insert drawing designation>.

i. Telephone Entry Systems:

- 1) [Quantity as indicated on Drawings of][One]<Insert quantity> analog audio telephone entry system(s) <Insert drawing designation>.
- 2) [Quantity as indicated on Drawings of][One]<Insert quantity> digital audio-video telephone entry system(s) <Insert drawing designation>.

j. Intercom Entry Systems:

- 1) [Quantity as indicated on Drawings of][One]<Insert quantity> digital audio intercom entry system(s) <Insert drawing designation>.
- 2) [Quantity as indicated on Drawings of][One]<Insert quantity> digital audio-video intercom entry system(s) <Insert drawing designation>.

k. Electronic Key Management Systems:

- 1) [Quantity as indicated on Drawings of][One]<Insert quantity> electronic key management system unit(s) <Insert drawing designation>.
- 2) [Quantity as indicated on Drawings of][One]<Insert quantity> mechanical key management system unit(s) <Insert drawing designation>.

l. Access Control Electronic Turnstiles and Mobility Systems:

- 1) [Quantity as indicated on Drawings of][One]<Insert quantity> turnstile operator(s) with access control devices <Insert drawing designation>.

3. Operation:

- a. Exchange database information directly with DGPs.
- b. <Insert specific requirements for sending and receiving access control data to and from external database or storage array>.

D. Special Techniques:

1. Comply with manufacturer's published instructions.
2. Mounting Heights: Mount field devices in accessible locations in accordance with United States Access Board ADA-ABA Accessibility Guidelines standards.
3. Wiring Methods:
 - a. Backbone Cable Type: [Single-mode fiber][and][or][multi-mode fiber][or][copper]<Insert cable type>.
 - b. Cable Type: [Shielded][Unshielded]<Insert cable size>.
 - c. Analog Maximum Cable Length: [1000 ft]<Insert cable length>.
 - d. Digital Maximum Cable Length: [300 ft][500 ft]<Insert cable length>.

E. Interfaces with Other Work:

1. Coordinate installation of new access control system components with existing conditions.
 - a. <Insert requirements for transition between new and existing>.
2. Coordinate with [Section 087100 "Door Hardware"] [Section 087111 "Door Hardware (Descriptive Specification)"] [applicable Division 08 Sections] for interfacing access control system devices with door hardware.
3. Coordinate with [Section 142100 "Electric Traction Elevators"] [Section 142400 "Hydraulic Elevators"] for interfacing access control system with elevator controls.
4. Coordinate with [Section 230923 "Direct Digital Control (DDC) System for HVAC"] [Section 230993.11 "Sequence of Operations for HVAC DDC"] for interfacing access control system with temperature controls to turn HVAC system on and off.
5. Coordinate with [Section 260923 "Lighting Control Devices"] [Section 260943.16 "Addressable Luminaire Lighting Controls"] [Section 260943.23 "Relay-Based Lighting Controls"] for interfacing access control system with lighting controls.
6. Coordinate with Section 284600 "Fire Detection and Alarm" for unlocking secured doors that are in exit ways, with or without delay.
7. Coordinate with Section 284700 "Mass Notification" for unlocking secured doors that are in exit ways, with or without delay.
8. Coordinate with Section 285213 "Detention Monitoring and Control System and Interfaces" for interfacing access control system with detention monitoring and controls.
9. Coordinate with Section 323113 "Chain Link Fences and Gates" for interfacing access control system with fence and gate controls.

F. Systems Integration:

1. Coordinate with [Section 283100 "Intrusion Detection"] [Section 283121 "Area and Perimeter Intrusion Detection"] for integrating access control system with intrusion detection system.
2. Coordinate with Section 282000 "Video Surveillance" for integrating access control system with video surveillance controls.
3. <Insert requirements for integrating access control system with other systems>.

3.2 FIELD QUALITY CONTROL OF ACCESS CONTROL SYSTEM COMPONENTS

A. Administrant for Security Tests and Inspections:

1. [Owner][Tenant] will engage qualified security testing and inspecting agency to administer and perform tests and inspections.
2. Engage qualified security testing and inspecting agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections[with assistance of factory-authorized service representative].

B. Acceptance Testing Preparation:

1. <Insert requirements>.

C. Field tests and inspections must be witnessed by [Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>.

D. Tests and Inspections:

1. Perform manufacturer's recommended tests and inspections for access control system components.
2. Perform **[industry standard]<Insert test>** tests and inspections for power supplies, batteries, and other standby power provisions.
3. Engage factory-authorized service representative to test end-to-end system connection and functionality.
4. Verify monitoring of access control system status and diagnostics information.

E. Nonconforming Work:

1. Access control equipment will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

F. Collect, assemble, and submit test and inspection reports.

G. Manufacturer Services:

1. Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.

3.3 SYSTEM STARTUP

A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.

1. Complete installation and startup checks in accordance with manufacturer's published instructions.
2. **<Insert startup steps>**.

3.4 ADJUSTING

A. Control Sensor Adjustments: Adjust control devices to suit actual occupied conditions.

1. For proximity motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.

3.5 PROTECTION

A. After installation, protect access control system components from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

3.6 MAINTENANCE

A. Control Sensor Readjustments: When requested within **[12]<Insert number>** months from date of Substantial Completion, provide on-site assistance in readjusting system to suit actual occupied conditions. Provide up to **[two]<Insert number>** visits to Project during other-than-normal occupancy hours for this purpose.



28 - Electronic Safety and Security

END OF SECTION 28 10 00 00



SECTION 28 10 00 00A - ACCESS CONTROL SYSTEM HARDWARE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Access control system units.
2. Access control system power supplies and battery chargers.
3. Access control system supplementary computer equipment.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. Section 281300 "Access Control Software and Database Requirements" for software required to run hardware specified in this Section.
5. Section 281500 "Integrated Access Control Hardware Devices" for access control field devices controlled by hardware specified in this Section.

1.2 DEFINITIONS

- A. DGP: Data gathering panel.
- B. LAN: Local area network.
- C. RAID: Redundant array of inexpensive disks; redundant array of independent disks.
- D. RAM: Random-access memory.
- E. WAN: Wide area network.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Coordination Meeting(s): For access control system hardware. Conduct meeting(s) **[as videoconference][or][at Project site]<Insert location> before <Insert construction activity>.**
 1. Attendees: Installers, fabricators, representatives of manufacturers, representatives from telecommunications, **[Owner's security representatives,][IT representatives,]** and administrators for field tests and inspections. Notify Architect[, **Construction Manager**][, and **Owner's Commissioning Authority**] of scheduled meeting dates.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings:
 - 1. Project general notes.
 - 2. Hardware and equipment locations.
 - 3. Block diagram and cable/conduit routing.
 - 4. System communications details.
 - 5. Hardware and equipment installation details.
 - 6. Secondary power calculations.
- C. Certificates:
 - 1. **<Insert certificate requirement>**.
- D. Field quality-control reports.

1.5 INFORMATIONAL SUBMITTALS

- A. Manufacturers' Published Instructions: Record copy of official installation[**and testing**] instructions issued to Installer by manufacturer for the following:
 - 1. Installation instructions for access control system servers.
 - 2. Installation instructions for access control system DGPs.
 - 3. Installation instructions for access control system input/output interface.
 - 4. Installation instructions for access control system door controllers.
 - 5. Installation instructions for access control system workstation.
 - 6. Manufacturer's recommended testing and inspection procedure for operation of access control system servers, panels, input/output interfaces, door controllers, and workstations.
 - 7. Installation instructions for access control system power supplies and battery chargers.
 - 8. Manufacturer's recommended testing and inspection procedure for operation of access control system power supplies and battery chargers.
 - 9. Installation instructions for access control system printers.
 - 10. Manufacturer's recommended testing and inspection procedure for operation of access control system printers.
- B. Sample warranties.

1.6 CLOSEOUT SUBMITTALS

- A. Warranty documentation.

1.7 QUALIFICATIONS

- A. Security Design Professional: Design professional with active Physical Security Professional (PSP) certification issued by American Society for Industrial Security (ASIS) and with documented experience managing installation of security systems in similar size and complexity.
- B. Security Testing and Inspecting Agency: Entity possessing active credentials from qualified electrical

testing laboratory recognized by authorities having jurisdiction.

1. On-site security testing supervisor must have **[ASIS][PSP]<Insert organization>** certification and documented training and experience with testing security equipment in accordance with **[ASIS]<Insert organization>** testing standards.

1.8 WARRANTY FOR ACCESS CONTROL SYSTEM HARDWARE

- A. Special Installer Extended Warranty: Installer warrants that fabricated and installed access control system hardware perform in accordance with specified requirements and agrees to repair or replace systems, assemblies, components, or products that fail to perform as specified within extended-warranty period.
 1. Extended-Warranty Period: **[Two][Three][Four]<Insert number>** years from date of Substantial Completion; full coverage for labor, materials, and equipment.
- B. Special Manufacturer Extended Warranty: Manufacturer warrants that access control system hardware perform in accordance with specified requirements and agrees to provide repair or replacement of components or products that fail to perform as specified within extended-warranty period.
 1. Initial Extended-Warranty Period: **[Three][Four][Five]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for labor, materials, and equipment.
 2. Follow-On Extended-Warranty Period: **[Eight]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for materials **[that failed because of transient voltage surges]** only, free on board **[origin][destination]**, freight prepaid.

1.9 WARRANTY FOR BATTERIES

- A. Special Manufacturer Extended Warranty for Batteries: Manufacturer warrants that batteries perform in accordance with specified requirements and agrees to provide repair or replacement of batteries that fail to perform as specified within extended-warranty period.
 1. Initial Extended-Warranty Period for Li-ion Batteries: **[Three][Four][Five]<Insert number>** years from date of Substantial Completion; full coverage for materials only, free on board **[origin][destination]**, freight prepaid.
 2. Follow-On Extended-Warranty Period for Li-ion Batteries: **[Ten]<Insert number>** years from date of Substantial Completion; prorated coverage for materials only, free on board **[origin][destination]**, freight prepaid.
 3. Extended-Warranty Period for Ni-MH Batteries: **[Three]<Insert number>** years from date of Substantial Completion; prorated coverage for materials only, free on board **[origin][destination]**, freight prepaid.
 4. Extended-Warranty Period for Ni-Cd Batteries: **[Five]<Insert number>** years from date of Substantial Completion; prorated coverage for materials only, free on board **[origin][destination]**, freight prepaid.
 5. Warranted Cycle Life for Valve Regulated (Sealed) Lead Acid Batteries: Equal to or greater than that represented in manufacturer's published table, but not less than the following, based on annual average battery temperature of **77 deg F (25 deg C)**:
 - a. For discharge rate not faster than eight hours, discharge duration not longer than eight hours, and voltage at end of discharge not less than 1.67 V, warranted life must be not fewer than six discharge cycles.
 - b. For discharge rate not faster than 30 minutes, discharge duration not longer than 30 minutes, and voltage at end of discharge not less than 1.67 V, warranted life must be not fewer than 20 discharge cycles.

- c. For discharge rate not faster than 15 minutes, discharge duration not longer than 45 seconds, and voltage at end of discharge not less than 1.67 V, warranted life must be not fewer than 120 discharge cycles.
- 6. Warranted Cycle Life for Premium Valve Regulated (Sealed) Lead Acid Batteries: Equal to or greater than that represented in manufacturer's published table, but not less than the following, based on annual average battery temperature of **77 deg F (25 deg C)**:
 - a. For discharge rate not faster than eight hours, discharge duration not longer than eight hours, and voltage at end of discharge not less than 1.67 V, warranted life must be not fewer than 40 discharge cycles.
 - b. For discharge rate not faster than 30 minutes, discharge duration not longer than 30 minutes, and voltage at end of discharge not less than 1.67 V, warranted life must be not fewer than 125 discharge cycles.
 - c. For discharge rate not faster than 15 minutes, discharge duration not longer than 90 seconds, and voltage at end of discharge not less than 1.67 V, warranted life must be not fewer than 750 discharge cycles.
- 7. Warranted Cycle Life for Flooded (Wet Cell or Open) Lead Acid Batteries: Equal to or greater than that represented in manufacturer's published table, but not less than the following, based on annual average battery temperature of **77 deg F (25 deg C)** and preventive maintenance performed in accordance with manufacturer's published instructions:
 - a. For discharge rate not faster than eight hours, discharge duration not longer than eight hours, and voltage at end of discharge not less than 1.75 V, warranted life must be not fewer than 40 discharge cycles.
 - b. For discharge rate not faster than one hour, discharge duration not longer than one hour, and voltage at end of discharge not less than 1.75 V, warranted life must be not fewer than 80 discharge cycles.
 - c. For discharge rate not faster than 15 minutes, discharge duration not longer than 45 seconds, and voltage at end of discharge not less than 1.67 V, warranted life must be not fewer than 2700 discharge cycles.

PART 2 - PRODUCTS

2.1 ACCESS CONTROL SYSTEM UNITS

- A. Description: This category covers head end units for access control systems, providing a means of regulating or controlling physical entry into an area, or access to or use of device by electrical, electronic, and/or mechanical means. Access control systems are investigated as complete configuration based upon manufacturer's specified system components. Access control systems are intended to comply with applicable life safety access and egress requirements.
- B. Performance Criteria:
 - 1. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70 and NFPA 72, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - b. Comply with NFPA 1, NFPA 730, NFPA 731, and ICC IBC.
 - 2. Listing Criteria: UL CCN ALVY; including UL 294.

C. Access Control System Server :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Cisco Systems, Inc.]**
 - b. **[Dell Technologies Inc.]**
 - c. **[International Business Machines Corp. (IBM)]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Cisco Systems, Inc.]**
 - b. **[Dell Technologies Inc.]**
 - c. **[International Business Machines Corp. (IBM)]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Additional Characteristics:
 - a. Ethernet port for connection to LAN/WAN.
 - b. **<Insert characteristics>**.
5. Options:
 - a. Input Voltage: **[120 V(ac)]<Insert power input>**.
 - b. Operating Temperature: **[50 to 82 deg F (10 to 28 deg C)]<Insert operating temperature>**.
 - c. Server Type: **[IBM][Windows][Lenovo]<Insert make>**.
 - d. Server Model: **<Insert model>**.
 - e. Server Size: **[One rack-unit (1U)][Two rack-units (2U)]<Insert size>**.
 - f. Drive Space: **[100 GB][500 GB][1 TB]<Insert size>**.
 - g. Memory: **[16 GB][24 GB][32 GB][48 GB]<Insert size> RAM**.
 - h. RAID Level: **[RAID 0][RAID 1]<Insert level>**.
 - i. Mounting: EIA/ECA-310 standard **19 inch (482.6 mm) [rack mount][cabinet mount]**.
6. Operation:
 - a. **<Insert server operating requirements>**.
7. Accessories:
 - a. DIN rails for mounting.

D. Access Control System DGPs :

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

- b. **[RS2 Technologies; ACRE, LLC]**
 - c. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Honeywell Commercial Security; Honeywell International, Inc.]**
 - b. **[RS2 Technologies; ACRE, LLC]**
 - c. **<Insert manufacturer's name>**
- 3. Source Limitations: Obtain products from single manufacturer.
- 4. Additional Characteristics:
 - a. Data ports for connection to LAN and downstream DGPs.
 - b. Integral terminal blocks secured to enclosure.
 - c. Enclosure lock with tamper switch and monitoring.
 - d. **<Insert characteristics>**.
- 5. Options:
 - a. Input Voltage: **[120 V(ac)]<Insert power input>**.
 - b. Internal Power Supply: **[16.5 V(ac) transformer][24 V(dc) power supply]<Insert power supply>**.
 - c. Operating Temperature: **[32 to 120 deg F (0 to 49 deg C)]<Insert temperature>**.
 - d. Enclosure Size: **<Insert size>**.
 - e. Materials: **[Steel]<Insert material>**.
 - f. Finishes: **<Insert finish>**.
 - g. Battery Backup: **[12 V][24 V]<Insert battery type>**.
 - h. DGP Communication: **[Ethernet][TIA-485]<Insert type>**.
 - i. Mounting: **[Wall mount][EIA/ECA-310 standard 19 inch (482.6 mm)][Rack mount][Cabinet mount]**.
- 6. Operation:
 - a. **<Insert panel operating requirements>**.
- 7. Accessories:
 - a. **<Insert accessory>**.

E. Access Control System Door Controllers :

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[HID Global; ASSA ABLOY]**
 - b. **[IDTECK Global, Inc.]**
 - c. **[Openpath Security, Inc.]**
 - d. **[RS2 Technologies; ACRE, LLC]**
 - e. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert**

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

- a. **[HID Global; ASSA ABLOY]**
 - b. **[IDTECK Global, Inc.]**
 - c. **[Openpath Security, Inc.]**
 - d. **[RS2 Technologies; ACRE, LLC]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
 4. Additional Characteristics:
 - a. Data ports for connection to LAN and downstream controllers.
 - b. Integral terminal blocks for connection of inputs/outputs to field devices.
 - c. Controller Inputs:
 - 1) Auxiliary input.
 - 2) Door contact.
 - 3) Request to exit.
 - 4) Cabinet tamper.
 - 5) Power monitor.
 - d. Controller Outputs:
 - 1) Auxiliary output.
 - 2) Door strike.
 - 3) Door operators.
 - 4) Credential readers.
 - e. **<Insert characteristics>**.
 5. Options:
 - a. Input Voltage: **[12 to 24 V(dc)]<Insert power input>**.
 - b. Operating Temperature: **[32 to 158 deg F (0 to 70 deg C)]<Insert temperature>**.
 - c. Controller Size: **<Insert size>**.
 - d. Controller Communication: **[Ethernet][TIA-232][TIA-485]<Insert type>**.
 - e. Mounting: **[Cabinet mount]<Insert mounting arrangement>**.
 6. Operation:
 - a. **<Insert controller operating requirements>**.
 7. Accessories:
 - a. **<Insert accessory>**.

F. Access Control System Input/Output Interface :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[LenelS2; Carrier Global Corporation]**
 - b. **[Openpath Security, Inc.]**

- c. [RS2 Technologies; ACRE, LLC]
 - d. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [LenelS2; Carrier Global Corporation]
 - b. [Openpath Security, Inc.]
 - c. [RS2 Technologies; ACRE, LLC]
 - d. <Insert manufacturer's name>
- 3. Source Limitations: Obtain products from single manufacturer.
- 4. Additional Characteristics:
 - a. Input Voltage: [12 to 24 V(dc)]<Insert power input>.
 - b. Operating Temperature: [32 to 158 deg F (0 to 70 deg C)]<Insert temperature>.
 - c. Size: <Insert size>.
 - d. Data ports for connection to LAN and downstream panels/controllers.
 - e. Integral terminal blocks for connection of inputs/outputs to field devices.
 - f. Inputs:
 - 1) Auxiliary inputs from building systems.
 - 2) Door contact.
 - 3) Request to exit.
 - 4) Cabinet tamper.
 - 5) Power monitor.
 - g. Outputs:
 - 1) Auxiliary outputs to building systems.
 - 2) Door strike.
 - 3) Credential readers.
 - 4) Audible devices.
 - h. <Insert characteristics>.
- 5. Options:
 - a. Communication: [Ethernet][TIA-232][TIA-485]<Insert type>.
 - b. Mounting: [Cabinet mount]<Insert mounting arrangement>.
- 6. Operation:
 - a. <Insert interface operating requirements>.
- 7. Accessories:
 - a. <Insert accessory>.

2.2 ACCESS CONTROL SYSTEM POWER SUPPLIES AND BATTERY CHARGERS

- A. Description: This category covers power supplies and battery chargers for access control system units,

controllers, input/output interfaces, workstations, printers, and encoders.

B. Performance Criteria:

1. Regulatory Requirements:

- a. Listed and labeled in accordance with NFPA 70 and NFPA 72, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- b. Comply with NFPA 1, NFPA 730, NFPA 731, and ICC IBC.

2. Listing Criteria: UL CCN ALVY; including UL 294.

C. Access Control System Power Supply and Battery Charger :

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Altronix Corp.]**
 - b. **[Honeywell Commercial Security; Honeywell International, Inc.]**
 - c. **[LifeSafety Power (LSP); ASSA ABLOY]**
 - d. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Altronix Corp.]**
 - b. **[Honeywell Commercial Security; Honeywell International, Inc.]**
 - c. **[LifeSafety Power (LSP); ASSA ABLOY]**
 - d. **<Insert manufacturer's name>**
- 3. Source Limitations: Obtain products from single manufacturer.
- 4. Additional Characteristics:
 - a. Input Voltage: **[120 V(ac)]<Insert power input>**.
 - b. Output Voltage: **[12 to 24 V(dc)]<Insert power output>**.
 - c. Operating Temperature: **[32 to 120 deg F (0 to 49 deg C)]<Insert temperature>**.
 - d. Network connection for remote supervision, management, and testing.
 - e. Enclosure lock with tamper switch and monitoring.
 - f. Built-in battery charger.
 - g. Enclosure Size: **<Insert size>**.
 - h. Battery Size: **<Insert size>**.
 - i. Materials: **[Steel]<Insert material>**.
 - j. Finishes: **<Insert finish>**.
 - k. **<Insert characteristics>**.
- 5. Options:
 - a. Output Current: **[2.5 A][4 A][6 A]<Insert current>**.
 - b. Number of Outputs: **[One][Four][Eight][16]<Insert number>**.
 - c. Mounting: **[Wall mount][EIA/ECA-310 standard 19 inch (482.6 mm)][Rack mount][Cabinet mount]**.

6. Operation:
 - a. <Insert power supply and charger operating requirements>.
7. Accessories:
 - a. DIN rails for mounting.

2.3 ACCESS CONTROL SYSTEM SUPPLEMENTARY COMPUTER EQUIPMENT

- A. Description: This category covers access control system supplementary computer equipment that does not inhibit safety or intended operation of access control system hardware devices when they are shut off, lose power, or otherwise fail.
- B. Performance Criteria:
 1. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70 and NFPA 72, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 2. Listing Criteria: UL CCN NWGQ; including UL 294.
- C. Access Control System Workstation :
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Apple Inc.]**
 - b. **[ASUSTek Computer Inc.]**
 - c. **[Dell Technologies Inc.]**
 - d. **[HP Inc.]**
 - e. **[Lenovo Holding Co., Inc.; Lenovo Group Ltd.]**
 - f. **[LG Electronics USA, Inc.; LG Electronics Inc.]**
 - g. **[Microsoft Corporation]**
 - h. **[Samsung Electronics America, Inc. (SEA); Samsung Electronics Co., Ltd. (SEC)]**
 - i. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Apple Inc.]**
 - b. **[ASUSTek Computer Inc.]**
 - c. **[Dell Technologies Inc.]**
 - d. **[HP Inc.]**
 - e. **[Lenovo Holding Co., Inc.; Lenovo Group Ltd.]**
 - f. **[LG Electronics USA, Inc.; LG Electronics Inc.]**
 - g. **[Microsoft Corporation]**
 - h. **[Samsung Electronics America, Inc. (SEA); Samsung Electronics Co., Ltd. (SEC)]**
 - i. **<Insert manufacturer's name>**

3. Source Limitations: Obtain products from single manufacturer.
4. Additional Characteristics:
 - a. Input Voltage: **[120 V(ac)]<Insert power input>**.
 - b. Operating Temperature: **[50 to 82 deg F (10 to 28 deg C)]<Insert temperature>**.
 - c. Ethernet port for connection to LAN/WAN.
 - d. PC-based operating system with high-definition display.
 - e. **<Insert characteristics>**.
5. Options:
 - a. Operating System: **[Windows 7][Windows 10]<Insert operating system and version>**.
 - b. Display Size: **[22 inch (560 mm)][24 inch (610 mm)]<Insert size>**.
 - c. Display Resolution: **[1280×720][1920×1080]<Insert resolution>**.
 - d. Drive Space: **[100 GB][500 GB][1 TB]<Insert size>**.
 - e. Memory: **[16 GB][24 GB][32 GB][48 GB]<Insert size> RAM**.
 - f. User Control: **[Touchscreen][and][or][keyboard and mouse]**.
 - g. Mounting: **[EIA/ECA-310 standard 19 inch (482.6 mm)][Rack mount][Cabinet mount][desktop mount]**.
6. Operation:
 - a. **<Insert workstation operating requirements>**.
7. Accessories:
 - a. Printer for identification/credential cards.
 - b. Encoder for programming of access control credentials.
 - c. **<Insert accessory>**.

D. Access Control System Printers and Encoders :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[HID Global; ASSA ABLOY]**
 - b. **[Magicard Ltd.]**
 - c. **[Zebra Technologies Corp.]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[HID Global; ASSA ABLOY]**
 - b. **[Magicard Ltd.]**
 - c. **[Zebra Technologies Corp.]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Additional Characteristics:
 - a. Password-protected access for secure printing.
 - b. User Control: Touchscreen graphical display.

- c. Mounting: Desktop mounted.
 - d. **<Insert characteristics>.**
- 5. Options:
 - a. Input Voltage: **[100 to 240 V(ac)]<Insert power input>.**
 - b. Operating Temperature: **[65 to 80 deg F (18 to 27 deg C)]<Insert temperature>.**
 - c. Operating System: **[Windows 7][Windows 10]<Insert operating system and version>.**
 - d. Data Connection: **[USB 2.0][Ethernet]<Insert connection type>.**
 - e. Standard Card Size: **[CR-79][CR-80]<Insert size>.**
 - f. Printing Resolution: **[300 dpi]<Insert resolution>.**
 - g. Memory: **[16 MB][32 MB][1 GB]<Insert size> RAM.**
 - h. Access Control Credential Programming: **[Proximity smart card][Magnetic stripe card].**
 - i. Interface with secure visitor management solutions.
- 6. Operations:
 - a. **<Insert printer and encoder operating requirements>.**
- 7. Accessories:
 - a. WiFi accessory for Ethernet-enabled printers.
 - b. **<Insert accessory>.**

PART 3 - EXECUTION

3.1 INSTALLATION OF ACCESS CONTROL SYSTEM HARDWARE

- A. Comply with manufacturer's published instructions.
- B. Reference Standards:
 - 1. Installation of Access Control System Hardware and Wiring: Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with requirements in guide information for UL CCN ALVY.
 - 2. Consult Architect for resolution of conflicting requirements.
- C. Special Techniques:
 - 1. **<Insert more stringent installation requirements that supplement or supersede listed standards and manufacturers' published instructions>.**
- D. Interfaces with Other Work:
 - 1. Coordinate installation of new products for access control system hardware with existing conditions.
 - a. **<Insert requirements for transition between new and existing>.**
 - 2. Coordinate with Section 281000 "Access Control" for physical and functional interfaces with access control system and for compliance with system-wide performance requirements.
 - 3. Coordinate with **[Section 284600 "Fire Detection and Alarm"]****[and]****[Section 284614 "Single-**

and Multiple-Station Alarms"] for interfacing security system inputs/outputs with fire-alarm system inputs/outputs.

E. Systems Integration:

1. <Insert requirements for integration with other systems>.

3.2 FIELD QUALITY CONTROL OF ACCESS CONTROL SYSTEM HARDWARE

A. Administrant for Security Tests and Inspections:

1. [Owner][Tenant] will engage qualified security testing and inspecting agency to administer and perform tests and inspections.
2. Engage qualified security testing and inspecting agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].

B. Acceptance Testing Preparation:

1. <Insert requirements>.

C. Field tests and inspections must be witnessed by [Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>.

D. Tests and Inspections:

1. Perform manufacturer's recommended tests and inspections.

E. Nonconforming Work:

1. Hardware and components will be considered defective if they do not pass tests and inspections.
2. Remove and replace defective units and retest.

F. Collect, assemble, and submit test and inspection reports.

G. Manufacturer Services:

1. Engage factory-authorized service representative to [support][supervise] field tests and inspections.

3.3 SYSTEM STARTUP

A. [Engage a factory-authorized service representative to perform][Perform] startup service.

1. Complete installation and startup checks in accordance with manufacturer's published instructions.
2. <Insert startup steps>.



3.4 ADJUSTING

- A. Adjust printers and ribbons to function smoothly, and lubricate as recommended in writing by manufacturer.

3.5 PROTECTION

- A. After installation, protect access control system hardware from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 28 10 00 00A

SECTION 28 15 00 00 - INTEGRATED ACCESS CONTROL HARDWARE DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Integrated credential readers and entry management.
2. Access control credentials.
3. Electrified locking devices and accessories.
4. Egress management devices.
5. Access control remote devices.
6. Electronic key management systems.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. Section 281511 "Integrated Credential Readers and Entry Management" for additional integrated access control hardware device products.
5. Section 281513 "Access Control Credentials" for additional access control hardware credential products.
6. Section 281515 "Electrified Locking Devices and Accessories" for additional electronically controlled lock and latch products.
7. Section 281517 "Egress Management Devices" for additional access control hardware device products intended for use along the means of egress.
8. Section 281519 "Access Control Remote Devices" for additional wireless access control hardware device products.
9. Section 281521 "Telephone Entry Systems" for access control telephone entry products.
10. Section 281523 "Intercom Entry Systems" for access control intercom entry products.
11. Section 281525 "Electronic Key Management Systems" for additional key management system products with access control interfaces.
12. Section 281527 "Access Control Electronic Turnstiles and Mobility Systems" for security turnstile operator products with access control interfaces.

1.2 DEFINITIONS

- A. BMS: Building management system.
- B. NFC: Near Field Communications.
- C. PoE: Power over Ethernet.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Coordination Meeting(s): For integrated access control hardware devices. Conduct meeting(s) **[as videoconference][or][at Project site]<Insert location>** before **<Insert construction activity>**.
 - 1. Attendees: Installers, fabricators, representatives of manufacturers, representatives from telecommunications, **[Owner's security representatives,][IT representatives,]** and administrators for field tests and inspections. Notify Architect[, **Construction Manager**][, and **Owner's Commissioning Authority**] of scheduled meeting dates.

1.4 ACTION SUBMITTALS

- A. Product Data:
 - 1. For each type of product.
- B. Shop Drawings:
 - 1. Project general notes.
 - 2. Device layout.
 - 3. Block diagram and cable/conduit routing.
 - 4. System communications details.
 - 5. System mounting details.
 - 6. Secondary power calculations.
- C. Certificates:
 - 1. **<Insert certificate requirement>**.
- D. Field quality-control reports.

1.5 INFORMATIONAL SUBMITTALS

- A. Manufacturers' Published Instructions: Record copy of official installation[**and testing**] instructions issued to Installer by manufacturer for the following:
 - 1. Installation instructions for integrated credential readers and entry management devices.
 - 2. Manufacturer's recommended tests and inspections for integrated credential readers and entry management devices.
 - 3. Printing, programming, and handling instructions for access control credentials.
 - 4. Installation instructions for electrified locking devices and accessories.
 - 5. Manufacturer's recommended tests and inspections for electrified locking devices and accessories.
 - 6. Installation instructions for egress management devices.
 - 7. Manufacturer's recommended tests and inspections for egress management devices.
 - 8. Installation instructions for access control remote devices.
 - 9. Manufacturer's recommended tests and inspections for access control remote devices.
 - 10. Installation instructions for electronic key management systems.
 - 11. Manufacturer's recommended tests and inspections for electronic key management systems.
- B. Sample warranties.

1.6 CLOSEOUT SUBMITTALS

- A. Maintenance Contracts:
 - 1. Software and firmware service agreements.
- B. Warranty documentation.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Extra Stock Material: Furnish to Owner extra materials[, **from same production run,**] that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.[**Include the following:**]
 - 1. Integrated Credential Readers and Entry Management Devices: [**One**]**<Insert number>** of each type.
 - 2. Electrified Locking Devices and Accessories: [**One**]**<Insert number>** of each type.
- B. Special Tools: Furnish to Owner proprietary equipment, keys, and software required to operate, maintain, repair, adjust, or implement future changes to integrated access control hardware devices, that are packaged with protective covering for storage on-site and identified with labels describing contents.[**Include the following:**]
 - 1. **<Insert item>**.

1.8 REGULATORY AGENCY APPROVALS FOR EGRESS MANAGEMENT DEVICES

- A. Submittals for egress management devices requiring approval by authorities having jurisdiction must be signed and sealed by qualified life safety professional engineer responsible for their preparation.
[Obtain approval by authorities having jurisdiction prior to submitting for action by Architect.][Submit for action by Architect prior to submitting for approval by authorities having jurisdiction.]
- B. Submittals for egress management devices require action by Architect prior to submitting for approval by authorities having jurisdiction.

1.9 QUALIFICATIONS

- A. Security Design Professional: Design professional with active Physical Security Professional (PSP) certification issued by American Society for Industrial Security (ASIS) and with documented experience managing installation of security systems in similar size and complexity.
- B. Security Testing and Inspecting Agency: Entity possessing active credentials from qualified electrical testing laboratory recognized by authorities having jurisdiction.
 - 1. On-site security testing supervisor must have [**ASIS**][**PSP**]**<Insert organization>** certification and documented training and experience with testing security equipment in accordance with [**ASIS**]**<Insert organization>** testing standards.



1.10 WARRANTY

A. Integrated Credential Readers and Entry Management Devices Warranty:

1. Special Installer Extended Warranty: Installer warrants that fabricated and installed integrated credential readers and entry management devices perform in accordance with specified requirements and agrees to repair or replace components that fail to perform as specified within extended-warranty period.
 - a. Extended-Warranty Period: **[Two][Three][Four]<Insert number>** years from date of Substantial Completion; full coverage for labor, materials, and equipment.
2. Special Manufacturer Extended Warranty: Manufacturer warrants that integrated credential readers and entry management devices perform in accordance with specified requirements and agrees to provide repair or replacement of components or products that fail to perform as specified within extended-warranty period.
 - a. Initial Extended-Warranty Period: **[Three][Four][Five]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for labor, materials, and equipment.
 - b. Follow-On Extended-Warranty Period: **[Eight]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for materials only, free on board **[origin][destination]**, freight prepaid.

B. Electrified Locking Devices and Accessories Warranty:

1. Special Installer Extended Warranty: Installer warrants that fabricated and installed electrified locking devices and accessories perform in accordance with specified requirements and agrees to repair or replace components that fail to perform as specified within extended-warranty period.
 - a. Extended-Warranty Period: **[Two][Three][Four]<Insert number>** years from date of Substantial Completion; full coverage for labor, materials, and equipment.
2. Special Manufacturer Extended Warranty: Manufacturer warrants that electrified locking devices and accessories perform in accordance with specified requirements and agrees to provide repair or replacement of components or products that fail to perform as specified within extended-warranty period.
 - a. Initial Extended-Warranty Period: **[Three][Four][Five]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for labor, materials, and equipment.
 - b. Follow-On Extended-Warranty Period: **[Eight]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for materials only, free on board **[origin][destination]**, freight prepaid.

PART 2 - PRODUCTS

2.1 INTEGRATED CREDENTIAL READERS AND ENTRY MANAGEMENT

A. Swipe Card Reader :

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

following]:

- a. [aptiQ; an Allegion brand]
 - b. [Cansec Systems Ltd.]
 - c. [HID Global; ASSA ABLOY]
 - d. [Peripheral Dynamics, Inc.]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [aptiQ; an Allegion brand]
 - b. [Cansec Systems Ltd.]
 - c. [HID Global; ASSA ABLOY]
 - d. [Peripheral Dynamics, Inc.]
 - e. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Performance Criteria:
 - a. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - b. Listing Criteria:
 - 1) UL CCN ALVY; including UL 294.
 - 2) Plastic Enclosure: UL CCN QMFZ2; including UL 94.
 - c. General Characteristics: Visual LED indication of card read.
5. Options:
 - a. Enclosure Rating: IEC 60529, [IP55][IP65][IP66]<Insert IP rating>.
 - b. Input Voltage: [5 to 12 V(dc)]<Insert power input>.
 - c. Operating Temperature: [Minus 40 to plus 160 deg F (Minus 40 to plus 71 deg C)]<Insert temperature>.
 - d. Materials: [Long-wearing polymeric plastic][Polycarbonate][Metal].
 - e. Colors: [Black][Gray]<Insert color>.
 - f. Climate: [Indoor][and][outdoor].
 - g. Size: [Single gang][or][double gang].

B. Proximity Reader for Card, Fob, or Smartphone :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [AMAG Technology; G4S USA]
 - b. [aptiQ; an Allegion brand]
 - c. [Farpointe Data Inc.; DORMA USA, Inc.; dormakaba Group]
 - d. [HID Global; ASSA ABLOY]
 - e. [IDenticard Systems; Precision Dynamics Corporation]
 - f. [Openpath Security, Inc.]
 - g. [XceedID; an Allegion brand]

- h. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [AMAG Technology; G4S USA]
 - b. [aptiQ; an Allegion brand]
 - c. [Farpointe Data Inc.; DORMA USA, Inc.; dormakaba Group]
 - d. [HID Global; ASSA ABLOY]
 - e. [IDenticard Systems; Precision Dynamics Corporation]
 - f. [Openpath Security, Inc.]
 - g. [XceedID; an Allegion brand]
 - h. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Performance Criteria:
 - a. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - b. Listing Criteria:
 - 1) UL CCN ALVY; including UL 294.
 - 2) Plastic Enclosure: UL CCN QMFZ2; including UL 94.
 - c. General Characteristics: Visual LED indication of card read.
5. Options:
 - a. Enclosure Rating: IEC 60529, [IP55][IP65][IP66]<Insert IP rating>.
 - b. Input Voltage: [5 to 16 V(dc)][PoE]<Insert power input>.
 - c. Operating Temperature: [Minus 40 to plus 160 deg F (Minus 40 to plus 71 deg C)]<Insert temperature>.
 - d. Read Range: Up to [1 inch (25 mm)][2 inch (51 mm)][3 inch (76 mm)].
 - e. Transmit Frequency: [125 kHz][13.56 MHz][2.4 GHz].
 - f. Materials: [Long-wearing polymeric plastic][Polycarbonate][Metal].
 - g. Colors: [Black][Gray]<Insert color>.
 - h. Climate: [Indoor][and][outdoor].
 - i. Size: [Single gang][or][double gang].
6. Accessories:
 - a. Long-range receiver module.
- C. Door Lock Keypad :
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Alarm Lock; NAPCO Security Technologies, Inc.]
 - b. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Alarm Lock; NAPCO Security Technologies, Inc.]**
 - b. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Performance Criteria:
 - a. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - b. Listing Criteria:
 - 1) UL CCN ALVY; including UL 294.
 - 2) Plastic Enclosure: UL CCN QMFZ2; including UL 94.
5. Options:
 - a. Enclosure Rating: IEC 60529, **[IP55][IP65][IP66]<Insert IP rating>**.
 - b. Visual LED indication of **[three-][or][six-]**digit code read.
 - c. Input Power: **[5 to 16 V(dc)][12 to 28 V(dc)][Alkaline batteries]<Insert power input>**.
 - d. Operating Temperature: **[Minus 20 to plus 150 deg F (Minus 29 to plus 66 deg C)]<Insert temperature>**.
 - e. Materials: **[Long-wearing polymeric plastic][Polycarbonate][Metal]**.
 - f. Colors: **[Black][Gray]<Insert color>**.
 - g. Climate: **[Indoor][and][outdoor]**.
 - h. Size: **[Single gang][or][double gang]**.
 - i. Mounting:
 - 1) Door/window mullions.
 - 2) Outlet boxes.
 - 3) Flat surfaces.
 - 4) Integrated door lock keypad.

D. Scramble Keypad :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Hirsch; a brand of Identiv, Inc.]**
 - b. **[Schlage; an Allegion brand]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Hirsch; a brand of Identiv, Inc.]**
 - b. **[Schlage; an Allegion brand]**
 - c. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.



4. Performance Criteria:
 - a. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - b. Listing Criteria:
 - 1) UL CCN ALVY; including UL 294.
 - 2) Plastic Enclosure: UL CCN QMFZ2; including UL 94.
5. Options:
 - a. Enclosure Rating: IEC 60529, [IP55][IP65][IP66]<Insert IP rating>.
 - b. Visual LED indication of [three-][or][six-][or][nine-]digit code read.
 - c. Input Power: [8 to 12 V(dc)]<Insert power input>.
 - d. Operating Temperature: [5 to 122 deg F (Minus 15 to plus 50 deg C)]<Insert operating temperature>.
 - e. Materials: [Long-wearing polymeric plastic][Polycarbonate][Metal].
 - f. Colors: [Black][Gray]<Insert color>.
 - g. Climate: [Indoor][and][outdoor].
 - h. Mounting: [Single-gang][or][double-gang] outlet box.

E. Combination Card Reader and Keypad :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Farpointe Data Inc.; DORMA USA, Inc.; dormakaba Group]
 - b. [Hirsch; a brand of Identiv, Inc.]
 - c. [Open Options; ACRE, LLC]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Farpointe Data Inc.; DORMA USA, Inc.; dormakaba Group]
 - b. [Hirsch; a brand of Identiv, Inc.]
 - c. [Open Options; ACRE, LLC]
 - d. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Performance Criteria:
 - a. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - b. Listing Criteria:
 - 1) UL CCN ALVY; including UL 294.
 - 2) Plastic Enclosure: UL CCN QMFZ2; including UL 94.
 - c. General Characteristics: Visual LED indication of code and/or card read.

5. Options:
- a. Enclosure Rating: IEC 60529, [IP55][IP65][IP66]<Insert IP rating>.
 - b. Input Power: [5 to 16 V(dc)][12 to 28 V(dc)]<Insert power input>.
 - c. Operating Temperature: [32 to 122 deg F (0 to 50 deg C)]<Insert temperature>.
 - d. Materials: [Long-wearing polymeric plastic][Polycarbonate][Metal].
 - e. Colors: [Black][Gray][White]<Insert color>.
 - f. Climate: [Indoor][and][outdoor].
 - g. Mounting:
 - 1) Surface mount.
 - 2) Triple-gang wall box.

2.2 ACCESS CONTROL CREDENTIALS

A. Access Control Cards :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Cansec Systems Ltd.]
 - b. [Farpointe Data Inc.; DORMA USA, Inc.; dormakaba Group]
 - c. [HID Global; ASSA ABLOY]
 - d. [Hirsch; a brand of Identiv, Inc.]
 - e. [Honeywell Commercial Security; Honeywell International, Inc.]
 - f. [IDenticard Systems; Precision Dynamics Corporation]
 - g. [IDTECK Global, Inc.]
 - h. [Viking Electronics, Inc.]
 - i. [XceedID; an Allegion brand]
 - j. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Cansec Systems Ltd.]
 - b. [Farpointe Data Inc.; DORMA USA, Inc.; dormakaba Group]
 - c. [HID Global; ASSA ABLOY]
 - d. [Hirsch; a brand of Identiv, Inc.]
 - e. [Honeywell Commercial Security; Honeywell International, Inc.]
 - f. [IDenticard Systems; Precision Dynamics Corporation]
 - g. [IDTECK Global, Inc.]
 - h. [Viking Electronics, Inc.]
 - i. [XceedID; an Allegion brand]
 - j. <Insert manufacturer's name>
3. Performance Criteria:
 - a. Reference Standards:
 - 1) Personal Identity Verification (PIV): FIPS PUB 201-2.
 - 2) Physical: IEC 7810; IEC 10373; IEC 7816 for contact cards; and IEC 14443 for contactless cards.

- 3) Functional: UL 294; IEC 60839-11-1; and IEC 60839-11-2.
 - 4) Material Durability: INCITS 322.
- b. Format: Customizable, including artwork. **[Provide credential template with provisions for the following:]**
- 1) On Front: Photograph, full name (surname first), affiliation, organization, card expiration date, color-coding, Owner's name, Owner's logo, two-dimensional bar code.
 - 2) On Back: Physical characteristics of cardholder, employee ID number, card number, magnetic stripe, linear bar code, return address. Include the following message:
 - a) **<Insert message>**.
 - 3) Stored Data Elements: PIN, employee ID number, two fingerprint templates, electronic facial image, one iris image, digital signature private key and certificate, key management private key and certificate, card authenticate data, and PIV authentication data.
4. Options:
- a. Data Format: Wiegand **[26 bit][34 bit][37 bit]**.
 - b. Transmit Frequency: **[125 kHz][and][13.56 MHz]**.
 - c. Data Retention: **[10][20]** years.
 - d. Memory Capacity: **[2.5 kB][8 kB][16 kB][32 kB]**.
 - e. Operating Temperature: **[Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C)]**.
 - f. Materials: **[Plastic][ABS][PVC laminate]**.
 - g. Color: **[White][Off-white][Glossy white]<Insert color>**.
 - h. Reading Medium: **[Multi-criteria use][Proximity][and][chip][and][magnetic strip]**.

2.3 ELECTRIFIED LOCKING DEVICES AND ACCESSORIES

A. Electrically Controlled Single-Point Latch :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Corbin Russwin, Inc.; an ASSA ABLOY Group company]**
 - b. **[Design Hardware; Mesker Openings Group; dormakaba]**
 - c. **[Schlage; an Allegion brand]**
 - d. **[Security Door Controls]**
 - e. **[Yale Security Inc; ASSA ABLOY]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Corbin Russwin, Inc.; an ASSA ABLOY Group company]**
 - b. **[Design Hardware; Mesker Openings Group; dormakaba]**
 - c. **[Schlage; an Allegion brand]**
 - d. **[Security Door Controls]**

- e. **[Yale Security Inc; ASSA ABLOY]**
 - f. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
 4. Performance Criteria:
 - a. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - b. Listing Criteria:
 - 1) Special Locking Arrangements: UL CCN FWAX; including UL 294, NFPA 101, and ICC IBC.
 - 2) Electrically Controlled Single-Point Locks and Latches: UL CCN GYQS, UL 10B, and UL 10C; designed to be used with Class 2 control-voltage circuits in accordance with Article 725 of NFPA 70.
 5. Options:
 - a. **[Audible][and][visual]** indication of door unlock.
 - b. Input Power: **[12 V(ac/dc)][or][24 V(ac/dc)][PoE][AA batteries]<Insert power input>**.
 - c. Operating Temperature: **[Minus 31 to plus 151 deg F (Minus 35 to plus 66 deg C)]<Insert temperature>**.
 - d. Connectivity: **[Hardwired][Wireless]**.
 - e. Materials: **[Zinc]<Insert material>**.
 - f. Finishes: **[US26D Satin Chrome]<Insert finish>**.
 - g. Integrated Credential Reader:
 - 1) Proximity (125 kHz).
 - 2) Smart (13.56 MHz).
 - 3) Bluetooth, low energy (2.4 GHz).
 - 4) NFC.
 - h. Integrated **[combination lock][keypad]**.
 - i. Failure Mode: **[Fail-safe][Fail-secure]**.
 - j. Mechanical key override.
 - k. Latch bolt monitor.
 - l. **[With][or][without]** deadbolt.
- B. Electrically Controlled Three-Point Latches :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Corbin Russwin, Inc.; an ASSA ABLOY Group company]**
 - b. **[SARGENT Manufacturing Company; ASSA ABLOY]**
 - c. **[Schlage; an Allegion brand]**
 - d. **[Von Duprin; Allegion plc]**
 - e. **[Yale Security Inc; ASSA ABLOY]**
 - f. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. [Corbin Russwin, Inc.; an ASSA ABLOY Group company]
 - b. [SARGENT Manufacturing Company; ASSA ABLOY]
 - c. [Schlage; an Allegion brand]
 - d. [Von Duprin; Allegion plc]
 - e. [Yale Security Inc; ASSA ABLOY]
 - f. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
 4. Performance Criteria:
 - a. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - b. Listing Criteria:
 - 1) Special Locking Arrangements: UL CCN FWAX; including UL 294, NFPA 101, and ICC IBC.
 - 2) Two- and Three-Point Locks and Latches: UL CCN GYXR; including UL 10B.
 5. Options:
 - a. [Audible][and][visual] indication of door unlock.
 - b. Input Power: [12 V(ac/dc)][or][24 V(ac/dc)][PoE]<Insert power input>.
 - c. Operating Temperature: [Minus 31 to plus 151 deg F (Minus 35 to plus 66 deg C)]<Insert temperature>.
 - d. Connectivity: [Hardwired][Wireless].
 - e. Materials: [Zinc]<Insert material>.
 - f. Finishes: [US26D Satin Chrome]<Insert finish>.
 - g. Integrated Credential Reader:
 - 1) Proximity (125 kHz).
 - 2) Smart (13.56 MHz).
 - 3) Bluetooth, low energy (2.4 GHz).
 - 4) NFC.
 - h. Integrated [combination lock][keypad].
 - i. Failure Mode: [Fail-safe][Fail-secure].
 - j. Mechanical key override.
 - k. Latch bolt monitor.

C. Type 1 High-Security Electronic Lock :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [American Security Products Co.]
 - b. [dormakaba USA Inc.]
 - c. [FireKing International]
 - d. [NKL Industries Ltd.; FireKing International LLC]
 - e. [SARGENT Manufacturing Company; ASSA ABLOY]
 - f. [SECURAM Systems Inc.]
 - g. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Security Products Co.]**
 - b. **[dormakaba USA Inc.]**
 - c. **[FireKing International]**
 - d. **[NKL Industries Ltd.; FireKing International LLC]**
 - e. **[SARGENT Manufacturing Company; ASSA ABLOY]**
 - f. **[SECURAM Systems Inc.]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Performance Criteria:
 - a. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - b. Listing Criteria:
 - 1) Special Locking Arrangements: UL CCN FWAX; including UL 294, NFPA 101, and ICC IBC.
 - 2) High-Security Electronic Locks: UL CCN OZDC; including UL Subject 2058.
 - 3) Type 1 Locks: UL CCN OZDU.
5. Options:
 - a. **[Audible][and][visual]** indication of door unlock.
 - b. Input Power: **[12 V(ac/dc)][or][24 V(ac/dc)][PoE][Li-ion battery]<Insert power input>**.
 - c. Operating Temperature: **[Minus 4 to plus 140 deg F (Minus 20 to plus 60 deg C)]<Insert temperature>**.
 - d. Connectivity: **[Hardwired][Wireless]**.
 - e. Memory:
 - 1) Access time/date stamp stored in **[key][and][cylinder]**.
 - 2) Audit Trail: **[100][1000]<Insert number>** events.
 - 3) Directory of authorized keys stored in cylinder.
 - f. Cylinder Type: **[Single][Double][Mortise]<Insert type>**.
 - g. Materials: **[Zinc][Steel]<Insert material>**.
 - h. Finishes: **[US26D Satin Chrome]<Insert finish>**.
 - i. Integrated credential reader.
 - j. Failure Mode: **[Fail-safe][Fail-secure]**.
 - k. Mechanical key override.

D. Type 1F High-Security Electronic Lock :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Kaba Mas - LA GARD; dormakaba Group]**
 - b. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert**



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

- a. **[Kaba Mas - LA GARD; dormakaba Group]**
 - b. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
 4. Performance Criteria:
 - a. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - b. Listing Criteria:
 - 1) Special Locking Arrangements: UL CCN FWAX; including UL 294, NFPA 101, and ICC IBC.
 - 2) High-Security Electronic Locks: UL CCN OZDC; including UL Subject 2058.
 - 3) Type 1F Locks: **[UL CCN OZEM; including]**Fed. Spec. FF-L-2740.
 5. Options:
 - a. **[Audible][and][visual]** indication of door unlock.
 - b. Input Power: **[12 V(ac/dc)][or][24 V(ac/dc)][PoE][Li-ion battery]<Insert power input>**.
 - c. Operating Temperature: **[Minus 4 to plus 140 deg F (Minus 20 to plus 60 deg C)]<Insert temperature>**.
 - d. Connectivity: **[Hardwired][Wireless]**.
 - e. Materials: **[Zinc][Steel]<Insert material>**.
 - f. Finishes: **[US26D Satin Chrome]<Insert finish>**.
 - g. Failure Mode: **[Fail-safe][Fail-secure]**.
 - h. Mechanical key override.

E. Request-to-Exit (REX) Motion Sensor :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ASSA ABLOY Electronic Security Hardware; ASSA ABLOY]**
 - b. **[Honeywell Commercial Security; Honeywell International, Inc.]**
 - c. **[Vicon Industries, Inc]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ASSA ABLOY Electronic Security Hardware; ASSA ABLOY]**
 - b. **[Honeywell Commercial Security; Honeywell International, Inc.]**
 - c. **[Vicon Industries, Inc]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Performance Criteria:

- a. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - b. Listing Criteria: UL CCN ALVY; including UL 294.
5. Options:
 - a. Input Power: **[125 V(ac)]<Insert power input>**.
 - b. Operating Temperature: **[Minus 13 to plus 140 deg F (Minus 25 to plus 60 deg C)]<Insert temperature>**.
 - c. Sensing Technology: **[Passive infrared (PIR)][Active infrared (AIR)]**.
 - d. Color: **[Black][Gray][White]<Insert color>**.
 - e. Mounting: **[Wall surface][Recessed in ceiling][Door frame]**.
- F. Request-to-Exit (REX) Push Button :
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ASSA ABLOY Electronic Security Hardware; ASSA ABLOY]**
 - b. **[Schlage; an Allegion brand]**
 - c. **[Von Duprin; Allegion plc]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ASSA ABLOY Electronic Security Hardware; ASSA ABLOY]**
 - b. **[Schlage; an Allegion brand]**
 - c. **[Von Duprin; Allegion plc]**
 - d. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain products from single manufacturer.
 4. Performance Criteria:
 - a. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - b. Listing Criteria: UL CCN ALVY; including UL 294.
 5. Options:
 - a. Input Power: **[12 to 24 V(ac/dc)]<Insert power input>**.
 - b. Operating Temperature: **[Minus 13 to plus 140 deg F (Minus 25 to plus 60 deg C)]<Insert operating temperature>**.
 - c. Operating Mechanism: **[Pneumatic][Piezoelectric]**.
 - d. Faceplate Material: **[Stainless steel]<Insert material>**.
 - e. Button Material: **[Plastic][Anodized aluminum]<Insert material>**.
 - f. Button Color: **[Green][Blue][Red]<Insert color>**.
 - g. Lettering Color: **[White][Black]<Insert color>**.
 - h. Failure Mode: **[Fail-safe][Fail-secure]**.

2.4 EGRESS MANAGEMENT DEVICES

A. Magnetic Lock Hardware with Special Locking Arrangement for Fire-Rated Doors :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Alarm Controls; Hanchett Entry Systems, Inc.; ASSA ABLOY Group]**
 - b. **[BEA Americas; Halma plc]**
 - c. **[Gianni Electro Magnet (GEM); Gianni Industries, Inc.]**
 - d. **[Hager Companies]**
 - e. **[Rutherford Controls Int'l. (RCI); dormakaba Group]**
 - f. **[SARGENT Manufacturing Company; ASSA ABLOY]**
 - g. **[Schlage; an Allegion brand]**
 - h. **[Vanguard Security Engineering Corp. (VGSE)]**
 - i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Alarm Controls; Hanchett Entry Systems, Inc.; ASSA ABLOY Group]**
 - b. **[BEA Americas; Halma plc]**
 - c. **[Gianni Electro Magnet (GEM); Gianni Industries, Inc.]**
 - d. **[Hager Companies]**
 - e. **[Rutherford Controls Int'l. (RCI); dormakaba Group]**
 - f. **[SARGENT Manufacturing Company; ASSA ABLOY]**
 - g. **[Schlage; an Allegion brand]**
 - h. **[Vanguard Security Engineering Corp. (VGSE)]**
 - i. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Performance Criteria:
 - a. Regulatory Requirements:
 - 1) Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - 2) Compliant with NFPA 101, ICC IBC, and local life safety code requirements for use along means of egress.
 - b. Listing Criteria:
 - 1) Special Locking Arrangements: UL CCN FWAX or UL CCN FWAX2; including UL 294, NFPA 101, and ICC IBC.
 - 2) Electromagnetic Locks for Fire-Rated Doors: UL CCN GWXT; including UL 10B and UL 10C.
5. Options:
 - a. Input Voltage: **[12 to 24 V(dc)]<Insert voltage>**.
 - b. Holding Force: **[1200 lbf (5338 N)]<Insert force>**.

- c. Release Delay: **[Zero][Five][10][15]<Insert number>** seconds.
 - d. Relock Function: **[Manual][Delayed automatic]** relock.
 - e. Door Prop Alarm Delay: **[None][30 seconds]<Insert delay>**.
 - f. Door Movement Detection: **[1/8 inch (3 mm)][1/4 inch (6 mm)][1/2 inch (13 mm)][3/4 inch (19 mm)][1 inch (25 mm)]**.
 - g. Dry contact for external alarm relay **[to security system][to fire-alarm system][to BMS]**.
- B. Panic Hardware with Special Locking Arrangement for Fire-Rated Doors :
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ASSA ABLOY Electronic Security Hardware; ASSA ABLOY]**
 - b. **[Corbin Russwin, Inc.; an ASSA ABLOY Group company]**
 - c. **[Detex Corporation]**
 - d. **[Kaba Mas - LA GARD; dormakaba Group]**
 - e. **[Von Duprin; Allegion plc]**
 - f. **[Yale Security Inc; ASSA ABLOY]**
 - g. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ASSA ABLOY Electronic Security Hardware; ASSA ABLOY]**
 - b. **[Corbin Russwin, Inc.; an ASSA ABLOY Group company]**
 - c. **[Detex Corporation]**
 - d. **[Kaba Mas - LA GARD; dormakaba Group]**
 - e. **[Von Duprin; Allegion plc]**
 - f. **[Yale Security Inc; ASSA ABLOY]**
 - g. **<Insert manufacturer's name>**
 - 3. Source Limitations: Obtain products from single manufacturer.
 - 4. Performance Criteria:
 - a. Regulatory Requirements:
 - 1) Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - 2) Compliant with NFPA 101, ICC IBC, and local life safety code requirements for use along means of egress.
 - b. Listing Criteria:
 - 1) Special Locking Arrangements: UL CCN FWAX or UL CCN FWAX2; including UL 294, NFPA 101, and ICC IBC.
 - 2) Panic Hardware for Fire-Rated Doors: UL CCN GXHX, UL 10C, and UL 305.
 - 3) Controlled-Exit Panic Devices: UL CCN FULA; including UL 305.
 - 5. Options:
 - a. Input Voltage: **[12 to 24 V(dc)]<Insert voltage>**.
 - b. Release Delay: **[Zero][Five][10][15]<Insert number>** seconds.

- c. Door Prop Alarm: **[None][Activate after 30 seconds]<Insert delay>**.
- d. Dry contact for external alarm relay **[to security system][to fire-alarm system][to BMS]**.
- e. Secondary Power: **[9 V battery]<Insert power source>**.

2.5 ACCESS CONTROL REMOTE DEVICES

A. Near Field Communications (NFC) Access Control Devices :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[AMAG Technology; G4S USA]**
 - b. **[aptiQ; an Allegion brand]**
 - c. **[Farpointe Data Inc.; DORMA USA, Inc.; dormakaba Group]**
 - d. **[HID Global; ASSA ABLOY]**
 - e. **[IDenticard Systems; Precision Dynamics Corporation]**
 - f. **[Schlage; an Allegion brand]**
 - g. **[XceedID; an Allegion brand]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[AMAG Technology; G4S USA]**
 - b. **[aptiQ; an Allegion brand]**
 - c. **[Farpointe Data Inc.; DORMA USA, Inc.; dormakaba Group]**
 - d. **[HID Global; ASSA ABLOY]**
 - e. **[IDenticard Systems; Precision Dynamics Corporation]**
 - f. **[Schlage; an Allegion brand]**
 - g. **[XceedID; an Allegion brand]**
 - h. **<Insert manufacturer's name>**
3. Performance Criteria:
 - a. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - b. Listing Criteria: UL CEN ALVY; including UL 294.
4. Options:
 - a. Enclosure Rating: IEC 60529, **[IP55][IP65][IP66]<Insert IP rating>**.
 - b. Input Voltage: **[5 to 12 V(dc)][PoE]<Insert voltage>**.
 - c. Operating Temperature: **[Minus 40 to plus 160 deg F (Minus 40 to plus 71 deg C)]<Insert temperature>**.
 - d. Read Range: Up to **[1 inch (25 mm)][2 inch (51 mm)][3 inch (76 mm)]**.
 - e. Transmit Frequency: **[125 kHz][13.56 MHz]**.
 - f. Materials: **[Long-wearing polymeric plastic][Polycarbonate][Metal]**.
 - g. Colors: **[Black][Gray]<Insert color>**.
 - h. Climate: **[Indoor][and][outdoor]**.
 - i. Size: **[Single gang][or][double gang]**.

2.6 ELECTRONIC KEY MANAGEMENT SYSTEMS

A. Electronic Key Management System Unit :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Deister Electronic USA, Inc.]**
 - b. **[KEYper Systems; Marcon International, Inc.]**
 - c. **[MATRIX Cabinet]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Deister Electronic USA, Inc.]**
 - b. **[KEYper Systems; Marcon International, Inc.]**
 - c. **[MATRIX Cabinet]**
 - d. **<Insert manufacturer's name>**
3. Performance Criteria:
 - a. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - b. Listing Criteria: UL CCN ALZK; including UL 294.
4. Options:
 - a. Input Voltage: **[110 to 240 V(ac)]<Insert voltage>**.
 - b. Operating Temperature: **[32 to 122 deg F (0 to 50 deg C)]<Insert temperature>**.
 - c. Key Storage Capacity: **<Insert number>**.
 - d. Operating Frequency: **[125 kHz][13.56 MHz]**.
 - e. Materials: **[Stainless steel]<Insert material>**.
 - f. Finishes: **[Powder coated]<Insert finish>**.
 - g. Backup Battery: **[12 V(dc)]<Insert battery size>**.
 - h. Front Cover: **[Clear display window][Solid panel]**.
 - i. Enclosure Size: **<Insert size>**.
5. Operation:
 - a. Access Method: **[Proximity card][and][biometrics][and][keypad][and][standard key]**.
 - b. Alarm output: **[Local sounder][Output contacts]**.

PART 3 - EXECUTION

3.1 DEPLOYMENT OF CREDENTIALS

- A. Comply with manufacturer's published instructions.



B. Third-Party Issuing of Access Control Credentials:

1. Printing of New Credentials: Contractor must be capable of programming and issuing credentials compatible with Owner's access control system.
 - a. Initial Issuance: Provide spreadsheet or form for collecting data for generation of credentials. Owner will submit completed form containing data for personnel to be issued credentials. Print and provide initial run, printed and programmed credentials in specified format within **[four]<Insert number>** weeks of request.
 - b. Ongoing Issuance: Produce additional credentials upon Owner request. Owner will submit completed form containing data for personnel to be issued credentials. Print and program credentials in specified format within **[one][two]** weeks of request.

3.2 INSTALLATION OF INTEGRATED ACCESS CONTROL HARDWARE DEVICES

A. Comply with manufacturer's published instructions.

B. Special Techniques:

1. Cable Type: **[Shielded][Unshielded]<Insert cable size>**.
2. Analog Maximum Cable Length: **[1000 ft (300 m)]<Insert cable length>**.
3. Digital Maximum Cable Length: **[300 ft (100 m)][500 ft (150 m)]<Insert cable length>**.

C. Interfaces with Other Work:

1. Coordinate installation of new products for access control hardware devices with existing conditions.
 - a. **<Insert requirements for transition between new and existing>**.
2. Coordinate access control credentials with integrated credential readers and access control system architecture.
3. Egress Management Interfaces:
 - a. Coordinate with Section 282000 "Video Surveillance" for automatic video feed callup upon delayed egress activation.
 - b. Coordinate with Section 230923 "Direct Digital Control (DDC) System for HVAC" for monitoring of egress management device alarms by BMS.
 - c. Coordinate with Section 284600 "Fire Detection and Alarm" for monitoring of egress management device alarms by fire-alarm system.

3.3 FIELD QUALITY CONTROL

A. Administrant for Security Tests and Inspections:

1. **[Owner][Tenant]** will engage qualified security testing and inspecting agency to administer and perform tests and inspections.
2. Engage qualified security testing and inspecting agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections **[with assistance of factory-authorized service**

representative].

B. Acceptance Testing Preparation:

1. <Insert requirements>.

C. Field tests and inspections must be witnessed by [Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>.

D. Tests and Inspections:

1. Perform manufacturer's recommended tests and inspections.

E. Nonconforming Work:

1. Device will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

F. Collect, assemble, and submit test and inspection reports.

G. Manufacturer Services:

1. Engage factory-authorized service representative to [support][supervise] field tests and inspections.

3.4 PROTECTION

A. After installation, protect integrated access control hardware devices from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

3.5 MAINTENANCE

A. Software and Firmware Service Agreement:

1. Technical Support: Beginning at Substantial Completion, verify that software and firmware service agreement includes software and firmware support for [two]<Insert number> years.
2. Upgrade Service: At Substantial Completion, update software and firmware to latest version. Install and program software and firmware upgrades that become available within [two]<Insert number> years from date of Substantial Completion. [Verify that upgrading software includes operating system and new or revised licenses for using software.]
 - a. Upgrade Notice: No fewer than [30]<Insert number> days to allow Owner to schedule and access the system[and to upgrade computer equipment if necessary].
3. Upgrade Reports: Prepare report after each update, documenting upgrades installed.

END OF SECTION 28 15 00 00



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SECTION 28 15 00 00A - ACCESS CONTROL CREDENTIALS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Access control credentials.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Manufacturers' Published Instructions: Record copy of official deployment[**and testing**] instructions issued to Contractor by manufacturer for the following:

1. Printing, programming, and handling instructions for access control credentials.

PART 2 - PRODUCTS

2.1 EXISTING PRODUCTS FOR CONTINUED USE

A. Basis for Pricing: **<Insert name of manufacturer; model number or series for existing product>.**

B. Description: **<Insert description of existing product, including special features, options, and finishes that may impact Work>.**

C. Accessories: **<Insert accessories included with existing product>.**

2.2 ACCESS CONTROL CREDENTIALS

A. Access Control Cards :

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

following]:

- a. [Cansec Systems Ltd.]
 - b. [Farpointe Data Inc.; DORMA USA, Inc.; dormakaba Group]
 - c. [HID Global; ASSA ABLOY]
 - d. [Hirsch; a brand of Identiv, Inc.]
 - e. [Honeywell Commercial Security; Honeywell International, Inc.]
 - f. [IDenticard Systems; Precision Dynamics Corporation]
 - g. [IDTECK Global, Inc.]
 - h. [Viking Electronics, Inc.]
 - i. [XceedID; an Allegion brand]
 - j. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Cansec Systems Ltd.]
 - b. [Farpointe Data Inc.; DORMA USA, Inc.; dormakaba Group]
 - c. [HID Global; ASSA ABLOY]
 - d. [Hirsch; a brand of Identiv, Inc.]
 - e. [Honeywell Commercial Security; Honeywell International, Inc.]
 - f. [IDenticard Systems; Precision Dynamics Corporation]
 - g. [IDTECK Global, Inc.]
 - h. [Viking Electronics, Inc.]
 - i. [XceedID; an Allegion brand]
 - j. <Insert manufacturer's name>
3. Standard Features:
- a. Reference Standards:
 - 1) Personal Identity Verification (PIV): FIPS PUB 201-2.
 - 2) Physical: IEC 7810; IEC 10373; IEC 7816 for contact cards; and IEC 14443 for contactless cards.
 - 3) Functional: UL 294; IEC 60839-11-1; and IEC 60839-11-2.
 - 4) Material Durability: INCITS 322.
 - b. Configuration: Customizable, including artwork.[**Provide credential template with provisions for the following:**]
 - 1) On Front: Photograph, full name (surname first), affiliation, organization, card expiration date, color-coding, Owner's name, Owner's logo, two-dimensional bar code.
 - 2) On Back: Physical characteristics of cardholder, employee ID number, card number, magnetic stripe, linear bar code, return address. Include the following message:
 - a) <Insert message>.
 - 3) Stored Data Elements: PIN, employee ID number, two fingerprint templates, electronic facial image, one iris image, digital signature private key and certificate, key management private key and certificate, card authenticate data, and PIV authentication data.
 - c. Data Format: Wiegand [26 bit][34 bit][37 bit].

- d. Transmit Frequency: [125 kHz][and][13.56 MHz].
- e. Data Retention: [10][20] years.
- f. Memory Capacity: [2.5 kB][8 kB][16 kB][32 kB].
- g. Operating Temperature: [Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C)]<Insert temperature range>.
- h. Materials: [Plastic][ABS][PVC laminate].
- i. Color: [White][Off-white][Glossy white]<Insert color>.
- j. Reading Medium: [Multi-criteria use][Proximity][and][chip][and][magnetic strip].

B. Wireless Key Fobs :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Cansec Systems Ltd.]
 - b. [Farpointe Data Inc.; DORMA USA, Inc.; dormakaba Group]
 - c. [HID Global; ASSA ABLOY]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Cansec Systems Ltd.]
 - b. [Farpointe Data Inc.; DORMA USA, Inc.; dormakaba Group]
 - c. [HID Global; ASSA ABLOY]
 - d. <Insert manufacturer's name>
3. Standard Features:
 - a. Reference Standards:
 - 1) Physical: IEC 7810; IEC 10373; IEC 7816 for contact cards; and IEC 14443 for contactless cards.
 - 2) Functional: UL 294; IEC 60839-11-1; and IEC 60839-11-2.
 - 3) Material Durability: INCITS 322.
 - b. Configuration: Customizable, including artwork.
 - 1) Stored Data Elements: PIN, employee ID number, two fingerprint templates, electronic facial image, one iris image, digital signature private key and certificate, key management private key and certificate, and card authenticate data.
 - c. Memory: [1 kB][4 kB][80 kB].
 - d. Operating Temperature: [Minus 49 to plus 185 deg F (Minus 45 to plus 85 deg C)]<Insert temperature range>.
 - e. Transmit Frequency: [125 kHz][and][13.56 MHz].
 - f. Read Range: Up to [3/4 inch (19 mm)][2 inch (51 mm)][3 inch (76 mm)][4 inch (102 mm)].
 - g. Format: Wiegand [26 bit][37 bit].
 - h. Data Retention: [10][20] years.
 - i. Materials: [Plastic][Epoxy][Polycarbonate][ABS shell with TPE insert].
 - j. Color: [Dark gray][Black][Transparent blue][White]<Insert color>.
 - k. Connector: USB 2.0 connector, Type A (male).



- I. External numbering.
- 4. Accessories:
 - a. Key ring.

PART 3 - EXECUTION

3.1 DEPLOYMENT

- A. Comply with manufacturer's published instructions.
- B. Third-Party Issuing of Access Control Credentials:
 - 1. Printing of New Credentials: Contractor must be capable of programming and issuing credentials compatible with Owner's access control system.
 - a. Initial Issuance: Provide spreadsheet or form for collecting data for generation of credentials. Owner will submit completed form containing data for personnel to be issued credentials. Print and provide initial run, printed and programmed credentials in specified format within **[four]<Insert number>** weeks of request.
 - b. Ongoing Issuance: Produce additional credentials upon Owner request. Owner will submit completed form containing data for personnel to be issued credentials. Print and program credentials in specified format within **[one][two]** weeks of request.
- C. Interfaces with Other Work:
 - 1. Coordinate access control credentials with integrated credential readers and access control system architecture.

END OF SECTION 28 15 00 00A

SECTION 28 15 00 00B - ELECTRIFIED LOCKING DEVICES AND ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Electrically controlled single-point locks and latches.
2. Electrically controlled two- and three-point locks and latches.
3. High-security electronic locks.
4. Status monitoring and egress devices.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.

1.2 DEFINITIONS

A. NFC: Near Field Communications.

B. PoE: Power over Ethernet.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Coordination Meeting(s): For electrified locking devices and accessories. Conduct meeting(s) **[as videoconference][or][at Project site]<Insert location> before <Insert construction activity>.**

1. Installers, fabricators, representatives of manufacturers, representatives from telecommunications, **[Owner's security representatives,][IT representatives,]** and administrators for field tests and inspections. Notify Architect[, **Construction Manager**][, and **Owner's Commissioning Authority**] of scheduled meeting dates.

1.4 ACTION SUBMITTALS

A. Product Data:

1. Electrically controlled single-point locks and latches.
2. Electrically controlled two- and three-point locks and latches.
3. High-security electronic locks.
4. Status monitoring and egress devices.

B. Shop Drawings:

1. Project general notes.
2. Device layout.
3. Block diagram and cable/conduit routing.
4. System communications details.
5. System mounting details.
6. Secondary power calculations.

C. Certificates:

1. **<Insert certificate requirement>.**

D. Field Quality-Control Submittals:

1. Field quality-control reports.

1.5 INFORMATIONAL SUBMITTALS

A. Manufacturers' Published Instructions: Record copy of official installation[**and testing**] instructions issued to Installer by manufacturer for the following:

1. Installation instructions for electrified locking devices and accessories.

B. Sample warranties.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Contracts:

1. Firmware service agreement.

B. Warranty documentation.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Extra Stock Material: Furnish to Owner extra materials[, **from same production run,**] that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.[**Include the following:**]

1. Electrified Locking Devices and Accessories: [**One**]**<Insert number>** of each type.

B. Special Tools: Furnish to Owner proprietary equipment, keys, and software required to operate, maintain, repair, adjust, or implement future changes to electrified locking devices and accessories, that are packaged with protective covering for storage on-site and identified with labels describing contents.[**Include the following:**]

1. **<Insert item>.**

1.8 QUALIFICATIONS

- A. Security Design Professional: Design professional with active Physical Security Professional (PSP) certification issued by American Society for Industrial Security (ASIS) and with documented experience managing installation of security systems in similar size and complexity.
- B. Security Testing and Inspecting Agency: Entity possessing active credentials from qualified electrical testing laboratory recognized by authorities having jurisdiction.
 - 1. On-site security testing supervisor must have **[ASIS][PSP]<Insert organization>** certification and documented training and experience with testing security equipment in accordance with **[ASIS]<Insert organization>** testing standards.

1.9 WARRANTY

- A. Special Installer Extended Warranty: Installer warrants that fabricated and installed electrified locking devices and accessories perform in accordance with specified requirements and agrees to repair or replace components or products that fail to perform as specified within extended-warranty period.
 - 1. Extended-Warranty Period: **[Two][Three][Four]<Insert number>** years from date of Substantial Completion; full coverage for labor, materials, and equipment.
- B. Special Manufacturer Extended Warranty: Manufacturer warrants that electrified locking devices and accessories perform in accordance with specified requirements and agrees to provide repair or replacement of components or products that fail to perform as specified within extended-warranty period.
 - 1. Initial Extended-Warranty Period: **[Three][Four][Five]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for labor, materials, and equipment.
 - 2. Follow-On Extended-Warranty Period: **[Eight]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for materials only, free on board **[origin][destination]**, freight prepaid.

PART 2 - PRODUCTS

2.1 ELECTRICALLY CONTROLLED SINGLE-POINT LOCKS AND LATCHES

- A. Description: This category covers single-point electrified locksets, including cylindrical and mortise-style locks, which are connected to the access control system via hardwired cabling or wireless. Electrified locksets communicate with credential readers through the access control system to unlock doors upon credential authorization. Electrified locksets may also be programmed to lock or unlock directly via a signal from the access control system without the need for credential authorization.
- B. Performance Criteria:
 - 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - 2. Listing Criteria:
 - a. Special Locking Arrangements: UL CCN FWAX; including UL 294, NFPA 101, and ICC IBC.

- b. Electrically Controlled Single-Point Locks and Latches: UL CCN GYQS, UL 10B, and UL 10C; designed to be used with Class 2 control-voltage circuits in accordance with Article 725 of NFPA 70.

C. Electrically Controlled Single-Point Latch :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Corbin Russwin, Inc.; an ASSA ABLOY Group company]**
 - b. **[Design Hardware; Mesker Openings Group; dormakaba]**
 - c. **[Schlage; an Allegion brand]**
 - d. **[Security Door Controls]**
 - e. **[Yale Security Inc; ASSA ABLOY]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Corbin Russwin, Inc.; an ASSA ABLOY Group company]**
 - b. **[Design Hardware; Mesker Openings Group; dormakaba]**
 - c. **[Schlage; an Allegion brand]**
 - d. **[Security Door Controls]**
 - e. **[Yale Security Inc; ASSA ABLOY]**
 - f. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Options:
 - a. **[Audible][and][visual]** indication of door unlock.
 - b. Input Power: **[12 V(ac/dc)][or][24 V(ac/dc)][PoE][AA batteries]<Insert power input>**.
 - c. Operating Temperature: **[Minus 31 to plus 151 deg F (Minus 35 to plus 66 deg C)]<Insert temperature>**.
 - d. Connectivity: **[Hardwired][Wireless]**.
 - e. Materials: **[Zinc]<Insert material>**.
 - f. Finishes: **[US26D Satin Chrome]<Insert finish>**.
 - g. Integrated Credential Reader:
 - 1) Proximity (125 kHz).
 - 2) Smart (13.56 MHz).
 - 3) Bluetooth low energy (2.4 GHz).
 - 4) NFC.
 - h. Integrated **[combination lock][keypad]**.
 - i. Failure Mode: **[Fail-safe][Fail-secure]**.
 - j. Mechanical key override.
 - k. Latch bolt monitor.
 - l. **[With][or][without]** deadbolt.

2.2 ELECTRICALLY CONTROLLED TWO- AND THREE-POINT LOCKS AND LATCHES

- A. Description: This category covers two- and three-point electrified locksets, which are connected to the access control system via hardwired cabling or wireless. Electrified locksets communicate with credential readers through the access control system to unlock doors upon credential authorization. Electrified locksets may also be programmed to lock or unlock directly via a signal from the access control system without the need for credential authorization.
- B. Performance Criteria:
1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 2. Listing Criteria:
 - a. Special Locking Arrangements: UL CCN FWAX; including UL 294, NFPA 101, and ICC IBC.
 - b. Two- and Three-Point Locks and Latches: UL CCN GYXR; including UL 10B.
- C. Electrically Controlled Two-Point Latch :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Corbin Russwin, Inc.; an ASSA ABLOY Group company]**
 - b. **[SARGENT Manufacturing Company; ASSA ABLOY]**
 - c. **[Schlage; an Allegion brand]**
 - d. **[Von Duprin; Allegion plc]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Corbin Russwin, Inc.; an ASSA ABLOY Group company]**
 - b. **[SARGENT Manufacturing Company; ASSA ABLOY]**
 - c. **[Schlage; an Allegion brand]**
 - d. **[Von Duprin; Allegion plc]**
 - e. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain products from single manufacturer.
 4. Options:
 - a. **[Audible][and][visual]** indication of door unlock.
 - b. Input Power: **[12 V(ac/dc)][or][24 V(ac/dc)][PoE]<Insert power input>**.
 - c. Operating Temperature: **[Minus 31 to plus 151 deg F (Minus 35 to plus 66 deg C)]<Insert temperature>**.
 - d. Connectivity: **[Hardwired][Wireless]**.
 - e. Materials: **[Zinc]<Insert material>**.
 - f. Finishes: **[US26D Satin Chrome]<Insert finish>**.
 - g. Integrated Credential Reader:
 - 1) Proximity (125 kHz).
 - 2) Smart (13.56 MHz).

- 3) Bluetooth low energy (2.4 GHz).
- 4) NFC.

- h. Integrated **[combination lock][keypad]**.
- i. Failure Mode: **[Fail-safe][Fail-secure]**.
- j. Mechanical key override.
- k. Latch bolt monitor.

D. Electrically Controlled Three-Point Latch :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Corbin Russwin, Inc.; an ASSA ABLOY Group company]**
 - b. **[SARGENT Manufacturing Company; ASSA ABLOY]**
 - c. **[Schlage; an Allegion brand]**
 - d. **[Von Duprin; Allegion plc]**
 - e. **[Yale Security Inc; ASSA ABLOY]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Corbin Russwin, Inc.; an ASSA ABLOY Group company]**
 - b. **[SARGENT Manufacturing Company; ASSA ABLOY]**
 - c. **[Schlage; an Allegion brand]**
 - d. **[Von Duprin; Allegion plc]**
 - e. **[Yale Security Inc; ASSA ABLOY]**
 - f. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Options:
 - a. **[Audible][and][visual]** indication of door unlock.
 - b. Input Power: **[12 V(ac/dc)][or][24 V(ac/dc)][PoE]<Insert power input>**.
 - c. Operating Temperature: **[Minus 31 to plus 151 deg F (Minus 35 to plus 66 deg C)]<Insert temperature>**.
 - d. Connectivity: **[Hardwired][Wireless]**.
 - e. Materials: **[Zinc]<Insert material>**.
 - f. Finishes: **[US26D Satin Chrome]<Insert finish>**.
 - g. Integrated Credential Reader:
 - 1) Proximity (125 kHz).
 - 2) Smart (13.56 MHz).
 - 3) Bluetooth low energy (2.4 GHz).
 - 4) NFC.
 - h. Integrated **[combination lock][keypad]**.
 - i. Failure Mode: **[Fail-safe][Fail-secure]**.
 - j. Mechanical key override.
 - k. Latch bolt monitor.

2.3 HIGH-SECURITY ELECTRONIC LOCKS

- A. Description: This category covers high-security electronic locks, which are connected to the access control system via hardwired cabling or wireless. High-security electronic locks typically have multilevel authentication or utilize heavy-duty components for increased security.
- B. Performance Criteria:
1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 2. Listing Criteria:
 - a. Special Locking Arrangements: UL CCN FWAX; including UL 294, NFPA 101, and ICC IBC.
 - b. High-Security Electronic Locks: UL CCN OZDC; including UL Subject 2058.
- C. Type 1 High-Security Electronic Lock :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American Security Products Co.]**
 - b. **[dormakaba USA Inc.]**
 - c. **[FireKing International]**
 - d. **[NKL Industries Ltd.; FireKing International LLC]**
 - e. **[SARGENT Manufacturing Company; ASSA ABLOY]**
 - f. **[SECURAM Systems Inc.]**
 - g. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Security Products Co.]**
 - b. **[dormakaba USA Inc.]**
 - c. **[FireKing International]**
 - d. **[NKL Industries Ltd.; FireKing International LLC]**
 - e. **[SARGENT Manufacturing Company; ASSA ABLOY]**
 - f. **[SECURAM Systems Inc.]**
 - g. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain products from single manufacturer.
 4. Additional Listing Criteria: UL CCN OZDU.
 5. Options:
 - a. **[Audible][and][visual]** indication of door unlock.
 - b. Input Power: **[12 V(ac/dc)][or][24 V(ac/dc)][PoE][Li-ion battery]<Insert power input>**.
 - c. Operating Temperature: **[Minus 4 to plus 140 deg F (Minus 20 to plus 60 deg C)]<Insert temperature>**.
 - d. Connectivity: **[Hardwired][Wireless]**.
 - e. Memory:
 - 1) Access time/date stamp stored in **[key][and][cylinder]**.

- 2) Audit Trail: **[100][1000]<Insert number>** events.
- 3) Directory of authorized keys stored in cylinder.

- f. Cylinder Type: **[Single][Double][Mortise]<Insert type>**.
- g. Materials: **[Zinc][Steel]<Insert material>**.
- h. Finishes: **[US26D Satin Chrome]<Insert finish>**.
- i. Integrated credential reader.
- j. Failure Mode: **[Fail-safe][Fail-secure]**.
- k. Mechanical key override.

D. Type 1F High-Security Combination Lock :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Kaba Mas - LA GARD; dormakaba Group]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Kaba Mas - LA GARD; dormakaba Group]**
 - b. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Additional Listing Criteria: **[UL CCN OZEM; including]**Fed. Spec. FF-L-2740.
5. Options:
 - a. **[Audible][and][visual]** indication of door unlock.
 - b. Input Power: **[12 V(ac/dc)][or][24 V(ac/dc)][PoE][Li-ion battery][Electromechanically self-powered]<Insert power input>**.
 - c. Operating Temperature: **[Minus 10 to plus 155 deg F (Minus 23 to plus 68 deg C)]<Insert temperature>**.
 - d. Connectivity: **[Hardwired][Wireless]**.
 - e. Materials: **[Zinc][Steel]<Insert material>**.
 - f. Finishes: **[US26D Satin Chrome]<Insert finish>**.
 - g. Failure Mode: **[Fail-safe][Fail-secure]**.
 - h. Mechanical key override.

E. Type 2 High-Security Combination Lock :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American Security Products Co.]**
 - b. **[dormakaba USA Inc.]**
 - c. **[NKL Industries Ltd.; FireKing International LLC]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert**

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

- a. **[American Security Products Co.]**
 - b. **[dormakaba USA Inc.]**
 - c. **[NKL Industries Ltd.; FireKing International LLC]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
 4. Additional Listing Criteria: UL CCN OZFE.
 5. Options:
 - a. **[Audible][and][visual]** indication of door unlock.
 - b. Input Power: **[12 V(ac/dc)][or][24 V(ac/dc)][PoE][Li-ion battery]<Insert power input>**.
 - c. Operating Temperature: **[Minus 4 to plus 140 deg F (Minus 20 to plus 60 deg C)]<Insert operating temperature>**.
 - d. Connectivity: **[Hardwired][Wireless]**.
 - e. Materials: **[Zinc][Steel]<Insert material>**.
 - f. Finishes: **[US26D Satin Chrome]<Insert finish>**.
 - g. Integrated credential reader.
 - h. Request-to-Exit (REX) switch.
 - i. Failure Mode: **[Fail-safe][Fail-secure]**.
 - j. Mechanical key override.
 - k. Keyed Cylinder Configurations:
 - 1) Standard key in lever.
 - 2) Small-format interchangeable core (SFIC).
 - 3) Yale large-format removeable core.

2.4 STATUS MONITORING AND EGRESS DEVICES

- A. Description: This category covers egress devices and sensors, which are installed integral to or adjacent to door assemblies. Equipment under this category may be interconnected to other access control equipment, such as credential readers and locking devices. Equipment under this category may also be directly connected to the access control system to report door status.
- B. Performance Criteria:
 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 2. Listing Criteria: UL CCN ALVY; including UL 294.
- C. Request-to-Exit (REX) Motion Sensor :
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ASSA ABLOY Electronic Security Hardware; ASSA ABLOY]**
 - b. **[Honeywell Commercial Security; Honeywell International, Inc.]**
 - c. **[Vicon Industries, Inc]**
 - d. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ASSA ABLOY Electronic Security Hardware; ASSA ABLOY]**
 - b. **[Honeywell Commercial Security; Honeywell International, Inc.]**
 - c. **[Vicon Industries, Inc]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Options:
 - a. Input Power: **[125 V(ac)]<Insert power input>**.
 - b. Operating Temperature: **[Minus 13 to plus 140 deg F (Minus 25 to plus 60 deg C)]<Insert temperature>**.
 - c. Sensing Technology **[Passive infrared (PIR)][Active infrared (AIR)]**.
 - d. Color: **[Black][Gray][White]<Insert color>**.
 - e. Mounting: **[Wall surface][Recessed in ceiling][Door frame]**.

D. Request-to-Exit (REX) Push Button :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ASSA ABLOY Electronic Security Hardware; ASSA ABLOY]**
 - b. **[Schlage; an Allegion brand]**
 - c. **[Von Duprin; Allegion plc]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ASSA ABLOY Electronic Security Hardware; ASSA ABLOY]**
 - b. **[Schlage; an Allegion brand]**
 - c. **[Von Duprin; Allegion plc]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Options:
 - a. Input Power: **[12 to 24 V(ac/dc)]<Insert power input>**.
 - b. Operating Temperature: **[Minus 13 to plus 140 deg F (Minus 25 to plus 60 deg C)]<Insert temperature>**.
 - c. Operating Mechanism: **[Pneumatic][Piezoelectric]**.
 - d. Faceplate Material: **[Stainless steel]<Insert material>**.
 - e. Button Material: **[Plastic][Anodized aluminum]<Insert material>**.
 - f. Button Color: **[Green][Blue][Red]<Insert color>**.
 - g. Lettering Color: **[White][Black]<Insert color>**.
 - h. Failure Mode: **[Fail-safe][Fail-secure]**.



PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with manufacturer's published instructions.
- B. Special Techniques:
 - 1. Cable Type: **[Shielded][Unshielded]<Insert cable size>**.
 - 2. Maximum Cable Length: **[15 ft (5 m)][50 ft (15 m)][100 ft (30 m)]<Insert cable length>**.
- C. Interfaces with Other Work:
 - 1. Coordinate installation of new products for electrified locking devices and accessories with existing conditions.
 - a. **<Insert requirements for transition between new and existing>**.

3.2 FIELD QUALITY CONTROL

- A. Adminstrant for Security Tests and Inspections:
 - 1. **[Owner][Tenant]** will engage qualified security testing and inspecting agency to administer and perform tests and inspections.
 - 2. Engage qualified security testing and inspecting agency to administer and perform tests and inspections.
 - 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
 - 4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].
- B. Acceptance Testing Preparation:
 - 1. **<Insert requirements>**.
- C. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.
- D. Tests and Inspections:
 - 1. Perform manufacturer's recommended tests and inspections.
- E. Nonconforming Work:
 - 1. Device will be considered defective if it does not pass tests and inspections.
 - 2. Remove and replace defective units and retest.
- F. Collect, assemble, and submit test and inspection reports.
- G. Manufacturer Services:
 - 1. Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.



3.3 PROTECTION

- A. After installation, protect electrified locking devices and accessories from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

3.4 MAINTENANCE

- A. Firmware Service Agreement:
 - 1. Technical Support: Beginning at Substantial Completion, verify that firmware service agreement includes software and firmware support for **[two]<Insert number>** years.
 - 2. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software and firmware upgrades that become available within **[two]<Insert number>** years from date of Substantial Completion.
 - a. Upgrade Notice: No fewer than **[30]<Insert number>** days to allow Owner to schedule and access the system.
 - 3. Upgrade Reports: Prepare report after each update, documenting upgrades installed.

END OF SECTION 28 15 00 00B



SECTION 28 15 00 00C - EGRESS MANAGEMENT DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Magnetic lock hardware with special locking arrangement for non-fire-rated doors.
2. Magnetic lock hardware with special locking arrangement for fire-rated doors.
3. Panic hardware with special locking arrangement for fire-rated doors.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.

1.2 DEFINITIONS

A. BMS: Building management system.

B. NFC: Near Field Communications.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Coordination Meeting(s): For egress management devices. Conduct meeting(s) **[as videoconference][or][at Project site]<Insert location>** before **<Insert construction activity>**.

1. Installers, fabricators, representatives of manufacturers, representatives from telecommunications, **[Owner's security representatives,][IT representatives,]** and administrators for field tests and inspections. Notify Architect[, **Construction Manager**][, and **Owner's Commissioning Authority**] of scheduled meeting dates.

1.4 ACTION SUBMITTALS

A. Product Data:

1. For each type of product.

B. Shop Drawings:

1. Project general notes.
2. Device layout.
3. Block diagram and cable/conduit routing.

4. System communications details.
5. System mounting details.
6. Secondary power calculations.

C. Certificates:

1. **<Insert certificate requirement>.**

D. Field Quality-Control Submittals:

1. Field quality-control reports.

1.5 INFORMATIONAL SUBMITTALS

A. Manufacturers' Published Instructions: Record copy of official installation[**and testing**] instructions issued to Installer by manufacturer for the following:

1. Installation instructions for egress management devices.
2. Manufacturer's recommended tests and inspections for egress management devices.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Special Tools: Furnish to Owner proprietary equipment, keys, and software required to operate, maintain, repair, adjust, or implement future changes to egress management devices, that are packaged with protective covering for storage on-site and identified with labels describing contents.[**Include the following:**]

1. **<Insert item>.**

1.7 REGULATORY AGENCY APPROVALS

A. Submittals for egress management devices requiring approval by authorities having jurisdiction must be signed and sealed by qualified professional engineer responsible for their preparation. **[Obtain approval by authorities having jurisdiction prior to submitting for action by Architect.][Submit for action by Architect prior to submitting for approval by authorities having jurisdiction.]**

B. Submittals for egress management devices require action by Architect prior to submitting for approval by authorities having jurisdiction.

1.8 QUALIFICATIONS

A. Security Design Professional: Design professional with active Physical Security Professional (PSP) certification issued by American Society for Industrial Security (ASIS) and with documented experience managing installation of security systems in similar size and complexity.

B. Security Testing and Inspecting Agency: Entity possessing active credentials from qualified electrical testing laboratory recognized by authorities having jurisdiction.

1. On-site security testing supervisor must have **[ASIS][PSP]<Insert organization>** certification and documented training and experience with testing security equipment in accordance with

[ASIS]<Insert organization> testing standards.

PART 2 - PRODUCTS

2.1 MAGNETIC LOCK HARDWARE WITH SPECIAL LOCKING ARRANGEMENT FOR NON-FIRE-RATED DOORS

- A. Description: Magnetic lock connected to access control system and programmed for desired function. Magnetic lock may be programmed for release by access control system. Magnetic lock may also be pressure sensing, programmed to release and alarm after pressure is applied for a designated period.
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Camden Door Controls]**
 - 2. **[Gianni Electro Magnet (GEM); Gianni Industries, Inc.]**
 - 3. **[Schlage; an Allegion brand]**
 - 4. **[SECO-LARM U.S.A., Inc.]**
 - 5. **[Vanguard Security Engineering Corp. (VGSE)]**
 - 6. **<Insert manufacturer's name>**
- C. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Camden Door Controls]**
 - 2. **[Gianni Electro Magnet (GEM); Gianni Industries, Inc.]**
 - 3. **[Schlage; an Allegion brand]**
 - 4. **[SECO-LARM U.S.A., Inc.]**
 - 5. **[Vanguard Security Engineering Corp. (VGSE)]**
 - 6. **<Insert manufacturer's name>**
- D. Source Limitations: Obtain products from single manufacturer.
- E. Performance Criteria:
 - 1. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - b. Compliant with NFPA 101, ICC IBC, and local life safety code requirements for use along means of egress.
 - 2. Listing Criteria:
 - a. Special Locking Arrangements: UL CCN FWAX or UL CCN FWAX2; including UL 294, NFPA 101, and ICC IBC.
 - b. Electromagnetic Locks for Non-Fire-Rated Doors: UL CCN CVYT; including UL 1034.
- F. Options:
 - 1. Input Voltage: **[12 to 24 V(dc)]<Insert voltage>**.



2. Holding Force: [1200 lbf (5338 N)]<Insert force>.
3. Release Delay: [Zero][Five][10][15]<Insert number> seconds.
4. Relock Function: [Manual][Delayed automatic] relock.
5. Door Prop Alarm Delay: [None][30 seconds]<Insert delay>.
6. Door Movement Detection: [1/8 inch (3 mm)][1/4 inch (6 mm)][1/2 inch (13 mm)][3/4 inch (19 mm)][1 inch (25 mm)].
7. Dry contact for external alarm relay[to security system][to fire-alarm system][to BMS].

2.2 MAGNETIC LOCK HARDWARE WITH SPECIAL LOCKING ARRANGEMENT FOR FIRE-RATED DOORS

- A. Description: Magnetic lock connected to access control system and programmed for desired function. Magnetic lock may be programmed for release by access control system. Magnetic lock may also be pressure sensing, programmed to release and alarm after pressure is applied for a designated period.
- B. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 1. [Alarm Controls; Hanchett Entry Systems, Inc.; ASSA ABLOY Group]
 2. [BEA Americas; Halma plc]
 3. [Gianni Electro Magnet (GEM); Gianni Industries, Inc.]
 4. [Hager Companies]
 5. [Rutherford Controls Int'l. (RCI); dormakaba Group]
 6. [SARGENT Manufacturing Company; ASSA ABLOY]
 7. [Schlage; an Allegion brand]
 8. [Vanguard Security Engineering Corp. (VGSE)]
 9. <Insert manufacturer's name>
- C. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 1. [Alarm Controls; Hanchett Entry Systems, Inc.; ASSA ABLOY Group]
 2. [BEA Americas; Halma plc]
 3. [Gianni Electro Magnet (GEM); Gianni Industries, Inc.]
 4. [Hager Companies]
 5. [Rutherford Controls Int'l. (RCI); dormakaba Group]
 6. [SARGENT Manufacturing Company; ASSA ABLOY]
 7. [Schlage; an Allegion brand]
 8. [Vanguard Security Engineering Corp. (VGSE)]
 9. <Insert manufacturer's name>
- D. Source Limitations: Obtain products from single manufacturer.
- E. Performance Criteria:
 1. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - b. Compliant with NFPA 101, ICC IBC, and local life safety code requirements for use along means of egress.

2. Listing Criteria:

- a. Special Locking Arrangements: UL CCN FWAX or UL CCN FWAX2; including UL 294, NFPA 101, and ICC IBC.
- b. Electromagnetic Locks for Fire-Rated Doors: UL CCN GWXT; including UL 10B and UL 10C.

F. Options:

1. Input Voltage: [12 to 24 V(dc)]<Insert voltage>.
2. Holding Force: [1200 lbf (5338 N)]<Insert force>.
3. Release Delay: [Zero][Five][10][15]<Insert number> seconds.
4. Relock Function: [Manual][Delayed automatic] relock.
5. Door Prop Alarm Delay: [None][30 seconds]<Insert delay>.
6. Door Movement Detection: [1/8 inch (3 mm)][1/4 inch (6 mm)][1/2 inch (13 mm)][3/4 inch (19 mm)][1 inch (25 mm)].
7. Dry contact for external alarm relay[to security system][to fire-alarm system][to BMS].

2.3 PANIC HARDWARE WITH SPECIAL LOCKING ARRANGEMENT FOR FIRE-RATED DOORS

- A. Description: This category covers devices mounted on outward-swinging exit doors to facilitate egress. When activated, devices monitor against unauthorized egress and allow exiting after specified time delay. These devices allow immediate exit in case of power failure or upon activation of fire-alarm system.
- B. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 1. [ASSA ABLOY Electronic Security Hardware; ASSA ABLOY]
 2. [Corbin Russwin, Inc.; an ASSA ABLOY Group company]
 3. [Detex Corporation]
 4. [Kaba Mas - LA GARD; dormakaba Group]
 5. [Von Duprin; Allegion plc]
 6. [Yale Security Inc; ASSA ABLOY]
 7. <Insert manufacturer's name>
- C. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 1. [ASSA ABLOY Electronic Security Hardware; ASSA ABLOY]
 2. [Corbin Russwin, Inc.; an ASSA ABLOY Group company]
 3. [Detex Corporation]
 4. [Kaba Mas - LA GARD; dormakaba Group]
 5. [Von Duprin; Allegion plc]
 6. [Yale Security Inc; ASSA ABLOY]
 7. <Insert manufacturer's name>
- D. Source Limitations: Obtain products from single manufacturer.
- E. Performance Criteria:
 1. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory



- recognized by authorities having jurisdiction, and marked for intended location and application.
- b. Compliant with NFPA 101, ICC IBC, and local life safety code requirements for use along means of egress.

2. Listing Criteria:

- a. Special Locking Arrangements: UL CCN FWAX or UL CCN FWAX2; including UL 294, NFPA 101, and ICC IBC.
- b. Panic Hardware for Fire-Rated Doors: UL CCN GXHX, UL 10C, and UL 305.
- c. Controlled-Exit Panic Devices: UL CCN FULA; including UL 305.

F. Options:

- 1. Input Voltage: **[12 to 24 V(dc)]<Insert voltage>**.
- 2. Release Delay: **[Zero][Five][10][15]<Insert number> seconds**.
- 3. Door Prop Alarm: **[None][Activate after 30 seconds]<Insert delay>**.
- 4. Dry contact for external alarm relay **[to security system][to fire-alarm system][to BMS]**.
- 5. Secondary Power: **[9 V battery]<Insert power source>**.

PART 3 - EXECUTION

3.1 INSTALLATION OF EGRESS MANAGEMENT DEVICES

A. Comply with manufacturer's published instructions.

B. Interfaces with Other Work:

- 1. Coordinate installation of new products for egress management devices with existing conditions.
 - a. **<Insert requirements for transition between new and existing>**.
- 2. Coordinate with Section 282000 "Video Surveillance" for coordination of automatic video feed callup upon delayed egress activation.
- 3. Coordinate with Section 230923 "Direct Digital Control (DDC) System for HVAC" for monitoring of egress management device alarms by BMS.
- 4. Coordinate with Section 284600 "Fire Detection and Alarm" for monitoring of egress management device alarms by fire-alarm system.

3.2 FIELD QUALITY CONTROL

A. Adminstrant for Security Tests and Inspections:

- 1. **[Owner][Tenant]** will engage qualified security testing and inspecting agency to administer and perform tests and inspections.
- 2. Engage qualified security testing and inspecting agency to administer and perform tests and inspections.
- 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
- 4. Administer and perform tests and inspections **[with assistance of factory-authorized service representative]**.



- B. Acceptance Testing Preparation:
 - 1. <Insert requirements>.
- C. Field tests and inspections must be witnessed by [Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>.
- D. Tests and Inspections:
 - 1. Perform manufacturer's recommended tests and inspections.
- E. Nonconforming Work:
 - 1. Device will be considered defective if it does not pass tests and inspections.
 - 2. Remove and replace defective units and retest.
- F. Collect, assemble, and submit test and inspection reports.
- G. Manufacturer Services:
 - 1. Engage factory-authorized service representative to [support][supervise] field tests and inspections.

END OF SECTION 28 15 00 00C



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SECTION 28 15 00 00D - TELEPHONE ENTRY SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Analog audio telephone entry systems.
2. Digital audio-video telephone entry systems.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Coordination Meeting(s): For telephone entry systems. Conduct meeting(s) **[as videoconference][or][at Project site]<Insert location> before <Insert construction activity>.**

1. Attendees: Installers, fabricators, representatives of manufacturers, representatives from telecommunications, **[Owner's security representatives,][IT representatives,]** and administrators for field tests and inspections. Notify Architect[, **Construction Manager**][, and **Owner's Commissioning Authority**] of scheduled meeting dates.

1.3 ACTION SUBMITTALS

A. Product Data:

1. Analog audio telephone entry systems.
2. Digital audio-video telephone entry systems.

B. Shop Drawings:

1. Project general notes.
2. Device layout.
3. Block diagram and cable/conduit routing.
4. System communications details.
5. System mounting details.
6. Secondary power calculations.

C. Certificates:

1. **<Insert certificate requirement>.**

D. Field Quality-Control Submittals:

1. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

A. Manufacturers' Published Instructions: Record copy of official installation[**and testing**] instructions issued to Installer by manufacturer for the following:

1. Installation instructions for telephone entry systems.
2. Manufacturer's recommended tests and inspections for telephone entry systems.

B. Sample warranties.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Contracts:

1. Software and firmware service agreement.

B. Warranty documentation.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Special Tools: Furnish to Owner proprietary equipment, keys, and software required to operate, maintain, repair, adjust, or implement future changes to telephone entry systems, that are packaged with protective covering for storage on-site and identified with labels describing contents.[**Include the following:**]

1. **<Insert item>**.

1.7 QUALIFICATIONS

A. Security Design Professional: Design professional with active Physical Security Professional (PSP) certification issued by American Society for Industrial Security (ASIS) and with documented experience managing installation of security systems in similar size and complexity.

B. Security Testing and Inspecting Agency: Entity possessing active credentials from qualified electrical testing laboratory recognized by authorities having jurisdiction.

1. On-site security testing supervisor must have **[ASIS][PSP]<Insert organization>** certification and documented training and experience with testing security equipment in accordance with **[ASIS]<Insert organization>** testing standards.

1.8 WARRANTY

A. Special Installer Extended Warranty: Installer warrants that fabricated and installed telephone entry system performs in accordance with specified requirements and agrees to repair or replace components or products that fail to perform as specified within extended-warranty period.



1. Extended-Warranty Period: **[Two][Three][Four]<Insert number>** years from date of Substantial Completion; full coverage for labor, materials, and equipment.
- B. Special Manufacturer Extended Warranty: Manufacturer warrants that telephone entry system performs in accordance with specified requirements and agrees to provide repair or replacement of components or products that fail to perform as specified within extended-warranty period.
 1. **[Initial]**Extended-Warranty Period: **[Three][Four][Five]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for labor, materials, and equipment.
 2. Follow-On Extended-Warranty Period: **[Eight]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for materials **[that failed because of transient voltage surges]** only, free on board **[origin][destination]**, freight prepaid.

PART 2 - PRODUCTS

2.1 ANALOG AUDIO TELEPHONE ENTRY SYSTEMS

- A. Description: This category covers telephone entry systems, together with controls and accessories for use with such operators, and similar devices.
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 1. **[CellGate]**
 2. **[DoorKing, Inc]**
 3. **[Viking Electronics, Inc.]**
 4. **<Insert manufacturer's name>**
- C. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 1. **[CellGate]**
 2. **[DoorKing, Inc]**
 3. **[Viking Electronics, Inc.]**
 4. **<Insert manufacturer's name>**
- D. Performance Criteria:
 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 2. Listing Criteria: UL CCN ALVY; including UL 294.
 3. General Characteristics:
 - a. Minimum Ring Voltage: 25 V(ac rms).
 - b. Maximum Ring Voltage: 90 V(ac rms).
- E. Options:
 1. Operating Temperature Range: **[Minus 29 to plus 140 deg F (Minus 34 to plus 60 deg C)]<Insert temperature range>**.
 2. Speaker Volume: Approximately **[62 dB][70 dB]** maximum at 1 m.
 3. CPC Disconnect Time: **[300 ms][500 ms]** minimum.



4. REN: [0.5 A][0.8 A].
5. Materials: [Painted aluminum][Stainless steel]<Insert material>.
6. Finishes: [Brushed stainless steel][Oil-rubbed bronze]<Insert finish>.
7. Built-in Reader: [125 kHz][and][13.56 MHz] Wiegand proximity card reader.
 - a. Proximity Card Reader Power: 5 to 14 V(dc).
 - b. Proximity Card Reader Range: 1-1/4 to 2 inch (32 to 51 mm).
8. Mounting: [Wall][Flat-sided post] mounted.
9. Auto Answer: Selectable.
10. Speed Dial Buttons: [12]<Insert number>.
11. Keyless Entry Code Capacity: [50]<Insert number>.
12. Communications: [VoIP][POTS].
13. Input Power: [12 to 24 V(ac/dc)][Telephone line powered 20 V(dc)].

F. Accessories:

1. Surface-mount box.
2. Pedestal-mount kit.

2.2 DIGITAL AUDIO-VIDEO TELEPHONE ENTRY SYSTEMS

- A. Description: This category covers digital audio-video telephone entry systems, together with controls and accessories for use with such operators, and similar devices.
- B. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 1. [CellGate]
 2. [Enterphone; a brand of Identiv, Inc.]
 3. [Viking Electronics, Inc.]
 4. <Insert manufacturer's name>
- C. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 1. [CellGate]
 2. [Enterphone; a brand of Identiv, Inc.]
 3. [Viking Electronics, Inc.]
 4. <Insert manufacturer's name>
- D. Performance Criteria:
 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 2. Listing Criteria: UL CCN ALVY; including UL 294.
- E. Options:
 1. Operating Temperature: [Minus 4 to plus 130 deg F (Minus 20 to plus 55 deg C)].
 2. Input Power: [120 V(ac)][13.8 V(ac) adapter][12 to 24 V(ac/dc)].
 3. Speaker Volume: Approximately [62 dB][70 dB] maximum at 1 m.

4. CPC Disconnect Time: [300 ms][500 ms] minimum.
 5. REN: [0.5 A][0.8 A].
 6. Materials: [Painted aluminum][Stainless steel]<Insert material>.
 7. Finishes: [Brushed stainless steel][Oil-rubbed bronze]<Insert finish>.
 8. Built-in Reader: [125 kHz][and][13.56 MHz] Wiegand proximity card reader.
 - a. Proximity Card Reader Power: 5 to 14 V(dc).
 - b. Proximity Card Reader Range: 1-1/4 to 2 inch (32 to 51 mm).
 9. Video Camera: Color video camera with wide viewing angle and tilt/swivel adjustments.
 - a. Display: [7 inch (178 mm)][11 inch (279 mm)] full-color[touchscreen].
 - b. Camera Relay Contact: [0.5 A at 125 V(ac)][1.0 A at 30 V(dc)].
 - c. Camera Power: [6 to 22 V(dc)][12 V(dc) adapter].
 - d. Camera Field of View: [80][90] degrees.
 - e. Camera Tilt/Swivel Adjustment: Vertical plus-or-minus 20 degrees; horizontal plus-or-minus 30 degrees.
 - f. Night Vision: [Infrared Illumination][Optical filter].
 10. Mounting: Devices must be [wall][flat-sided post] mounted.
 11. Auto Answer: Selectable.
 12. Speed Dial Buttons: [12]<Insert number>.
 13. Keyless Entry Code Capacity: [50]<Insert number>.
- F. Accessories:
1. Surface-mount box.
 2. Pedestal-mount kit.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with manufacturer's published instructions.
- B. Special Techniques:
1. Cable Type: [Shielded][Unshielded]<Insert cable size>.
 2. Maximum Cable Length: [1000 ft (300 m)]<Insert length>.
- C. Interfaces with Other Work:
1. Coordinate installation of new products for telephone entry system with existing conditions.
 - a. <Insert requirements for transition between new and existing>.

3.2 FIELD QUALITY CONTROL

- A. Administrant for Security Tests and Inspections:
1. [Owner][Tenant] will engage qualified security testing and inspecting agency to administer and perform tests and inspections.



2. Engage qualified security testing and inspecting agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].

B. Acceptance Testing Preparation:

1. **<Insert requirements>**.

C. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.

D. Tests and Inspections:

1. Perform manufacturer's recommended tests and inspections.

E. Nonconforming Work:

1. System will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

F. Collect, assemble, and submit test and inspection reports.

G. Manufacturer Services:

1. Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.

3.3 SYSTEM STARTUP

A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.

1. Complete installation and startup checks in accordance with manufacturer's published instructions.
2. **<Insert startup steps if any>**.

3.4 PROTECTION

A. After installation, protect telephone entry system from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

3.5 MAINTENANCE

A. Software and Firmware Service Agreement:

1. Technical Support: Beginning at Substantial Completion, verify that software and firmware service agreement includes software and firmware support for **[two]<Insert number>** years.
2. Upgrade Service: At Substantial Completion, update software and firmware to latest version.



Install and program software and firmware upgrades that become available within [two]<Insert number> years from date of Substantial Completion.[**Verify that upgrading software includes operating system and new or revised licenses for using software.**]

- a. Upgrade Notice: No fewer than [30]<Insert number> days to allow Owner to schedule and access the system[**and to upgrade computer equipment if necessary**].
3. Upgrade Reports: Prepare report after each update, documenting upgrades installed.

END OF SECTION 28 15 00 00D



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SECTION 28 15 00 00E - INTERCOM ENTRY SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Digital audio intercom entry systems.
2. Digital audio-video intercom entry systems.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Coordination Meeting(s): For intercom entry system. Conduct meeting(s) **[as videoconference][or][at Project site]<Insert location> before <Insert construction activity>.**

1. Attendees: Installers, fabricators, representatives of manufacturers, representatives from telecommunications, **[Owner's security representatives,][IT representatives,]** and administrators for field tests and inspections. Notify Architect[, **Construction Manager**][, and **Owner's Commissioning Authority**] of scheduled meeting dates.

1.3 ACTION SUBMITTALS

A. Product Data:

1. Digital audio intercom entry systems.
2. Digital audio-video intercom entry systems.

B. Shop Drawings:

1. Project general notes.
2. Device layout.
3. Block diagram and cable/conduit routing.
4. System communications details.
5. System mounting details.
6. Secondary power calculations.

C. Certificates:

1. **<Insert certificate requirement>.**

D. Field Quality-Control Submittals:

1. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

A. Manufacturers' Published Instructions: Record copy of official installation[**and testing**] instructions issued to Installer by manufacturer for the following:

1. Installation and startup instructions for intercom entry systems.
2. Manufacturer's recommended tests and inspections for intercom entry systems.

B. Sample warranties.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Contracts:

1. Software and firmware service agreement.

B. Warranty documentation.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Special Tools: Furnish to Owner proprietary equipment, keys, and software required to operate, maintain, repair, adjust, or implement future changes to intercom entry system, that are packaged with protective covering for storage on-site and identified with labels describing contents.[**Include the following:**]

1. **<Insert item>**.

1.7 QUALIFICATIONS

A. Security Design Professional: Design professional with active Physical Security Professional (PSP) certification issued by American Society for Industrial Security (ASIS) and with documented experience managing installation of security systems in similar size and complexity.

B. Security Testing and Inspecting Agency: Entity possessing active credentials from qualified electrical testing laboratory recognized by authorities having jurisdiction.

1. On-site security testing supervisor must have **[ASIS][PSP]<Insert organization>** certification and documented training and experience with testing security equipment in accordance with **[ASIS]<Insert organization>** testing standards.

1.8 WARRANTY

A. Special Installer Extended Warranty: Installer warrants that fabricated and installed intercom entry system perform in accordance with specified requirements and agrees to repair or replace components or products that fail to perform as specified within extended-warranty period.

1. Extended-Warranty Period: **[Two][Three][Four]<Insert number>** years from date of Substantial Completion; full coverage for labor, materials, and equipment.
- B. Special Manufacturer Extended Warranty: Manufacturer warrants that intercom entry system perform in accordance with specified requirements and agrees to provide repair or replacement of components or products that fail to perform as specified within extended-warranty period.
 1. **[Initial]**Extended-Warranty Period: **[Three][Four][Five]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for labor, materials, and equipment.
 2. Follow-On Extended-Warranty Period: **[Eight]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for materials **[that failed because of transient voltage surges]** only, free on board **[origin][destination]**, freight prepaid.

PART 2 - PRODUCTS

2.1 DIGITAL AUDIO INTERCOM ENTRY SYSTEMS

- A. Description: This category covers digital audio intercom entry systems, together with controls and accessories for use with such operators, and similar devices.
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 1. **[Aiphone Corporation]**
 2. **[Stentofon; a brand of Zenitel USA]**
 3. **<Insert manufacturer's name>**
- C. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 1. **[Aiphone Corporation]**
 2. **[Stentofon; a brand of Zenitel USA]**
 3. **<Insert manufacturer's name>**
- D. Performance Criteria:
 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 2. Listing Criteria: UL CCN ALVY; including UL 294.
- E. Options:
 1. Operating Temperature: **[Minus 29 to plus 150 deg F (Minus 34 to plus 65 deg C)]**.
 2. Input Power: **[18 to 24 V(dc)]**.
 3. Connectivity: **[Hardwired][Wireless]**.
 4. Minimum Ring Voltage: 25 V(ac rms).
 5. Maximum Ring Voltage: 90 V(ac rms).
 6. Speaker Volume: Approximately **[62 dB][70 dB]** maximum at 1 m.
 7. Materials: **[Painted aluminum][Stainless steel]**.
 8. Finishes: **[Brushed stainless steel][Oil-rubbed bronze][Satin white][Satin black][Textured black]**.
 9. Climate: **[Indoor][and][outdoor]**.



10. Mounting: Devices must be [wall][flat-sided post][gooseneck pedestal][flush] mounted.
11. Push-to-talk button.

F. Accessories:

1. [Surface][Recessed] back box.
2. External keypad.
3. Mounting adaptor plate.
4. Mullion mounting bracket.
5. Desk stand.

2.2 DIGITAL AUDIO-VIDEO INTERCOM ENTRY SYSTEMS

- A. Description: This category covers digital audio-video intercom entry systems, together with controls and accessories for use with such operators, and similar devices.

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

1. [Aiphone Corporation]
2. [CAME Americas Automation LLC]
3. [Enterphone; a brand of Identiv, Inc.]
4. [Stentofon; a brand of Zenitel USA]
5. <Insert manufacturer's name>

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

1. [Aiphone Corporation]
2. [CAME Americas Automation LLC]
3. [Enterphone; a brand of Identiv, Inc.]
4. [Stentofon; a brand of Zenitel USA]
5. <Insert manufacturer's name>

D. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
2. Listing Criteria: UL CCN ALVY; including UL 294.

E. Options:

1. Operating Temperature: [Minus 29 to plus 150 deg F (Minus 34 to plus 65 deg C)].
2. Input Power: [18 to 24 V(dc)].
3. Connectivity: [Hardwired][Wireless].
4. Minimum Ring Voltage: 25 V(ac rms).
5. Maximum Ring Voltage: 90 V(ac rms).
6. Speaker Volume: Approximately [62 dB][70 dB] maximum at 1 m.
7. Materials: [Painted aluminum][Stainless steel].
8. Finishes: [Brushed stainless steel][Oil-rubbed bronze][Polished brass][Satin white][Satin black].
9. Climate: [Indoor][and][outdoor].

10. Mounting: Devices must be [wall][flat-sided post][gooseneck pedestal] mounted.
11. Video Camera:
 - a. Display: [7 inch (178 mm)][11 inch (279 mm)] full-color[touchscreen].
 - b. Camera Input Power: [6 to 22 V(dc)][12 V(dc) adapter].
 - c. Camera Field of View: 80 degrees horizontal, 60 degrees vertical, and 100 degrees diagonal.
 - d. Camera Tilt/Swivel Adjustment: Vertical plus-or-minus 20 degrees; horizontal plus-or-minus 30 degrees.

F. Accessories:

1. [Surface][Recessed] back box.
2. External keypad.
3. Mounting adaptor plate.
4. Mullion mounting bracket.
5. Desk stand.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with manufacturer's published instructions.
- B. Special Techniques:
 1. Hardwired System:
 - a. Cable Type: [Shielded][Unshielded]<Insert cable size>.
 - b. Maximum Line Loop Cable Length: [6300 ft (1.9 km)]<Insert cable length>.
 - c. Maximum Power-over-Ethernet Cable Length: [150 ft (50 m)][300 ft (100 m)][450 ft (150 m)].
 2. Wireless Systems:
 - a. Maintain compliance with [Owner's][Project] wireless standards specified in Division 27.
 - b. <Insert requirement>.
- C. Interfaces with Other Work:
 1. Coordinate installation of new products for intercom entry systems with existing conditions.
 - a. <Insert requirements for transition between new and existing>.
 2. Coordinate with Division 27 for wireless network provisioning of wireless intercom entry systems.
- D. Wireless Security:
 1. IP Security:
 - a. Hardware Root of Trust.
 - b. SSH.
 - c. HTTPS.



d. Firewall.

2. Software Integrity Check: **[SHA256]<Insert type>**.
3. Access to system management is restricted via a separate interface.
4. Smartphone Interface: **[Enable][Disable]** smartphone connectivity.

3.2 FIELD QUALITY CONTROL

A. Administrant for Security Tests and Inspections:

1. **[Owner][Tenant]** will engage qualified security testing and inspecting agency to administer and perform tests and inspections.
2. Engage qualified security testing and inspecting agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].

B. Acceptance Testing Preparation:

1. **<Insert requirements>**.

C. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.

D. Tests and Inspections:

1. Perform manufacturer's recommended tests and inspections.

E. Nonconforming Work:

1. System will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

F. Collect, assemble, and submit test and inspection reports.

G. Manufacturer Services:

1. Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.

3.3 SYSTEM STARTUP

A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.

1. Complete installation and startup checks in accordance with manufacturer's published instructions.
2. **<Insert startup steps if any>**.



3.4 PROTECTION

- A. After installation, protect intercom entry system from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

3.5 MAINTENANCE

- A. Software and Firmware Service Agreement:
 - 1. Technical Support: Beginning at Substantial Completion, verify that software and firmware service agreement includes software and firmware support for **[two]<Insert number>** years.
 - 2. Upgrade Service: At Substantial Completion, update software and firmware to latest version. Install and program software and firmware upgrades that become available within **[two]<Insert number>** years from date of Substantial Completion. **[Verify that upgrading software includes operating system and new or revised licenses for using software.]**
 - a. Upgrade Notice: No fewer than **[30]<Insert number>** days to allow Owner to schedule and access the system **[and to upgrade computer equipment if necessary]**.
 - 3. Upgrade Reports: Prepare report after each update, documenting upgrades installed.

END OF SECTION 28 15 00 00E



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SECTION 28 15 00 00F - ELECTRONIC KEY MANAGEMENT SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Key management system units.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Coordination Meeting(s): For key management systems. Conduct meeting(s) **[as videoconference][or][at Project site]<Insert location>** before **<Insert construction activity>**.

1. Attendees: Installers, fabricators, representatives of manufacturers, representatives from telecommunications, **[Owner's security representatives,][IT representatives,]** and administrators for field tests and inspections. Notify Architect[, **Construction Manager**][, and **Owner's Commissioning Authority**] of scheduled meeting dates.

1.3 ACTION SUBMITTALS

A. Product Data:

1. Key management system units.

B. Shop Drawings:

1. Project general notes.
2. Device layout.
3. System mounting details.

C. Certificates:

1. **<Insert certificate requirement>**.

D. Field Quality-Control Submittals:

1. Field quality-control reports.



1.4 INFORMATIONAL SUBMITTALS

- A. Manufacturers' Published Instructions: Record copy of official installation[**and testing**] instructions issued to Installer by manufacturer for the following:
 - 1. Installation instructions for key management systems.
 - 2. Manufacturer's recommended tests and inspections for key management systems.

1.5 QUALIFICATIONS

- A. Security Design Professional: Design professional with active Physical Security Professional (PSP) certification issued by American Society for Industrial Security (ASIS) and with documented experience managing installation of security systems in similar size and complexity.
- B. Security Testing and Inspecting Agency: Entity possessing active credentials from qualified electrical testing laboratory recognized by authorities having jurisdiction.
 - 1. On-site security testing supervisor must have **[ASIS][PSP]<Insert organization>** certification and documented training and experience with testing security equipment in accordance with **[ASIS]<Insert organization>** testing standards.

PART 2 - PRODUCTS

2.1 KEY MANAGEMENT SYSTEM UNITS

- A. Description: This category covers units for key management systems providing a means of regulating or controlling keys by electrical, electronic and/or mechanical means. Key management systems allow authorized users access to keys upon verification of appropriate credentials.
- B. Performance Criteria:
 - 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - 2. Listing Criteria: UL CCN ALZK; including UL 294.
- C. Electronic Key Management System Unit :
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Deister Electronic USA, Inc.]**
 - b. **[KEYper Systems; Marcon International, Inc.]**
 - c. **[MATRIX Cabinet]**
 - d. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. [Deister Electronic USA, Inc.]
 - b. [KEYper Systems; Marcon International, Inc.]
 - c. [MATRIX Cabinet]
 - d. <Insert manufacturer's name>
 3. Options:
 - a. Input Voltage: [110 to 240 V(ac)]<Insert voltage>.
 - b. Operating Temperature: [32 to 122 deg F (0 to 50 deg C)]<Insert temperature>.
 - c. Key Storage Capacity: <Insert number>.
 - d. Operating Frequency: [125 kHz][13.56 MHz].
 - e. Materials: [Stainless steel]<Insert material>.
 - f. Finishes: [Powder coated]<Insert finish>.
 - g. Backup Battery: [12 V(dc)]<Insert battery size>.
 - h. Front Cover: [Clear display window][Solid panel].
 - i. Enclosure Size: <Insert size>.
 4. Operation:
 - a. Access Method: [Proximity card][and][biometrics][and][keypad][and][standard key].
 - b. Alarm Output: [Local sounder][Output contacts].
- D. Mechanical Key Management System Unit :
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Deister Electronic USA, Inc.]
 - b. [KEYper Systems; Marcon International, Inc.]
 - c. [XceedID; an Allegion brand]
 - d. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Deister Electronic USA, Inc.]
 - b. [KEYper Systems; Marcon International, Inc.]
 - c. [XceedID; an Allegion brand]
 - d. <Insert manufacturer's name>
 3. Options:
 - a. Key Storage Capacity: <Insert number>.
 - b. Materials: [Stainless steel]<Insert material>.
 - c. Finishes: [Powder coated]<Insert finish>.
 - d. Front Cover: [Clear display window][Solid panel].
 - e. Enclosure Size: <Insert size>.
 4. Accessories:
 - a. Mirror hangers.
 - b. Tamper deals.
 - c. Key plugs.



- d. Access pegs.
- e. Key connectors.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with manufacturer's published instructions.
- B. Interfaces with Other Work:
 - 1. Coordinate installation of new products for key management system units with existing conditions.
 - a. **<Insert requirements for transition between new and existing>.**

3.2 FIELD QUALITY CONTROL

- A. Administrant for Security Tests and Inspections:
 - 1. **[Owner][Tenant]** will engage qualified security testing and inspecting agency to administer and perform tests and inspections.
 - 2. Engage qualified security testing and inspecting agency to administer and perform tests and inspections.
 - 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
 - 4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].
- B. Acceptance Testing Preparation:
 - 1. **<Insert requirements>.**
- C. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>.**
- D. Tests and Inspections:
 - 1. Perform manufacturer's recommended tests and inspections.
- E. Nonconforming Work:
 - 1. Unit will be considered defective if it does not pass tests and inspections.
 - 2. Remove and replace defective units and retest.
- F. Collect, assemble, and submit test and inspection reports.
- G. Manufacturer Services:
 - 1. Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.



3.3 PROTECTION

- A. After installation, protect key management system units from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 28 15 00 00F



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SECTION 28 15 00 00G - ACCESS CONTROL ELECTRONIC TURNSTILES AND MOBILITY SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Turnstile operators with access control devices.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Coordination Meeting(s): For electronic turnstiles. Conduct meeting(s) **[as videoconference][or][at Project site]<Insert location>** before **<Insert construction activity>**.

1. Attendees: Installers, fabricators, representatives of manufacturers, representatives from telecommunications, **[Owner's security representatives,][IT representatives,]** and administrators for field tests and inspections. Notify Architect[, **Construction Manager**][, and **Owner's Commissioning Authority**] of scheduled meeting dates.

1.3 ACTION SUBMITTALS

A. Product Data:

1. For each type of product.

B. Shop Drawings:

1. Project general notes.
2. Device layout.
3. Block diagram and cable/conduit routing.
4. System communications details.
5. System mounting details.
6. Secondary power calculations.

C. Certificates:

1. **<Insert certificate requirement>**.

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D. Field Quality-Control Submittals:

1. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

A. Manufacturers' Published Instructions: Record copy of official installation[**and testing**] instructions issued to Installer by manufacturer for the following:

1. Installation instructions for electronic turnstiles.

B. Sample warranties.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Contracts:

1. Maintenance service agreement.
2. Software and firmware service agreement.

B. Warranty documentation.

1.6 QUALIFICATIONS

A. Security Design Professional: Design professional with active Physical Security Professional (PSP) certification issued by American Society for Industrial Security (ASIS) and with documented experience managing installation of security systems in similar size and complexity.

B. Security Testing and Inspecting Agency: Entity possessing active credentials from qualified electrical testing laboratory recognized by authorities having jurisdiction.

1. On-site security testing supervisor must have **[ASIS][PSP]<Insert organization>** certification and documented training and experience with testing security equipment in accordance with **[ASIS]<Insert organization>** testing standards.

1.7 WARRANTY

A. Special Installer Extended Warranty: Installer warrants that fabricated and installed turnstile operators with access control devices perform in accordance with specified requirements and agrees to repair or replace components or products that fail to perform as specified within extended-warranty period.

1. Extended-Warranty Period: **[Two][Three][Four]<Insert number>** years from date of Substantial Completion; full coverage for labor, materials, and equipment.

B. Special Manufacturer Extended Warranty: Manufacturer warrants that turnstile operators with access control devices perform in accordance with specified requirements and agrees to provide repair or replacement of components or products that fail to perform as specified within extended-warranty period.

1. Initial Extended-Warranty Period: **[Three][Four][Five]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for labor, materials, and equipment.
2. Follow-On Extended-Warranty Period: **[Eight]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for materials **[that failed because of transient voltage surges]** only, free on board **[origin][destination]**, freight prepaid.

PART 2 - PRODUCTS

2.1 TURNSTILE OPERATORS WITH ACCESS CONTROL DEVICES

- A. Description: This category covers electrical and pneumatic turnstile operators, together with controls and accessories for use with such operators, and similar devices.
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 1. **[Aeroturn]**
 2. **[Gunnebo; Gunnebo Group]**
 3. **[Orion Entrance Control, Inc.]**
 4. **<Insert manufacturer's name>**
- C. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 1. **[Aeroturn]**
 2. **[Gunnebo; Gunnebo Group]**
 3. **[Orion Entrance Control, Inc.]**
 4. **<Insert manufacturer's name>**
- D. Performance Criteria:
 1. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - b. Comply with the United States Access Board's ADA-ABA Accessibility Guidelines, NFPA 101, and accessibility requirements enforced by authorities having jurisdiction.
 2. Listing Criteria:
 - a. Turnstile Operators: UL CCN FDDR; including UL 325.
 - b. Access Control Devices: UL CCN ALVY; including UL 294.
 3. General Characteristics:
 - a. Access Control System Integration: Integrated with access control system to grant or deny access to facility.
 - b. Accessibility: Coordinated **[with Architect]** to accommodate accessibility requirements where required.
 - c. Key Override: Manual key emergency open override available at turnstile cabinet.



- d. Climb-over Detection: Sensors detect attempts to circumvent turnstile by climbing or jumping over, activating local alarm.

E. Options:

1. Capable of using **[flush-][or][surface-]**mounted readers.
2. Reader Mounting Location: **[Top][Front][Side]**.
3. Directional Control: **[Allow free egress][Prohibit passage]** in direction opposite of credential reading.
4. Odometer: Passageway odometer is to be **[internally][or][remotely]** mounted.
5. Locking: Normally locked in the **[egress][and][ingress]** directions.
6. Operating Element: **[Drop arm][Rotary tripod][Full-height glazed portal][Partial-height glazed portal]**.
7. Mounting: Devices must be **[floor][wall][ceiling]** mounted.
8. Finishes:
 - a. Stainless steel.
 - b. Galvanized painted steel.
 - c. Cast aluminum with painted gray finish.

PART 3 - EXECUTION

3.1 INSTALLATION OF ACCESS CONTROL ELECTRONIC TURNSTILES AND MOBILITY SYSTEMS

- A. Comply with manufacturer's published instructions.
- B. Special Techniques:
 1. Cable Type: **[Shielded][Unshielded]<Insert cable type>**.
- C. Interfaces with Other Work:
 1. Coordinate installation of new products for turnstile operator with access control device with existing conditions.
 - a. **<Insert requirements for transition between new and existing>**.
 2. Coordinate with Division 02[**and Division 03**] to perform cutting/drilling of existing floor slab for installation of electronic turnstiles.
 3. Coordinate with Division 26 to provide power to electronic turnstiles.
 4. Coordinate with Section 284600 "Fire Detection and Alarm" to interface fire-alarm control circuit with turnstiles to automatically open upon alarm activation.

3.2 FIELD QUALITY CONTROL

- A. Adminstrant for Security Tests and Inspections:
 1. **[Owner][Tenant]** will engage qualified security testing and inspecting agency to administer and perform tests and inspections.
 2. Engage qualified security testing and inspecting agency to administer and perform tests and

- inspections.
- 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
- 4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].
- B. Acceptance Testing Preparation:
 - 1. **<Insert requirements>**.
- C. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.
- D. Tests and Inspections:
 - 1. Perform manufacturer's recommended tests and inspections for turnstile operator and access control device.
- E. Nonconforming Work:
 - 1. Unit will be considered defective if it does not pass tests and inspections.
 - 2. Remove and replace defective units and retest.
- F. Collect, assemble, and submit test and inspection reports.
- G. Manufacturer Services:
 - 1. Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.

3.3 PROTECTION

- A. After installation, protect turnstile operators and access control devices from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

3.4 MAINTENANCE

- A. Maintenance Service Agreement: Beginning at Substantial Completion, verify that maintenance service agreement includes **[three][six][nine][12]** months' full maintenance by **[skilled employees of turnstile operator with access control device installer][manufacturer's authorized service representative]**. Include **[monthly][quarterly][semiannual][annual]** preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper turnstile operation. Verify that parts and supplies are manufacturer's authorized replacement parts and supplies.
- B. Software and Firmware Service Agreement:
 - 1. Technical Support: Beginning at Substantial Completion, verify that software and firmware service agreement includes software and firmware support for **[two]<Insert number>** years.
 - 2. Upgrade Service: At Substantial Completion, update software and firmware to latest version. Install and program software and firmware upgrades that become available within **[two]<Insert number>** years from date of Substantial Completion.[**Verify that upgrading software includes**



operating system and new or revised licenses for using software.]

- a. Upgrade Notice: No fewer than [30]<Insert number> days to allow Owner to schedule and access the system[**and to upgrade computer equipment if necessary**].
3. Upgrade Reports: Prepare report after each update, documenting upgrades installed.

END OF SECTION 28 15 00 00G



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Task	Specification	Specification Description
28 15 00 00	28 10 00 00	Access Control
28 15 00 00	28 10 00 00a	Access Control System Hardware



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SECTION 28 15 11 00 - INTEGRATED CREDENTIAL READERS AND ENTRY MANAGEMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Credential readers.
2. Keypads.
3. Biometric identity devices.
4. Combination reader devices.

B. Products Installed, but Not Furnished, under This Section:

1. **<Insert products identified in "Owner-Furnished Products" Article, "Existing Products to be Modified" Article, or "Existing Products to be Removed and Re-Installed" Article>.**

C. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. Section 281513 "Access Control Credentials" for credential products for use with reader devices.

1.2 ALTERNATES

- A. See Section 012300 "Alternates" for description of alternates affecting items specified in this Section.

1.3 DEFINITIONS

- A. PoE: Power over Ethernet.

1.4 PREINSTALLATION MEETINGS

- A. Preinstallation Coordination Meeting(s): For integrated credential readers and entry management systems. Conduct meeting(s) **[as videoconference][or][at Project site]<Insert location> before <Insert construction activity>.**

1. Attendees: Installers, fabricators, representatives of manufacturers, representatives from telecommunications, **[Owner's security representatives,][IT representatives,]** and administrators for field tests and inspections. Notify Architect[, **Construction Manager**][, and **Owner's Commissioning Authority**] of scheduled meeting dates.

1.5 ACTION SUBMITTALS

- A. Product Data: For each product type.
 - 1. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing laboratory, certifying that model number corresponding to specified product complies with specified listing criteria.
 - 2. Include manufacturer's sample extended warranty language.
- B. Shop Drawings: Prepare and submit the following:
 - 1. Project general notes.
 - 2. Device layout.
 - 3. Block diagram and cable/conduit routing.
 - 4. System communications details.
 - 5. System mounting details.
 - 6. Secondary power calculations.
- C. Sustainable Design Submittals:
 - 1. Product data for sustainable design features for each type of product.
- D. Field quality-control reports.

1.6 INFORMATIONAL SUBMITTALS

- A. Manufacturers' Published Instructions: Record copy of official installation[**and testing**] instructions issued to Installer by manufacturer for the following:
 - 1. Installation instructions for integrated credential readers and entry management devices.
 - 2. Inspection and testing recommendations for integrated credential readers and entry management devices.
- B. Field Reports:
 - 1. Manufacturer's field reports for field quality-control support.
 - 2. Field reports for firmware upgrades.

1.7 CLOSEOUT SUBMITTALS

- A. Maintenance Contracts:
 - 1. Firmware service agreement.
- B. Warranty documentation.

1.8 MAINTENANCE MATERIAL SUBMITTALS

- A. Extra stock material.
- B. Special tools.

1.9 QUALIFICATIONS

- A. Security Design Professional: Design professional with active Physical Security Professional (PSP) certification issued by American Society for Industrial Security (ASIS) and with documented experience managing installation of security systems in similar size and complexity.
- B. Security Testing and Inspecting Agency: Entity possessing active credentials from qualified electrical testing laboratory recognized by authorities having jurisdiction.
 - 1. On-site security testing supervisor must have **[ASIS][PSP]<Insert organization>** certification and documented training and experience with testing security equipment in accordance with **[ASIS]<Insert organization>** testing standards.

1.10 WARRANTY

- A. Special Installer Extended Warranty: Installer warrants that fabricated and installed integrated credential readers and entry management devices perform in accordance with specified requirements and agrees to repair or replace components that fail to perform as specified within extended-warranty period.
 - 1. Extended-Warranty Period: **[Two][Three][Four]<Insert number>** years from date of Substantial Completion; full coverage for labor, materials, and equipment.
- B. Special Manufacturer Extended Warranty: Manufacturer warrants that integrated credential readers and entry management devices perform in accordance with specified requirements and agrees to provide repair or replacement of components or products that fail to perform as specified within extended-warranty period.
 - 1. Initial Extended-Warranty Period: **[Three][Four][Five]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for labor, materials, and equipment.
 - 2. Follow-On Extended-Warranty Period: **[Eight]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for materials only, free on board **[origin][destination]**, freight prepaid.

PART 2 - PRODUCTS

2.1 OWNER-FURNISHED PRODUCTS

- A. Basis for Pricing: **<Insert name of manufacturer; model number or series for product that Owner intends to furnish to Contractor>**.
- B. Description: **<Insert description of product, including special features, options, and finishes for Owner-furnished product that may impact Contractor's installation>**.
- C. Accessories: **<Insert accessories that will be provided with product>**.

2.2 EXISTING PRODUCTS TO BE MODIFIED

- A. Basis for Pricing: **<Insert name of manufacturer; model number or series for existing product>**.
- B. Description: **<Insert description of existing product, including special features, options, and finishes that may impact Work>**.



1. Sustainable Design Features:
 - a. Material Reuse: Product is salvaged, refurbished, or reused.

C. Accessories: **<Insert accessories included with existing product>**.

2.3 EXISTING PRODUCTS TO BE REMOVED AND RE-INSTALLED

- A. Basis for Pricing: **<Insert name of manufacturer; model number or series for existing product>**.
- B. Description: **<Insert description of existing product, including special features, options, and finishes that may impact Work>**.

1. Sustainable Design Features:
 - a. Material Reuse: Product is salvaged, refurbished, or reused.

C. Accessories: **<Insert accessories included with existing product>**.

2.4 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2.5 CREDENTIAL READERS

- A. Description: Electronic devices that read one or more types of access credentials and are part of overall access control system. These devices read and transfer credential info to access control system for control of door locks and other access control components.

B. Swipe Card Reader :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[aptiQ; an Allegion brand]**
 - b. **[Cansec Systems Ltd.]**
 - c. **[HID Global; ASSA ABLOY]**
 - d. **[Peripheral Dynamics, Inc.]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[aptiQ; an Allegion brand]**
 - b. **[Cansec Systems Ltd.]**
 - c. **[HID Global; ASSA ABLOY]**

- d. [Peripheral Dynamics, Inc.]
 - e. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by [UL Solutions][or][FM Approvals][, CSA Group (with "US" marking)][, Intertek ETL][, TÜV Rheinland][, or other qualified electrical testing laboratory recognized by authorities having jurisdiction] in accordance with one or more of the following guide information and corresponding standards:
- a. UL CCN ALVY; including UL 294.
 - b. Plastic Enclosure: UL CCN QMFZ2; including UL 94.
5. Standard Features:
- a. Visual LED indication of credential authorization.
 - b. Enclosure Rating: IEC 60529, [IP55][IP65][IP66]<Insert IP rating>.
 - c. Input Voltage: [5 to 12 V(dc)]<Insert power input>.
 - d. Operating Temperature: [Minus 40 to plus 160 deg F (Minus 40 to plus 71 deg C)]<Insert temperature>.
 - e. Materials: [Long-wearing polymeric plastic][Polycarbonate][Metal].
 - f. Colors: [Black][Gray]<Insert color>.
 - g. Climate: [Indoor][and][outdoor].
 - h. Size: [Single gang][or][double gang].
- C. Chip Card Reader :
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
- a. [HID Global; ASSA ABLOY]
 - b. [Hirsch; a brand of Identiv, Inc.]
 - c. [XceedID; an Allegion brand]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [HID Global; ASSA ABLOY]
 - b. [Hirsch; a brand of Identiv, Inc.]
 - c. [XceedID; an Allegion brand]
 - d. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by [UL Solutions][or][FM Approvals][, CSA Group (with "US" marking)][, Intertek ETL][, TÜV Rheinland][, or other qualified electrical testing laboratory recognized by authorities having jurisdiction] in accordance with one or more of the following guide information and corresponding standards:
- a. UL CCN ALVY; including UL 294.
 - b. Plastic Enclosure: UL CCN QMFZ2; including UL 94.
5. Standard Features:

- a. Visual LED indication of credential authorization.
- b. Enclosure Rating: IEC 60529, [IP55][IP65][IP66]<Insert IP rating>.
- c. Input Voltage: [5 to 12 V(dc)]<Insert power input>.
- d. Operating Temperature: [Minus 40 to plus 160 deg F (Minus 40 to plus 71 deg C)]<Insert temperature>.
- e. Materials: [Long-wearing polymeric plastic][Polycarbonate][Metal].
- f. Colors: [Black][Gray]<Insert color>.
- g. Climate: [Indoor][and][outdoor].
- h. Size: [Single gang][or][double gang].

D. Proximity Reader for Card, Fob, or Smartphone :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [AMAG Technology; G4S USA]
 - b. [aptiQ; an Allegion brand]
 - c. [Farpointe Data Inc.; DORMA USA, Inc.; dormakaba Group]
 - d. [HID Global; ASSA ABLOY]
 - e. [IDenticard Systems; Precision Dynamics Corporation]
 - f. [Openpath Security, Inc.]
 - g. [Suprema Inc.]
 - h. [XceedID; an Allegion brand]
 - i. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [AMAG Technology; G4S USA]
 - b. [aptiQ; an Allegion brand]
 - c. [Farpointe Data Inc.; DORMA USA, Inc.; dormakaba Group]
 - d. [HID Global; ASSA ABLOY]
 - e. [IDenticard Systems; Precision Dynamics Corporation]
 - f. [Openpath Security, Inc.]
 - g. [Suprema Inc.]
 - h. [XceedID; an Allegion brand]
 - i. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by [UL Solutions][or][FM Approvals][, CSA Group (with "US" marking)][, Intertek ETL][, TÜV Rheinland][, or other qualified electrical testing laboratory recognized by authorities having jurisdiction] in accordance with one or more of the following guide information and corresponding standards:
 - a. UL CCN ALVY; including UL 294.
 - b. Plastic Enclosure: UL CCN QMFZ2; including UL 94.
5. Standard Features:
 - a. Visual LED indication of credential authorization.
 - b. Enclosure Rating: IEC 60529, [IP55][IP65][IP66]<Insert IP rating>.
 - c. Input Voltage: [5 to 16 V(dc)][PoE]<Insert power input>.

- d. Operating Temperature: [Minus 40 to plus 160 deg F (Minus 40 to plus 71 deg C)]<Insert temperature>.
 - e. Read Range: Up to [1 inch (25 mm)][2 inch (51 mm)][3 inch (76 mm)].
 - f. Transmit Frequency: [125 kHz][13.56 MHz][2.4 GHz].
 - g. Materials: [Long-wearing polymeric plastic][Polycarbonate][Metal].
 - h. Colors: [Black][Gray]<Insert color>.
 - i. Climate: [Indoor][and][outdoor].
 - j. Size: [Single gang][or][double gang].
6. Accessories:
- a. Long-range receiver module.
- E. Proximity Card Reader for Hazardous (Classified) Location :
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. [HID Global; ASSA ABLOY]
 - b. [XceedID; an Allegion brand]
 - c. <Insert manufacturer's name>
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [HID Global; ASSA ABLOY]
 - b. [XceedID; an Allegion brand]
 - c. <Insert manufacturer's name>
 - 3. Source Limitations: Obtain products from single manufacturer.
 - 4. Listing Criteria: Investigated, labeled, and marked by [UL Solutions][or][FM Approvals][, CSA Group (with "US" marking)][, Intertek ETL][, TÜV Rheinland][, or other qualified electrical testing laboratory recognized by authorities having jurisdiction] in accordance with one or more of the following guide information and corresponding standards:
 - a. UL CCN ALVY; including UL 294.
 - b. Plastic Enclosure: UL CCN QMFZ2; including UL 94.
 - c. Additional Listing Criteria:
 - 1) UL CCN AATF; including UL 294.
 - 2) UL CCN AAIZ for NFPA 70 Class I, Division 1, Group[A][B][C][D] hazardous locations; including NFPA 496, UL 1203, UL 913, or UL 60079-28.
 - 3) UL CCN AAIZ for NFPA 70 Class I, Division 2, Group[A][B][C][D] hazardous locations; including NFPA 496, UL 121201, or UL 60079-28.
 - 4) UL CCN AAIZ for NFPA 70 Class II, Division 1, Group[E][F][G] hazardous locations; including NFPA 496, UL 1203, UL 913, or UL 60079-28.
 - 5) UL CCN AAIZ for NFPA 70 Class II, Division 2, Group[F][G] hazardous locations; including NFPA 496, UL 121201, or UL 60079-28.
 - 6) UL CCN AAIZ for NFPA 70 Class III, Division 1 hazardous locations; including UL 913 or UL 121201.
 - 7) UL CCN AAIZ for NFPA 70 Class III, Division 2 hazardous locations; including UL 913 or UL 121201.

5. Standard Features:

- a. Visual LED indication of credential authorization.
- b. Enclosure Rating: IEC 60529, [IP55][IP65][IP66]<Insert IP rating>.
- c. Input Voltage: [5 to 16 V(dc)]<Insert power input>.
- d. Operating Temperature: [Minus 40 to plus 160 deg F (Minus 40 to plus 71 deg C)]<Insert temperature>.
- e. Read Range: Up to [1 inch (25 mm)][2 inch (51 mm)][3 inch (76 mm)][5 inch (127 mm)].
- f. Transmit Frequency: [125 kHz][2.4 GHz].
- g. Materials: [Long-wearing polymeric plastic][Polycarbonate][Metal].
- h. Colors: [Black][Gray]<Insert color>.
- i. Climate: [Indoor][and][outdoor].
- j. Size: [Single gang][or][double gang].

2.6 KEYPADS

A. Description: Electronic devices with[**numerical**] keypads for keyless entry.

B. Door Lock Keypad :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Alarm Lock; NAPCO Security Technologies, Inc.]
 - b. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Alarm Lock; NAPCO Security Technologies, Inc.]
 - b. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by [UL Solutions][or][FM Approvals][, CSA Group (with "US" marking)][, Intertek ETL][, TÜV Rheinland][, or other qualified electrical testing laboratory recognized by authorities having jurisdiction] in accordance with one or more of the following guide information and corresponding standards:
 - a. UL CCN ALVY; including UL 294.
 - b. Plastic Enclosure: UL CCN QMFZ2; including UL 94.
5. Standard Features:
 - a. Enclosure Rating: IEC 60529, [IP55][IP65][IP66]<Insert IP rating>.
 - b. Visual LED indication of [three-][or][six-]digit code read.
 - c. Input Power: [5 to 16 V(dc)][12 to 28 V(dc)][Alkaline batteries]<Insert power input>.
 - d. Operating Temperature: [Minus 20 to plus 150 deg F (Minus 29 to plus 66 deg C)]<Insert temperature>.
 - e. Materials: [Long-wearing polymeric plastic][Polycarbonate][Metal].
 - f. Colors: [Black][Gray]<Insert color>.
 - g. Climate: [Indoor][and][outdoor].

- h. Size: **[Single gang][or][double gang]**.
- i. Mounting:
 - 1) Door/window mullions.
 - 2) Outlet boxes.
 - 3) Flat surfaces.
 - 4) Integrated door lock keypad.

C. LCD Alarm Keypad :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Open Options; ACRE, LLC]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Open Options; ACRE, LLC]**
 - b. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by **[UL Solutions][or][FM Approvals][, CSA Group (with "US" marking)][, Intertek ETL][, TÜV Rheinland][, or other qualified electrical testing laboratory recognized by authorities having jurisdiction]** in accordance with one or more of the following guide information and corresponding standards:
 - a. UL CCN ALVY; including UL 294.
 - b. Plastic Enclosure: UL CCN QMFZ2; including UL 94.
5. Standard Features:
 - a. Visual LED indication of code read.
 - b. Enclosure Rating: IEC 60529, **[IP55][IP65][IP66]<Insert IP rating>**.
 - c. Input Power: **[5 to 16 V(dc)][12 to 28 V(dc)]<Insert power input>**.
 - d. Operating Temperature: **[32 to 122 deg F (0 to 50 deg C)]<Insert temperature>**.
 - e. Materials: **[Long-wearing polymeric plastic][Polycarbonate][Metal]**.
 - f. Colors: **[Black][Gray][White]<Insert color>**.
 - g. Climate: **[Indoor][and][outdoor]**.
 - h. Mounting:
 - 1) Surface mount.
 - 2) Triple-gang outlet box.

D. Scramble Keypad :

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



- b. [Schlage; an Allegion brand]
 - c. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Hirsch; a brand of Identiv, Inc.]
 - b. [Schlage; an Allegion brand]
 - c. <Insert manufacturer's name>
- 3. Source Limitations: Obtain products from single manufacturer.
- 4. Listing Criteria: Investigated, labeled, and marked by [UL Solutions][or][FM Approvals][, CSA Group (with "US" marking)][, Intertek ETL][, TÜV Rheinland][, or other qualified electrical testing laboratory recognized by authorities having jurisdiction] in accordance with one or more of the following guide information and corresponding standards:
 - a. UL CCN ALVY; including UL 294.
 - b. Plastic Enclosure: UL CCN QMFZ2; including UL 94.
- 5. Standard Features:
 - a. Enclosure Rating: IEC 60529, [IP55][IP65][IP66]<Insert IP rating>.
 - b. Visual LED indication of [three-][or][six-][or][nine-]digit code read.
 - c. Input Power: [8 to 12 V(dc)]<Insert power input>.
 - d. Operating Temperature: [5 to 122 deg F (Minus 15 to plus 50 deg C)]<Insert temperature>.
 - e. Materials: [Long-wearing polymeric plastic][Polycarbonate][Metal].
 - f. Colors: [Black][Gray]<Insert color>.
 - g. Climate: [Indoor][and][outdoor].
 - h. Mounting: [Single-gang][or][double-gang] outlet box.

2.7 BIOMETRIC IDENTITY DEVICES

- A. Description: Electronic devices that read biometrics information, including fingerprint, palm, iris and facial characteristics. These devices read and transfer credential info to the access control system for control of door locks and other access control components.
- B. Single Finger Scanners :
 - 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Cansec Systems Ltd.]
 - b. [HID Global; ASSA ABLOY]
 - c. [IDTECK Global, Inc.]
 - d. [Suprema Inc.]
 - e. <Insert manufacturer's name>
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. **[Cansec Systems Ltd.]**
 - b. **[HID Global; ASSA ABLOY]**
 - c. **[IDTECK Global, Inc.]**
 - d. **[Suprema Inc.]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by **[UL Solutions][or][FM Approvals][, CSA Group (with "US" marking)][, Intertek ETL][, TÜV Rheinland][, or other qualified electrical testing laboratory recognized by authorities having jurisdiction]** in accordance with one or more of the following guide information and corresponding standards:
 - a. UL CCN ALVY; including UL 294.
 - b. Plastic Enclosure: UL CCN QMFZ2; including UL 94.
5. Standard Features:
 - a. Visual LED indication of fingerprint read.
 - b. Enclosure Rating: IEC 60529, **[IP55][IP65][IP66]<Insert IP rating>**.
 - c. Input Power: **[5 to 12 V(dc)][5 V(dc)][12 V(dc)][PoE][Alkaline battery]<Insert power input>**.
 - d. Operating Temperature: **[5 to 122 deg F (Minus 15 to plus 50 deg C)]<Insert temperature>**.
 - e. Read Range: Up to **[1 inch (25 mm)][2 inch (51 mm)][3 inch (76 mm)][4 inch (102 mm)]**.
 - f. Transmit Frequency: **[125 kHz][13.56 MHz]**.
 - g. Materials: **[Long-wearing polymeric plastic][Polycarbonate][Metal]**.
 - h. Colors: **[Black][Gray]<Insert color>**.
 - i. Climate: **[Indoor][and][outdoor]**.
 - j. Mounting: **[Single-gang][or][double-gang]** outlet box.

C. Palm Scanner :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Fujitsu]**
 - b. **[IDEMIA; Oberthur Technologies and Safran Identity & Security]**
 - c. **[iDentityTech Solutions, Ltd.]**
 - d. **[Schlage; an Allegion brand]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Fujitsu]**
 - b. **[IDEMIA; Oberthur Technologies and Safran Identity & Security]**
 - c. **[iDentityTech Solutions, Ltd.]**
 - d. **[Schlage; an Allegion brand]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by **[UL Solutions][or][FM Approvals][, CSA Group (with "US" marking)][, Intertek ETL][, TÜV Rheinland][, or other qualified electrical**



testing laboratory recognized by authorities having jurisdiction] in accordance with one or more of the following guide information and corresponding standards:

- a. UL CCN ALVY; including UL 294.
- b. Plastic Enclosure: UL CCN QMFZ2; including UL 94.

5. Standard Features:

- a. Visual LED indication of palm read.
- b. Enclosure Rating: IEC 60529, [IP55][IP65][IP66]<Insert IP rating>.
- c. Input Power: [8 to 12 V(dc)][PoE][Alkaline battery]<Insert power input>.
- d. Operating Temperature: [14 to 131 deg F (Minus 10 to plus 55 deg C)]<Insert temperature>.
- e. Materials: [Long-wearing polymeric plastic][Polycarbonate][Metal].
- f. Colors: [Black][Gray]<Insert color>.
- g. Climate: [Indoor][and][outdoor].
- h. Mounting:
 - 1) Surface mount.
 - 2) [Single-gang][or][double-gang] outlet box.

D. Iris Scanner :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [EyeLock, LLC; VOXX International Corporation]
 - b. [Iris ID Systems, Inc.]
 - c. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [EyeLock, LLC; VOXX International Corporation]
 - b. [Iris ID Systems, Inc.]
 - c. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by [UL Solutions][or][FM Approvals][, CSA Group (with "US" marking)][, Intertek ETL][, TÜV Rheinland][, or other qualified electrical testing laboratory recognized by authorities having jurisdiction] in accordance with one or more of the following guide information and corresponding standards:
 - a. UL CCN ALVY; including UL 294.
 - b. Plastic Enclosure: UL CCN QMFZ2; including UL 94.
5. Standard Features:
 - a. Visual indication of iris read.
 - b. Enclosure Rating: IEC 60529, [IP55][IP65][IP66]<Insert IP rating>.
 - c. Input Power: [12 to 24 V(dc)][5 V(dc)]<Insert power input>.
 - d. Operating Temperature: [32 to 113 deg F (0 to 45 deg C)]<Insert temperature>.

- e. Scan Range: [8 inch (203 mm)][11 to 15 inch (279 to 381 mm)]<Insert scan range>.
- f. Materials: [Long-wearing polymeric plastic][Polycarbonate][Metal].
- g. Colors: [Black][Gray]<Insert color>.
- h. Climate: [Indoor][and][outdoor].
- i. Mounting:

- 1) Surface mount.
- 2) [Single-gang][or][double-gang] outlet box.

E. Facial Scanner :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [IDEMIA; Oberthur Technologies and Safran Identity & Security]
 - b. [Suprema Inc.]
 - c. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [IDEMIA; Oberthur Technologies and Safran Identity & Security]
 - b. [Suprema Inc.]
 - c. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by [UL Solutions][or][FM Approvals][, CSA Group (with "US" marking)][, Intertek ETL][, TÜV Rheinland][, or other qualified electrical testing laboratory recognized by authorities having jurisdiction] in accordance with one or more of the following guide information and corresponding standards:
 - a. UL CCN ALVY; including UL 294.
 - b. Plastic Enclosure: UL CCN QMFZ2; including UL 94.
5. Standard Features:
 - a. Visual display indication of facial read.
 - b. Enclosure Rating: IEC 60529, [IP55][IP65][IP66]<Insert IP rating>.
 - c. Input Power: [12 to 24 V(dc)][PoE]<Insert power input>.
 - d. Operating Temperature: [41 to 113 deg F (5 to 45 deg C)]<Insert temperature>.
 - e. Materials: [Long-wearing polymeric plastic][Polycarbonate][Metal].
 - f. Colors: [Black][Gray]<Insert color>.
 - g. Climate: [Indoor][and][outdoor].
 - h. Mounting:
 - 1) Stand up.
 - 2) Desktop.

2.8 COMBINATION READER DEVICES

- A. Description: Electronic devices that read credentials via a combination of swipe or proximity card readers, keypads, and biometrics scanners. These devices read and transfer credential info to the



access control system for control of door locks and other access control components.

B. Combination Card Reader and Keypad :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Farpointe Data Inc.; DORMA USA, Inc.; dormakaba Group]**
 - b. **[Hirsch; a brand of Identiv, Inc.]**
 - c. **[Open Options; ACRE, LLC]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Farpointe Data Inc.; DORMA USA, Inc.; dormakaba Group]**
 - b. **[Hirsch; a brand of Identiv, Inc.]**
 - c. **[Open Options; ACRE, LLC]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by **[UL Solutions][or][FM Approvals][, CSA Group (with "US" marking)][, Intertek ETL][, TÜV Rheinland][, or other qualified electrical testing laboratory recognized by authorities having jurisdiction]** in accordance with one or more of the following guide information and corresponding standards:
 - a. UL CCN ALVY; including UL 294.
 - b. Plastic Enclosure: UL CCN QMFZ2; including UL 94.
5. Standard Features:
 - a. Visual LED indication of code and/or card read.
 - b. Enclosure Rating: IEC 60529, **[IP55][IP65][IP66]<Insert IP rating>**.
 - c. Input Power: **[5 to 16 V(dc)][12 to 28 V(dc)]<Insert power input>**.
 - d. Operating Temperature: **[32 to 122 deg F (0 to 50 deg C)]<Insert temperature>**.
 - e. Materials: **[Long-wearing polymeric plastic][Polycarbonate][Metal]**.
 - f. Colors: **[Black][Gray][White]<Insert color>**.
 - g. Climate: **[Indoor][and][outdoor]**.
 - h. Mounting:
 - 1) Surface mount.
 - 2) Triple-gang wall box.

C. Combination Card Reader/Keypad and Biometrics Scanner :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Cansec Systems Ltd.]**
 - b. **[HID Global; ASSA ABLOY]**

- c. [IDTECK Global, Inc.]
 - d. [Tyco Security Products; brand of Johnson Controls International plc, Building Solutions North America]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Cansec Systems Ltd.]
 - b. [HID Global; ASSA ABLOY]
 - c. [IDTECK Global, Inc.]
 - d. [Tyco Security Products; brand of Johnson Controls International plc, Building Solutions North America]
 - e. <Insert manufacturer's name>
 3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: Investigated, labeled, and marked by [UL Solutions][or][FM Approvals][, CSA Group (with "US" marking)][, Intertek ETL][, TÜV Rheinland][, or other qualified electrical testing laboratory recognized by authorities having jurisdiction] in accordance with one or more of the following guide information and corresponding standards:
 - a. UL CCN ALVY; including UL 294.
 - b. Plastic Enclosure: UL CCN QMFZ2; including UL 94.
 5. Standard Features:
 - a. Visual LED indication of fingerprint and/or card read.
 - b. Enclosure Rating: IEC 60529, [IP55][IP65][IP66]<Insert IP rating>.
 - c. Input Power: [9 to 24 V(dc)][PoE][Lithium ion chargeable battery]<Insert power input>.
 - d. Operating Temperature: [32 to 104 deg F (0 to 40 deg C)]<Insert temperature>.
 - e. Read Range: Up to [1 inch (25 mm)][2 inch (51 mm)][3 inch (76 mm)][4 inch (102 mm)].
 - f. Transmit Frequency: [125 kHz][13.56 MHz].
 - g. Materials: [Long-wearing polymeric plastic][Polycarbonate][Metal].
 - h. Colors: [Black][Gray]<Insert color>.
 - i. Climate: [Indoor][and][outdoor].
 - j. Mounting:
 - 1) Surface mount.
 - 2) [Single-gang][or][double-gang] wall box.

2.9 MAINTENANCE MATERIAL ITEMS

- A. Extra Stock Material: Furnish to Owner extra materials[, from same production run,] that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.[Include the following:]
 1. Integrated Credential Readers and Entry Management Devices: [One]<Insert number> of each type.
- B. Special Tools: Furnish to Owner proprietary equipment, keys, and software required to operate, maintain, repair, adjust, or implement future changes to integrated credential readers and entry management devices, that are packaged with protective covering for storage on-site and identified with labels describing contents.[Include the following:]



1. <Insert item>.

PART 3 - EXECUTION

3.1 INSTALLATION OF INTEGRATED CREDENTIAL READERS AND ENTRY MANAGEMENT

- A. Comply with manufacturer's published instructions.
- B. Special Techniques:
 1. Cable Type: [**Shielded**][**Unshielded**]<Insert cable size>.
 2. Maximum Cable Length: [**300 ft (100 m)**][**500 ft (150 m)**]<Insert cable length>.
- C. Interfaces with Other Work:
 1. Coordinate installation of new products for integrated credential readers and entry management devices with existing conditions.
 - a. <Insert requirements for transition between new and existing>.
 2. Coordinate with <Insert Section number and title> for <Insert description of interfacing related Work>.
 - a. <Insert requirements for transition between this Section and related Work>.

3.2 FIELD QUALITY CONTROL OF INTEGRATED CREDENTIAL READERS AND ENTRY MANAGEMENT

- A. Administrant for Security Tests and Inspections:
 1. [**Owner**][**Tenant**] will engage qualified security testing and inspecting agency to administer and perform tests and inspections.
 2. Engage qualified security testing and inspecting agency to administer and perform tests and inspections.
 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
 4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].
- B. Acceptance Testing Preparation:
 1. <Insert requirements>.
- C. Field tests and inspections must be witnessed by [**Architect**][**Tenant**][**authorities having jurisdiction**]<Insert names or titles of witnesses>. [**Testing of devices along means of egress must be witnessed by authorities having jurisdiction.**]
- D. Tests and Inspections:
 1. Perform manufacturer's recommended tests and inspections for the following:



- a. Credential readers.
 - b. Keypads.
 - c. Biometric identity devices.
 - d. Combination reader devices.
- E. Nonconforming Work:
 - 1. Device will be considered defective if it does not pass tests and inspections.
 - 2. Remove and replace defective units and retest.
- F. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.
- G. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.
 - 1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.

3.3 PROTECTION

- A. After installation, protect integrated credential readers and entry management devices from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

3.4 MAINTENANCE

- A. Firmware Service Agreement:
 - 1. Technical Support: Beginning at Substantial Completion, verify that software and firmware service agreement includes software and firmware support for **[two]<Insert number>** years.
 - 2. Upgrade Service: At Substantial Completion, update software and firmware to latest version. Install and program software and firmware upgrades that become available within **[two]<Insert number>** years from date of Substantial Completion.
 - a. Upgrade Notice: No fewer than **[30]<Insert number>** days to allow Owner to schedule and access the system.
 - 3. Field Reports for Firmware Upgrades: Prepare report after each update, documenting upgrades installed.

END OF SECTION 28 15 11 00



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28 - Electronic Safety and Security

Task	Specification	Specification Description
28 15 11 00	28 10 00 00	Access Control
28 15 11 00	28 10 00 00a	Access Control System Hardware
28 15 11 00	28 15 00 00	Integrated Access Control Hardware Devices
28 15 11 00	28 15 00 00a	Access Control Credentials
28 15 11 00	28 15 00 00b	Electrified Locking Devices and Accessories
28 15 11 00	28 15 00 00c	Egress Management Devices
28 15 11 00	28 15 00 00d	Telephone Entry Systems
28 15 11 00	28 15 00 00e	Intercom Entry Systems
28 15 11 00	28 15 00 00f	Electronic Key Management Systems
28 15 11 00	28 15 00 00g	Access Control Electronic Turnstiles and Mobility Systems
28 15 11 13	28 10 00 00	Access Control
28 15 11 13	28 10 00 00a	Access Control System Hardware
28 15 11 13	28 15 00 00	Integrated Access Control Hardware Devices
28 15 11 13	28 15 11 00	Integrated Credential Readers and Entry Management
28 15 11 13	28 15 00 00a	Access Control Credentials
28 15 11 13	28 15 00 00b	Electrified Locking Devices and Accessories
28 15 11 13	28 15 00 00c	Egress Management Devices
28 15 11 13	28 15 00 00d	Telephone Entry Systems
28 15 11 13	28 15 00 00e	Intercom Entry Systems
28 15 11 13	28 15 00 00f	Electronic Key Management Systems
28 15 11 13	28 15 00 00g	Access Control Electronic Turnstiles and Mobility Systems
28 16 00 00	28 10 00 00	Access Control
28 16 00 00	28 10 00 00a	Access Control System Hardware



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SECTION 28 16 11 00 - AREA AND PERIMETER INTRUSION DETECTION

PART 1 - GENERAL

1.1 SUMMARY

A. This Section Includes:

1. Sensing devices.
2. Control devices.
3. Notification devices.
4. Security fasteners.

B. Related Sections:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. Section 271313 "Communications Copper Backbone Cabling" for Category 5e, 6, and 7 backbone (riser-rated) cabling.
5. Section 271323 "Communications Optical Fiber Backbone Cabling" for multi- and single-mode backbone (riser-rated) optical fiber.
6. Section 271513 "Communications Copper Horizontal Cabling" for Category 5e, 6, and 7 horizontal (general use, riser-, and plenum-rated) cabling.
7. Section 271523 "Communications Optical Fiber Horizontal Cabling" for multi- and single-mode horizontal (general use, riser-, and plenum-rated) optical fiber.
8. Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for cabling between master control units and field-mounted devices and control units.

1.2 DEFINITIONS

- A. CCTV: Closed-circuit television.
- B. EMI: Electromagnetic interference.
- C. PIR: Passive infrared.
- D. RFI: Radio-frequency interference.
- E. UPS: Uninterruptible power supply.
- F. Control Unit: System component that monitors inputs and controls outputs through various circuits.
- G. Master Control Unit: System component that accepts inputs from other control units and may also perform control-unit functions. The unit has limited capacity for the number of protected zones and is installed at an unattended location or at a location where it is not the attendant's primary function to monitor the security system.



- H. Monitoring Station: Facility that receives signals and has personnel in attendance at all times to respond to signals. A central station is a monitoring station that is listed.
- I. Protected Zone: A protected premises or an area within a protected premise that is provided with means to prevent an unwanted event.
- J. Standard Intruder: A person who weighs **100 lb (45 kg)** or less and whose height is **60 inch (1525 mm)** or less; dressed in a long-sleeved shirt, slacks, and shoes[**unless environmental conditions at the site require protective clothing**].
- K. Standard-Intruder Movement: Any movement, such as walking, running, crawling, rolling, or jumping, of a "standard intruder" in a protected zone.
- L. Systems Integration: The bringing together of components of several systems containing interacting components to achieve indicated functional operation of combined systems.
- M. Zone. A defined area within a protected premise. It is a space or area for which an intrusion must be detected and uniquely identified. The sensor or group of sensors must then be assigned to perform the detection, and any interface equipment between sensors and communication must link to master control unit.

1.3 ACTION SUBMITTALS

- A. Product Data:
 - 1. For each type of product.
 - a. Include manufacturer's sample extended warranty language.
- B. Shop Drawings: Detail assemblies of standard components that are custom assembled for specific application on this Project.
 - 1. Functional Block Diagram: Show single-line interconnections between components including interconnections between components specified in this Section and those furnished under other Sections. Indicate methods used to achieve systems integration. Indicate control, signal, and data communication paths and identify **[programmable logic controllers][networks][and]** control interface devices and media to be used. Describe characteristics of network and other data communication lines.
 - a. Indicate methods used to achieve systems integration.
 - b. Indicate control, signal, and data communication paths and identify PLCs, networks, control interface devices, and media to be used.
 - c. Describe characteristics of network and other data communication lines.
 - d. Describe methods used to protect against power outages and transient voltages including types and ratings of isolation and surge suppression devices used in data, communication, signal, control, and ac and dc power circuits.
 - 2. Raceway Riser Diagrams: Detail raceway runs required for perimeter security[**and for systems integration**]. Include designation of devices connected by raceway, raceway type and size, and type and size of wire and cable fill for each raceway run.
 - 3. UPS: Sizing calculations.
 - 4. Site and Floor Plans: Indicate final outlet and device locations, routing of raceways, and cables inside and outside the building.[**Include room layout for master control-unit console, terminal cabinet, racks, and UPS.**]

5. Master Control-Unit Console Layout: Show required artwork and device identification.
 6. Device Address List: Coordinate with final system programming.
 7. System Wiring Diagrams: Include system diagrams unique to Project. Show connections for all devices, components, and auxiliary equipment. Include diagrams for equipment and for system with all terminals and interconnections identified.
 8. Details of surge protection.
 9. Sensor detection patterns and adjustment ranges.
- C. Design Data: Include method of operation and supervision of each component and each type of circuit. Show sequence of operations for manually and automatically initiated system or equipment inputs. Description must cover this specific Project; manufacturer's standard descriptions for generic systems are unacceptable.
- D. Samples for Initial Selection: For units with factory-applied color finishes.
- E. Samples for Verification: For each type of exposed finish required.
- F. Field quality-control reports.
1. Anchor inspection reports documenting inspections of built-in and cast-in anchors.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For **[Installer][security systems integrator][testing agency]**.
- B. Manufacturer's published instructions.
- C. Field Reports:
1. Manufacturer's field reports for field quality-control support.
 2. Field Test Plans: Test plan and report defining all tests required to ensure that system meets technical, operational, and performance specifications within **[60 days]<Insert number>** of date of Contract award.
 3. Evaluation Reports: Examination reports documenting inspections of substrates, areas, and conditions.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For perimeter security system to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
1. Data for each type of product, including features and operating sequences, both automatic and manual.
 2. Master control-unit hardware and software data.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. **[One]<Insert number>** spare control-unit board(s) for strain-sensitive cable system and



- [one]<Insert number> cable repair and splice kit(s).
2. [One]<Insert number> of each type of microwave sensor and one of each type of power supply for microwave perimeter security system.
3. [One]<Insert number> of each spare sensor and PIR unit and [one]<Insert number> alignment telescope(s) for long-range PIR system.
4. [One]<Insert number> spare control-unit board(s) for electrostatic-field system.
5. [One]<Insert number> spare control-unit board(s) for buried, ported coaxial cable system, **10 ft (3 m)** of cable; and [one]<Insert number> cable repair and splice kit(s).
6. Fuses: [Three]<Insert number> of each kind and size.
7. Tool Kit: Provide [six]<Insert number> sets of tools for use with security fasteners, each packaged in a compartmented kit configured for easy handling and storage.
8. Security Fasteners: Furnish no fewer than **[1 box for every 50]<Insert numbers>** boxes or fraction thereof, of each type and size of security fastener installed.

1.7 QUALIFICATIONS

- A. Security Design Professional: Design professional with active Physical Security Professional (PSP) certification issued by American Society for Industrial Security (ASIS International) and with documented experience managing installation of security systems in similar size and complexity.
- B. Security Testing and Inspecting Agency: Entity possessing active credentials from qualified electrical testing laboratory recognized by authorities having jurisdiction.
 1. On-site security testing supervisor must have [ASIS][PSP]<Insert organization> certification and documented training and experience with testing security equipment in accordance with [ASIS]<Insert organization> testing standards.
- C. Intrusion Detection Systems Installer:
 1. An employer of workers, at least one of whom is a technician certified by the National Burglar & Fire Alarm Association.
 2. Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
 3. Layout Responsibility: Preparation of Shop Drawings[**and cabling administration Drawings**],[**cabling administration Drawings, and field testing program development**] by [an RCDD][a Technician].
 4. Installation Supervision: Installation must be under the direct supervision of [Technician][**Level 2 Commercial Installer**], who must be present at all times when Work of this Section is performed at Project site.
- D. Security Systems Integrator: An experienced perimeter security equipment supplier[**and Installer**] who has completed systems integration work for installations similar in material, design, and extent to that indicated for this Project, whose work has resulted in construction with a record of successful in-service performance.

1.8 PROJECT CONDITIONS

- A. Environmental Conditions: Capable of withstanding the requirements specified in Section 018116 "Facility Environmental Requirements" and the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
 1. Altitude: Sea level to **[4000 ft (1220 m)]<Insert elevation>**.
 2. Master Control Unit: Rated for continuous operation in an ambient of **60 to 85 deg F (16 to 29**

- deg C) and a relative humidity of 20 to 80 percent, noncondensing.
3. Exterior Environment: System components installed in locations exposed to weather must be rated for continuous operation in ambients of [minus 30 to plus 122 deg F (minus 34 to plus 50 deg C)]<Insert temperature range> dry bulb and 20 to 90 percent relative humidity, condensing. Comply with UL 294 and UL 639 for outdoor-use equipment. Rate for continuous operation when exposed to rain as specified in UL 50E, winds up to [85 mph (137 km/h)][and snow cover up to 24 inch (610 mm) thick].
 4. Hazardous Environment: System components located in areas where fire or explosion hazards may exist because of flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers or flyings must be rated, listed, and installed according to NFPA 70.

1.9 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer and Installer agree to repair or replace components of perimeter security devices and equipment that fail in materials or workmanship within specified warranty period.

1. Warranty Period: [Two]<Insert number> years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. System Description: Perimeter protection system with [fence-mounted systems][buried sensors][volumetric detectors] integrated into a single perimeter detection and alarm system.
 1. Supervision: System components are to be continuously monitored for normal, alarm, [supervisory], and trouble conditions. Indicate deviations from normal conditions at any location in system. Indication includes identification of device or circuit in which deviation has occurred and whether deviation is an alarm or malfunction.
 - a. Alarm Signal: Display at master control unit and actuate audible and visual alarm devices.
 - b. Trouble Condition Signal: Distinct from other signals, indicating that system is not fully functional. Trouble signal must indicate system problems such as battery failure, open or shorted transmission line conductors, or control-unit failure.
 - c. Supervisory Condition Signal: Distinct from other signals, indicating an abnormal condition as specified for the particular device or control unit.
 2. System Control:
 - a. Master control unit must directly monitor gate detection devices, perimeter detection units, and connecting wiring.
 - b. One or more remote, addressable control units operate under control of a master control-unit microcomputer in a multiplexed distributed control system or as part of a network. Control units must receive programming by multiplexed signal transmission from the associated master control unit and hold data in nonvolatile memory. System must automatically reboot program without error or loss of status or alarm data after any system disturbance.
 3. Operator Commands:
 - a. Help with System Operation: Display all commands available to operator. Help command, followed by a specific command, must produce a short explanation of the purpose, use,

- and system reaction to that command.
 - b. Acknowledge Alarm: To indicate that alarm message has been observed by operator.
 - c. Place Protected Zone in Access: Disable all intrusion-alarm circuits of a specific protected zone. Tamper circuits may not be disabled by operator.
 - d. Place Protected Zone in Secure: Activate all intrusion-alarm circuits of a protected zone.
 - e. Protected Zone Test: Initiate operational test of a specific protected zone.
 - f. System Test: Initiate system-wide operational test.
 - g. Print reports.
 4. Timed Control at Master Control Unit: Allow automatically timed "secure" and "access" functions of selected protected zones.
 5. Automatic Control of Related Systems: Alarm or supervisory signals from certain perimeter security devices control the following functions in related systems:
 - a. Switch selected lights.
 - b. Open a signal path between certain intercommunication stations.
 - c. Shift sound system to "listening mode" and open a signal path to certain system speakers.
 - d. Switch signal to selected monitor from CCTV camera in vicinity of sensor signaling an alarm.
 - e. **<Insert description of automatic control required>.**
 6. Printed Record of Events: Print a record of alarm, supervisory, and trouble events on system printer. Sort and report by protected zone, device, and function. When master control unit receives a signal, print a report of alarm, supervisory, or trouble condition. Report type of signal (alarm, supervisory, or trouble), control-unit address, protected zone description, date, and time of occurrence. Differentiate alarm signals from other indications. When system is reset, report reset event with the same information concerning device, location, date, and time. Commands must initiate the reporting of a list of current alarm, supervisory, and trouble conditions in system or a log of past events.
 7. Response Time: **[Two]<Insert number>** seconds between actuation of any alarm and its indication at master control unit.
 8. Circuit Supervision: Supervise all signal and data transmission lines, links with other systems, control units, and sensors from master control unit. Indicate circuit and detection device faults with both protected zone and trouble signals, sound a distinctive audible tone, and illuminate an LED. Maximum permissible elapsed time between occurrence of a trouble condition and indication at master control unit is 20 seconds. Initiate an alarm in response to opening, closing, shorting, or grounding of a signal or data transmission line.
 9. Programmed Secure-Access Control: System must be programmable to automatically change status of various combinations of protected zones between secure and access conditions at scheduled times. Status changes may be preset for repetitive, daily, and weekly; specially scheduled operations may be preset up to a year in advance. Manual secure-access control stations must override programmed settings.
 10. Manual Secure-Access Control: Coded entries at manual stations must change status of associated protected zone between secure and access conditions.
- B. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- C. Seismic and Wind Performance: Installed assembly must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria."
1. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events[**and unit must be fully operational after seismic events**]."

2. Component Importance Factor (Ip): [1.0][1.5].
 3. Component Amplification Factor (ap): [1.0][2.5]<Insert value>.
 4. Component Response Modification Factor (Rp): [1.5][2.0][2.5][6.0]<Insert value>.
 5. Component Overstrength Factor (Ω_o): [1.5][2.5]<Insert value>.
- D. Compatibility: Detection devices and their communication features, connecting wiring, and master control unit must be selected and configured with accessories for full compatibility with the following equipment:
1. Door hardware specified in Section 087100 "Door Hardware."
 2. Door hardware specified in Section 087111 "Door Hardware (Descriptive Specification)."
 3. Lighting controls specified in Section 260923 "Lighting Control Devices."
 4. Lighting controls specified in Section 260943.16 "Addressable-Luminaire Lighting Controls" and Section 260943.23 "Relay-Based Lighting Controls."
 5. Intercom and program systems specified in Section 275123.20 "Commercial Intercommunications and Program Systems."
 6. Intercom and program systems specified in Section 275123.50 "Educational Intercommunications and Program Systems."
 7. Access control system specified in Section 281300 "Access Control System Software and Database Management."
 8. Intrusion detection system specified in Section 283100 "Intrusion Detection."
 9. Video surveillance system specified in Section 282000 "Video Surveillance."
 10. <Insert system or equipment> specified in Section <Insert Section number> "<Insert Section title>."
- E. Surge Protection: Protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads. Include surge protection for external wiring of each conductor entry connection to components.
1. Minimum Protection for Power Lines 120 V and More: Auxiliary panel suppressors complying with requirements in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."
 2. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Lines: Listed and labeled by a qualified testing agency for compliance with NFPA 731.
- F. Interference Protection: Components must be unaffected by radiated RFI and electrical induction of 15 V/m over a frequency range of 10 to 10 000 MHz and conducted interference signals up to 0.25 V(rms) injected into power supply lines at 10 to 10 000 MHz.
- G. Tamper Protection: Tamper switches on detection devices, control units, annunciators, pull boxes, junction boxes, cabinets, and other system components must initiate a tamper-alarm signal when unit is opened or partially disassembled and when entering conductors are cut or disconnected. Master control-unit alarm display must identify tamper alarms and indicate locations.
- H. Self-Testing Devices: Automatically test themselves periodically, but not less than once per hour, to verify normal device functioning and alarm initiation capability. Devices transmit test failure to master control unit.
- I. Antimasking Devices: Automatically check operation continuously or at intervals of a minute or less, and use signal-processing logic to detect blocking, masking, jamming, tampering, or other operational dysfunction. Devices transmit detection of operational dysfunction to master control unit as an alarm signal.
- J. Addressable Devices: Transmitter and receivers must communicate unique device identification and status reports to master control unit.
- K. Remote-Controlled Devices: Individually and remotely adjustable for sensitivity and individually

monitored at master control unit for calibration, sensitivity, and alarm condition.

L. Enclosures:

1. Interior Electronics: UL 50E, Type 12.
2. Exterior Electronics: UL 50E, Type 4X, **[fiberglass][stainless steel]**.
3. Corrosion Resistant: UL 50E, Type 4X, **[PVC][stainless steel]**.
4. Terminal cabinets in handholes and manholes must be UL 50E, **[Type 6][Type 6P]**.
5. Screw Covers: Where enclosures are readily accessible, secure with security fasteners of type appropriate for enclosure.

M. Protective Coatings for Heat-Treated Alloy Steel:

1. Zinc chromate, ASTM F1135, Grade 3 or Grade 4, for exterior applications and interior applications where indicated.
2. Zinc phosphate with oil, ASTM F1137, Grade I, or black oxide unless otherwise indicated.

2.2 SENSING DEVICES

A. Strain-Sensitive Cable :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[BEI Communications, Inc]**
 - b. **[Integrated Security Corporation]**
 - c. **[Magal-Senstar, Inc.]**
 - d. **[Safeguards Technology]**
 - e. **[Southwest Microwave, Inc]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[BEI Communications, Inc]**
 - b. **[Integrated Security Corporation]**
 - c. **[Magal-Senstar, Inc.]**
 - d. **[Safeguards Technology]**
 - e. **[Southwest Microwave, Inc]**
 - f. **<Insert manufacturer's name>**
3. Listing Criteria:
 - a. Listed and labeled by a qualified electrical testing agency for compliance with UL 639.
 - b. Listed and labeled by a qualified electrical testing agency for compliance with SIA CP-01.
 - c. FM Global Compliance: FM Approved and labeled perimeter security devices and equipment.
4. Standard Features:
 - a. Fence-mounted strain-sensitive, coaxial transducer cable must monitor chain-link-type and

welded-mesh-type fence and generate an alarm when a standard intruder attempts to climb over, cut through, or lift fence fabric.

b. Environment: Suitable for exterior installation and the following conditions:

- 1) Ambient Temperatures: Ranging from [minus 22 to plus 158 deg F (minus 30 to plus 70 deg C)]<Insert temperature range>.
- 2) <Insert applicable environmental conditions>.

c. Transducer Cable:

- 1) UV-resistant cable furnished by system manufacturer.
- 2) Suitable for up to **1000 ft (300 m)** of sensor cable per single-zone control unit and up to **2000 ft (600 m)** of sensor cable per dual-zone processor.
- 3) Sensitivity must be uniform throughout its entire length, requiring only one variable sensitivity adjustment throughout its entire length.

d. Control Unit:

- 1) Field mounted, with tamper switch at control-unit board.
- 2) Electronic circuitry must discriminate between acceptable fence movement and intrusion-related disturbances.
- 3) Sensitivity, count control, and climb-over processors must be adjustable with a minimum of five individual count-control and climb-over adjustments.
- 4) Control-unit output must have adjustable pulse width to adjust the time the alarm relay will activate per detected intrusion attempt.

e. System Performance:

- 1) Immune to RFI and EMI environments; interference must have no effect on normal operational characteristics.
- 2) Trouble and Tamper: Entire sensor system must be fully supervised with individually monitored tamper and supervision alarms. Disconnecting, cutting, or shorting of strain-sensitive cable results in supervisory alarm.
- 3) Intrusion Simulation: Each zone must have a self-test feature that, when activated by a signal from master control unit will produce an intrusion alarm and verify operation of sensor.

B. Microwave Intrusion Detectors :

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

- a. [Bosch Security Systems, Inc.]
- b. [Crow Electronic Engineering, Inc]
- c. [Honeywell International Inc.]
- d. [Integrated Security Corporation]
- e. [Magal-Senstar, Inc.]
- f. [Optex Inc.]
- g. [Southwest Microwave, Inc]
- h. <Insert manufacturer's name>

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

- a. [Bosch Security Systems, Inc.]
- b. [Crow Electronic Engineering, Inc]
- c. [Honeywell International Inc.]
- d. [Integrated Security Corporation]
- e. [Magal-Senstar, Inc.]
- f. [Optex Inc.]
- g. [Southwest Microwave, Inc]
- h. <Insert manufacturer's name>

3. Listing Criteria:

- a. Listed and labeled by a qualified electrical testing agency for compliance with UL 639.
- b. Listed and labeled by a qualified electrical testing agency for compliance with SIA CP-01.
- c. FM Global Compliance: FM Approved and labeled perimeter security devices and equipment.

4. Standard Features:

- a. Volumetric microwave detection system.
- b. Microwave transmitter establishes an electromagnetic field in an adjustable detection pattern and detects intrusion by monitoring changes in that pattern.
- c. Movement Sensitivity: Adjustable, able to detect standard-intruder movement within sensor's detection pattern at any speed between **0.1 to 50 ft/s (0.03 to 15.2 m/s)**. Sensor sensitivity adjustments are accessible only when sensor housing is removed, and sensors must comply with 47 CFR 15.
- d. Detection Range: **15 to 600 ft (5 to 180 m)**.
- e. Range Sensitivity: Adjustable for setting area of protection between **15 to 500 ft (5 to 152 m)** in range and from **2 to 40 ft (0.6 to 12 m)** in beam diameter.
- f. Trouble and Tamper: Fully supervised with individually monitored tamper and supervision alarms. System failure must result in tamper alarm. System jamming or wrong modulation must result in supervisory alarm.
- g. Activation Indicator: LED indicator is not to be visible during normal operation. Indicator must light when sensor detects a standard intruder. Locate test-enabling switch under sensor housing cover.
- h. Remote Test: When initiated by master control unit, start a test sequence for each detector element that simulates standard-intruder movement within sensor's detection patterns, causing an alarm.
- i. Environment: Suitable for exterior installation and the following conditions:
 - 1) Ambient Temperatures: Ranging from [minus 30 to plus 158 deg F (minus 34 to plus 70 deg C)]<Insert temperature range> and in rainfall up to 4 inch (100 mm).
 - 2) <Insert applicable environmental conditions>.

C. Electrostatic Field :

- 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [BEI Communications, Inc]
 - b. [Integrated Security Corporation]
 - c. [Magal-Senstar, Inc.]
 - d. [Safeguards Technology]
 - e. [Southwest Microwave, Inc]

- f. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [BEI Communications, Inc]
 - b. [Integrated Security Corporation]
 - c. [Magal-Senstar, Inc.]
 - d. [Safeguards Technology]
 - e. [Southwest Microwave, Inc]
 - f. <Insert manufacturer's name>
- 3. Listing Criteria:
 - a. Listed and labeled by a qualified electrical testing agency for compliance with UL 639.
 - b. Listed and labeled by a qualified electrical testing agency for compliance with SIA CP-01.
 - c. FM Global Compliance: FM Approved and labeled perimeter security devices and equipment.
- 4. Standard Features:
 - a. Fence-mounted[, **independently mounted**], above-ground, electrostatic-field detection system, consisting of electronically balanced phase electrostatic-field detection system with a field generator that generates an electrical field in one or more field wires and that has two or more sensing wires, a sense filter, amplifier, and a control unit.
 - b. Detection fields must have a minimum of four different frequencies so adjacent zones cannot interfere with each other.
 - c. Environment: Suitable for exterior installation and the following conditions:
 - 1) Ambient Temperatures: Ranging from [minus 22 to plus 158 deg F (minus 30 to plus 70 deg C)]<Insert temperature range>.
 - 2) <Insert applicable environmental conditions>.
 - d. System Performance:
 - 1) Detect, via sense wires, a compound signal form consisting of amplitude change, rate of change, and preset time disturbance that forms a "signature" of human movement. Generate an alarm when all exist simultaneously. Provide detection fields of no fewer than four different frequencies so adjacent zones do not interfere with each other.
 - 2) Control Units: Single or multiple zone, with sense filter. Front panel with calibration meter, status of alarm transmitter, sensitivity selector, test point selector, power indicator, and power control. Control unit must reject signals due to wind and small objects striking the wires.
 - 3) Motion Detection: Sense standard-intruder movement at rates from **0.15 to 26 ft/s (0.045 to 8.0 m/s)**.
 - 4) Zone Length: Not to exceed [**500 ft (152 m)**][**325 ft (100 m)**].
 - 5) Supervision: Generate trouble signal if field or sense wires are cut or shorted to ground or to each other. Generate supervisory alarm if received signal is substantially reduced.
 - e. Insulators, Wire-Tensioning Devices, and Brackets: Manufacturer's standard for mounting and tensioning of wires.
 - f. Field and Sensing Wires: Stainless steel.

D. Buried, Ported Coaxial Cable :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Magal-Senstar, Inc.]**
 - b. **[Safeguards Technology]**
 - c. **[Southwest Microwave, Inc]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Magal-Senstar, Inc.]**
 - b. **[Safeguards Technology]**
 - c. **[Southwest Microwave, Inc]**
 - d. **<Insert manufacturer's name>**
3. Listing Criteria:
 - a. Listed and labeled by a qualified electrical testing agency for compliance with UL 639.
 - b. Listed and labeled by a qualified electrical testing agency for compliance with SIA CP-01.
 - c. FM Global Compliance: FM Approved and labeled perimeter security devices and equipment.
4. Standard Features:
 - a. Buried electrostatic-field detection system consisting of parallel, ported coaxial cables that generate a detection field between cables.
 - b. Environment: Suitable for exterior installation and the following conditions:
 - 1) Ambient Temperatures: Ranging from **[minus 22 to plus 158 deg F (minus 30 to plus 70 deg C)]<Insert temperature range>**.
 - 2) **<Insert applicable environmental conditions>**.
 - c. System Performance: One of two parallel cables receives a continuous wave signal from a transmitter module. Second cable, connected to a sensor module, detects, preamplifies, and analyzes variations in signal. When system senses "signature" of a standard intruder in the detection zone, based on mass, motion, and time of day, it generates an alarm.
 - 1) Transmitter: Locate at one end of zone, with standby battery.
 - 2) Preamplifier-Sensor: Locate at opposite end from transmitter, with standby battery.
 - 3) Front panel with sensitivity calibration meter, calibrated self-test potentiometer, power switch, and LED normal and malfunction indicators.
 - 4) Electromagnetic Radiation: Less than 50 mV per meter at 30 m.
 - 5) Motion Detection: Sense standard-intruder movement at rates from **0.17 to 26 ft/s (0.05 to 8.0 m/s)**.
 - 6) Zone Length: Not to exceed **[500 ft (152 m)][325 ft (100 m)]**.
 - 7) Zone Width: Not to exceed **15 ft (4.6 m)**, with an average width of **12 ft (3.7 m)**.
 - 8) Zone Height: Approximately **3.3 ft (1.0 m)**, depending on sensitivity setting.
 - 9) Supervision: Generate trouble signal if cable is cut or shorted to ground. Generate supervisory alarm if cabinets are tampered with.

- d. Enclosures: Hinged cover with tamper switch and security fasteners.
- e. Buried, Ported Coaxial Cable: Approximately 1/2 inch (1.3 mm) diameter, minimum 10 AWG center conductor, foam polyethylene dielectric, braided copper outer conductor, and polyethylene jacket.

E. Long-Range PIR Detectors :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Aleph America Corporation]**
 - b. **[Bosch Security Systems, Inc.]**
 - c. **[Crow Electronic Engineering, Inc]**
 - d. **[Digital Security Controls Ltd.]**
 - e. **[Honeywell International Inc.]**
 - f. **[Integrated Security Corporation]**
 - g. **[Optex Inc.]**
 - h. **[Safeguards Technology]**
 - i. **[Southwest Microwave, Inc]**
 - j. **[Visonic Inc]**
 - k. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Aleph America Corporation]**
 - b. **[Bosch Security Systems, Inc.]**
 - c. **[Crow Electronic Engineering, Inc]**
 - d. **[Digital Security Controls Ltd.]**
 - e. **[Honeywell International Inc.]**
 - f. **[Integrated Security Corporation]**
 - g. **[Optex Inc.]**
 - h. **[Safeguards Technology]**
 - i. **[Southwest Microwave, Inc]**
 - j. **[Visonic Inc]**
 - k. **<Insert manufacturer's name>**
3. Listing Criteria:
 - a. Listed and labeled by a qualified electrical testing agency for compliance with UL 639.
 - b. Listed and labeled by a qualified electrical testing agency for compliance with SIA CP-01.
 - c. Listed and labeled by a qualified electrical testing agency for compliance with SIA PIR-01.
 - d. FM Global Compliance: FM Approved and labeled perimeter security devices and equipment.
4. Standard Features:
 - a. Volumetric passive infrared detection system.
 - b. Environment: Suitable for exterior installation and the following conditions:
 - 1) Ambient Temperatures: Ranging from **[minus 30 to plus 150 deg F (minus 34 to plus 65 deg C)]<Insert temperature range>**.
 - 2) **<Insert applicable environmental conditions>**.

- c. System Performance: Detect an interruption of dual-infrared light beams that link transmitters and receivers. Generate an alarm when signal is interrupted due to presence of an object that interrupts both beams.
 - 1) Sensitivity: Field adjustable to allow adjustment of range from **25 to 500 ft (7.6 to 152 m)**, generating an alarm within 20 to 50 ms when both beams are interrupted.
 - 2) Detection system must adjust automatically to compensate for weather, including fog, rain, snow, blowing dust, and rapid temperature changes.
 - 3) Motion Detection: Detect standard-intruder movement at rates from **0.1 to 50 ft/s (0.03 to 15.2 m/s)**.
 - 4) Supervision: Generate supervisory alarm if any portion of system is tampered with.
 - 5) Remote Test: When initiated by master control unit, start a test sequence for each detector element that simulates standard-intruder movement within sensor's detection patterns, causing an alarm.

F. Geophone Fence Detection :

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[BEI Communications, Inc]**
 - b. **[Honeywell International Inc.]**
 - c. **[Magal-Senstar, Inc.]**
 - d. **[Safeguards Technology]**
 - e. **[Southwest Microwave, Inc]**
 - f. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[BEI Communications, Inc]**
 - b. **[Honeywell International Inc.]**
 - c. **[Magal-Senstar, Inc.]**
 - d. **[Safeguards Technology]**
 - e. **[Southwest Microwave, Inc]**
 - f. **<Insert manufacturer's name>**
- 3. Listing Criteria:
 - a. Listed and labeled by a qualified electrical testing agency for compliance with UL 639.
 - b. Listed and labeled by a qualified electrical testing agency for compliance with SIA CP-01.
 - c. FM Global Compliance: FM Approved and labeled perimeter security devices and equipment.
- 4. Standard Features:
 - a. Fence-mounted system to detect attempts to cut or climb the protected fence, using geophone sensors that respond to specific shock or vibrations.
 - b. Environment: Suitable for exterior installation and the following conditions:
 - 1) Ambient Temperatures: Ranging from **[minus 30 to plus 150 deg F (minus 34 to**

- plus 65 deg C)]<Insert temperature range>.
2) <Insert applicable environmental conditions>.

c. System Performance:

- 1) Control Unit: [10]<Insert number> zone capacity for processing geophone generated analog signals. Each zone must consist of not more than [10]<Insert number> sensors.
- a) Adjustments: For each zone, provide stepped gain control for sensitivity and switches for geophone signal filters to minimize nuisance alarms. System must adjust automatically to compensate for weather, including fog, rain, snow, blowing dust, and rapid temperature changes.
- b) Trouble Condition Signal: Generate when any zone fails.
- c) Supervisory Condition Signal: Generate on interference with control-unit operation or when detecting a break-in into an enclosure housing electronics.
- d. Sensors: Fence mounted [20 ft (6 m)]<Insert dimension> o.c.
- e. Cable for Interconnection of System Components: Shielded, PVC jacketed and armored, as supplied by system manufacturer.
- f. Test each zone simulating an alarm condition. Test by [command from master control][test switch at control unit inside the enclosure].

G. Video Motion Sensor :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
- a. [Bosch Security Systems, Inc.]
- b. [Honeywell International Inc.]
- c. [Magal-Senstar, Inc.]
- d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Bosch Security Systems, Inc.]
- b. [Honeywell International Inc.]
- c. [Magal-Senstar, Inc.]
- d. <Insert manufacturer's name>
3. Listing Criteria:
- a. Listed and labeled by a qualified electrical testing agency for compliance with UL 639.
- b. Listed and labeled by a qualified electrical testing agency for compliance with SIA CP-01.
- c. FM Global Compliance: FM Approved and labeled perimeter security devices and equipment.
4. Standard Features:
- a. Video-surveillance-based detection system.
- b. Detect changes in video signal within a user-defined protected zone. Provide an alarm output for each video input.

- 1) Detect movement within protected zone of standard intruders wearing clothing with a reflectivity that differs from that of background scene by a factor of 2. Reject all other changes in video signal.
- 2) Modular design that allows for expansion or modification of number of inputs.
- 3) Adjustable Controls:
 - a) Number of detection zones.
 - b) Size of detection zones.
 - c) Sensitivity of detection of each protected zone.
- c. Mounting: Standard **19 inch (480 mm)** rack as described in EIA/ECA 310-E.
- d. Environment: Suitable for installation in interior air-conditioned spaces. **<Insert applicable environmental conditions>**.

H. Gate Units :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Aleph America Corporation]**
 - b. **[Honeywell Commercial Security; Honeywell International, Inc.]**
 - c. **[Honeywell International Inc.]**
 - d. **[Safeguards Technology]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Aleph America Corporation]**
 - b. **[Honeywell Commercial Security; Honeywell International, Inc.]**
 - c. **[Honeywell International Inc.]**
 - d. **[Safeguards Technology]**
 - e. **<Insert manufacturer's name>**
3. Listing Criteria:
 - a. Listed and labeled by a qualified electrical testing agency for compliance with UL 639.
 - b. Listed and labeled by a qualified electrical testing agency for compliance with SIA CP-01.
 - c. FM Global Compliance: FM Approved and labeled perimeter security devices and equipment.
4. Standard Features:
 - a. Fence-mounted gate-movement detectors, balanced-magnetic type, and UL listed for outdoor locations. Units must be designed for mounting on single- or double-leaf swinging or rolling gates and have armored jumper cables between switch and stationary junction box for wiring to master control unit and tamper switches in junction box.
 - b. Bias magnet and at least three encapsulated-reed switches that resist compromise from introduction of foreign magnetic fields, with integral overcurrent protective device to limit current to 80 percent of switch capacity.
 - c. Remote Test: Simulate movement of actuating magnet from master control unit.

2.3 CONTROL DEVICES

A. Intrusion Detection Keypad and Display Module :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Bosch Security Systems, Inc.]**
 - b. **[Corby Industries, Inc.]**
 - c. **[Crow Electronic Engineering, Inc]**
 - d. **[DAQ Electronics, Inc]**
 - e. **[Digital Security Controls Ltd.]**
 - f. **[Edwards; Carrier Global Corporation]**
 - g. **[Honeywell International Inc.]**
 - h. **[Visonic Inc]**
 - i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Bosch Security Systems, Inc.]**
 - b. **[Corby Industries, Inc.]**
 - c. **[Crow Electronic Engineering, Inc]**
 - d. **[DAQ Electronics, Inc]**
 - e. **[Digital Security Controls Ltd.]**
 - f. **[Edwards; Carrier Global Corporation]**
 - g. **[Honeywell International Inc.]**
 - h. **[Visonic Inc]**
 - i. **<Insert manufacturer's name>**
3. Listing Criteria:
 - a. Listed and labeled by a qualified electrical testing agency for compliance with UL 639.
 - b. Listed and labeled by a qualified electrical testing agency for compliance with SIA CP-01.
 - c. FM Global Compliance: FM Approved and labeled perimeter security devices and equipment.
4. Standard Features: Arranged for entering and executing commands for system-status changes and for displaying system-status and command-related data.

B. Intrusion Detection Key-Operated Switch :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Bosch Security Systems, Inc.]**
 - b. **[Corby Industries, Inc.]**
 - c. **[Crow Electronic Engineering, Inc]**
 - d. **[DAQ Electronics, Inc]**
 - e. **[Digital Security Controls Ltd.]**
 - f. **[Edwards; Carrier Global Corporation]**

- g. [Honeywell International Inc.]
- h. [Visonic Inc]
- i. <Insert manufacturer's name>

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

- a. [Bosch Security Systems, Inc.]
- b. [Corby Industries, Inc.]
- c. [Crow Electronic Engineering, Inc]
- d. [DAQ Electronics, Inc]
- e. [Digital Security Controls Ltd.]
- f. [Edwards; Carrier Global Corporation]
- g. [Honeywell International Inc.]
- h. [Visonic Inc]
- i. <Insert manufacturer's name>

3. Listing Criteria:

- a. Listed and labeled by a qualified electrical testing agency for compliance with UL 639.
- b. Listed and labeled by a qualified electrical testing agency for compliance with SIA CP-01.
- c. FM Global Compliance: FM Approved and labeled perimeter security devices and equipment.

4. Standard Features: Changes protected zone between secure and access conditions.

C. Field-Mounted Control Unit :

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

- a. <Insert, in separate subparagraphs, manufacturer's name>.

2. Listing Criteria:

- a. Listed and labeled by a qualified electrical testing agency for compliance with UL 639.
- b. Listed and labeled by a qualified electrical testing agency for compliance with SIA CP-01.
- c. FM Global Compliance: FM Approved and labeled perimeter security devices and equipment.

3. Standard Features:

- a. Field-mounted control units must include the power supply and detector specific functions, and provide for communications with the master control unit. Control unit must include read-only resident software needed for startup, a time clock, and all automatic operations. Software must be downloaded from the master control unit.
- b. Battery Backup: UPS, providing [six]<Insert number> hours of run time during a power outage, with two-rate automatic battery charger to fully recharge batteries within [12]<Insert number> hours after normal power is restored.

- 1) Batteries: Rechargeable, valve-regulated, recombinant, sealed, lead-acid type with nominal 10-year life expectancy.

- 2) Battery Charger: Solid-state, fully automatic, variable-charging-rate type. Charger must recharge fully discharged battery within 24 hours.
 - c. Annunciation: Indicate a change in system condition and switching of system or component to backup power.
- D. Master Control Unit :
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Bosch Security Systems, Inc.]**
 - b. **[DAQ Electronics, Inc]**
 - c. **[Digital Security Controls Ltd.]**
 - d. **[Honeywell Commercial Security; Honeywell International, Inc.]**
 - e. **[Honeywell International Inc.]**
 - f. **[Interlogix; Carrier Global Corporation]**
 - g. **[Magal-Senstar, Inc.]**
 - h. **[Safeguards Technology]**
 - i. **[Southwest Microwave, Inc]**
 - j. **[Visonic Inc]**
 - k. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Bosch Security Systems, Inc.]**
 - b. **[DAQ Electronics, Inc]**
 - c. **[Digital Security Controls Ltd.]**
 - d. **[Honeywell Commercial Security; Honeywell International, Inc.]**
 - e. **[Honeywell International Inc.]**
 - f. **[Interlogix; Carrier Global Corporation]**
 - g. **[Magal-Senstar, Inc.]**
 - h. **[Safeguards Technology]**
 - i. **[Southwest Microwave, Inc]**
 - j. **[Visonic Inc]**
 - k. **<Insert manufacturer's name>**
 - 3. Listing Criteria:
 - a. Listed and labeled by a qualified electrical testing agency for compliance with UL 639.
 - b. Comply with **[UL 609][UL 681][UL 1076]**.
 - c. Listed and labeled by a qualified electrical testing agency for compliance with SIA CP-01.
 - d. FM Global Compliance: FM Approved and labeled perimeter security devices and equipment.
 - 4. Standard Features:
 - a. Supervises sensors and detection subsystems and their connecting communication links, status control (secure or access) of sensors and detector subsystems, activation of alarms and supervisory and trouble signals, and other indicated functions.
 - 1) System software and programs must be held in flash electrically erasable

- programmable read-only memory (EEPROM), retaining the information through failure of primary and secondary power supplies.
 - 2) Include a real-time clock for time annotation of events on the event recorder and printer.
 - 3) Addressable initiation devices that communicate device identity and status.
 - 4) Control circuits for operation of mechanical equipment in response to an alarm.
- b. Construction: **[Freestanding equipment rack][Desk-mounted console]**, modular, with separate and independent alarm and supervisory system modules. **[Alarm-initiating protected zone boards must be plug-in cards.]** Arrangements that require removal of field wiring for module replacement are unacceptable.
- c. Console Controls and Displays: Arranged for interface between human operator at master control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.
- d. Annunciator and Display: LCD type, **[one][two][three]** line(s) of **[40][80]** characters, minimum.
- e. Keypad: Arranged to permit entry and execution of programming, display, and control commands
- f. Control-Unit Network: Automatic communication of alarm, status changes, commands, and other communications required for system operation. Communication must return to normal after partial or total network interruption such as power loss or transient event. Total or partial signaling network failures must identify the failure and record the failure at the annunciator display and at the system printer.
- g. Field Device Network: Communicate between the control unit and field devices of the system. Communications must consist of alarm, network status, and status and control of field-mounted processors. Each field-mounted device must be interrogated during each interrogation cycle.
- h. Operator Controls: Manual switches and push-to-test buttons that do not require a key to operate. Prevent resetting of alarm, supervisory, or trouble signals while alarm or trouble condition persists. Include the following:
 - 1) Acknowledge alarm.
 - 2) Silence alarm.
 - 3) System reset.
 - 4) LED test.
 - 5) **<Insert operator functions>.**
- i. Timing Unit: Solid state, programmable, 365 days.
- j. Confirmation: Relays, contactors, and other control devices must have auxiliary contacts that provide confirmation signals to system for their on or off status. Software must interpret such signals, display equipment status, and initiate failure signals.
- k. Alarm Indication:
 - 1) An audible signal sounds and an LED lights at master control unit identifying the **[protected zone][addressable detector]** originating the alarm. **[Annunciator panel displays a common alarm light and sounds an audible tone.]**
 - 2) An audible signal sounds and a plain-language identification of the **[protected zone][addressable detector]** originating the alarm appears on **[LED][or][LCD]** display at master control unit. **[Annunciator panel displays a common alarm light and sounds an audible tone.]**
 - 3) An audible signal sounds and a plain-language identification of the **[protected zone][addressable detector]** originating the alarm appears on **[LED][LCD][or][cathode-ray-tube]** display at master control unit. **[Annunciator panel alarm light and audible tone identify protected zone signaling an alarm.]**

4) Alarm activation sounds a [bell][siren][strobe][bell or siren and strobe].

- l. Protected Zones: Quantity of alarm and supervisory zones as indicated, with capacity for expanding number of protected zones by a minimum of [25]<Insert number> percent.
- m. Power Supply Circuits: Master control units must provide power for remote power-consuming detection devices. Circuit capacity must be adequate for at least a [25]<Insert number> percent increase in load.
- n. UPS: Comply with Section 263353 "Static Uninterruptible Power Supply." UPS must be sized to provide a minimum of six hours of master control-unit operation.
- o. Cabinet: Lockable, steel enclosure arranged so operations required for testing, normal operation, and maintenance are performed from front of enclosure. If more than a single cabinet is required to form a complete control unit, provide exactly matching modular enclosures. Accommodate all components and allow ample gutter space for field wiring. Identify each enclosure by an engraved, laminated, phenolic-resin nameplate. Lettering on enclosure nameplate is not to be less than 1 inch (25 mm) high. Identify, with permanent labels, individual components and modules within cabinets.
- p. Transmission to Monitoring Station: A communications device to automatically transmit alarm, supervisory, and trouble signals to the monitoring station, operating over a standard voice grade telephone leased line. Comply with UL 1635.
- q. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble) and date and time of occurrence. Differentiate alarm signals from all other printed indications. Also print system reset event, including same information for device, location, date, and time. Commands initiate the printing of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.

2.4 NOTIFICATION DEVICES

A. Intrusion Detection Alarm Bell :

- 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Alarm Controls; Hanchett Entry Systems, Inc.; ASSA ABLOY Group]
 - b. [Cooper Wheelock; brand of Eaton]
 - c. [Edwards; Carrier Global Corporation]
 - d. [Honeywell International Inc.]
 - e. [Potter Electric Signal Company, LLC]
 - f. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Alarm Controls; Hanchett Entry Systems, Inc.; ASSA ABLOY Group]
 - b. [Cooper Wheelock; brand of Eaton]
 - c. [Edwards; Carrier Global Corporation]
 - d. [Honeywell International Inc.]
 - e. [Potter Electric Signal Company, LLC]
 - f. <Insert manufacturer's name>
- 3. Listing Criteria:



- a. Listed and labeled by a qualified electrical testing agency for compliance with UL 639.
- b. Listed and labeled by a qualified electrical testing agency for compliance with SIA CP-01.
- c. FM Global Compliance: FM Approved and labeled perimeter security devices and equipment.

4. Standard Features:

- a. **10 inch (254 mm)** in diameter, rated to produce a minimum sound output of 84 dB at **10 ft (3 m)** from master control unit.
- b. Enclosure: Weather-resistant steel box equipped with tamper switches on cover and on back of box.

B. Intrusion Detection Alarm Klaxon :

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

- a. **[Alarm Controls; Hanchett Entry Systems, Inc.; ASSA ABLOY Group]**
- b. **[Cooper Wheelock; brand of Eaton]**
- c. **[Edwards; Carrier Global Corporation]**
- d. **[Honeywell International Inc.]**
- e. **[Potter Electric Signal Company, LLC]**
- f. **<Insert manufacturer's name>**

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

- a. **[Alarm Controls; Hanchett Entry Systems, Inc.; ASSA ABLOY Group]**
- b. **[Cooper Wheelock; brand of Eaton]**
- c. **[Edwards; Carrier Global Corporation]**
- d. **[Honeywell International Inc.]**
- e. **[Potter Electric Signal Company, LLC]**
- f. **<Insert manufacturer's name>**

3. Listing Criteria:

- a. Listed and labeled by a qualified electrical testing agency for compliance with UL 639.
- b. Listed and labeled by a qualified electrical testing agency for compliance with SIA CP-01.
- c. FM Global Compliance: FM Approved and labeled perimeter security devices and equipment.

4. Standard Features:

- a. Weatherproof motor-driven hooter.
- b. Rated to produce minimum sound output of 120 dB at **3 ft (1 m)**, plus or minus 3 dB, at frequency of 470 Hz.
- c. Rated for intermittent use; two minutes on and five minutes off.
- d. Designed for use in industrial areas and in high-noise, severe-weather marine environments.

C. Intrusion Detection Alarm Siren :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Alarm Controls; Hanchett Entry Systems, Inc.; ASSA ABLOY Group]**
 - b. **[Cooper Wheelock; brand of Eaton]**
 - c. **[Edwards; Carrier Global Corporation]**
 - d. **[Honeywell International Inc.]**
 - e. **[Potter Electric Signal Company, LLC]**
 - f. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Alarm Controls; Hanchett Entry Systems, Inc.; ASSA ABLOY Group]**
 - b. **[Cooper Wheelock; brand of Eaton]**
 - c. **[Edwards; Carrier Global Corporation]**
 - d. **[Honeywell International Inc.]**
 - e. **[Potter Electric Signal Company, LLC]**
 - f. **<Insert manufacturer's name>**
 3. Listing Criteria:
 - a. Listed and labeled by a qualified electrical testing agency for compliance with UL 639.
 - b. Listed and labeled by a qualified electrical testing agency for compliance with SIA CP-01.
 - c. FM Global Compliance: FM Approved and labeled perimeter security devices and equipment.
 4. Standard Features:
 - a. 30 W speaker with siren driver, rated to produce a minimum sound output of 103 dB at **10 ft (3 m)** from master control unit.
 - b. Enclosure: Weather-resistant steel box with tamper switches on cover and on back of box.
- D. Intrusion Detection Alarm Strobe :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Alarm Controls; Hanchett Entry Systems, Inc.; ASSA ABLOY Group]**
 - b. **[Cooper Wheelock; brand of Eaton]**
 - c. **[Edwards; Carrier Global Corporation]**
 - d. **[Honeywell International Inc.]**
 - e. **[Potter Electric Signal Company, LLC]**
 - f. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Alarm Controls; Hanchett Entry Systems, Inc.; ASSA ABLOY Group]**
 - b. **[Cooper Wheelock; brand of Eaton]**



- c. **[Edwards; Carrier Global Corporation]**
- d. **[Honeywell International Inc.]**
- e. **[Potter Electric Signal Company, LLC]**
- f. **<Insert manufacturer's name>**

3. Listing Criteria:

- a. Listed and labeled by a qualified electrical testing agency for compliance with UL 639.
- b. UL 1638.
- c. Listed and labeled by a qualified electrical testing agency for compliance with SIA CP-01.
- d. FM Global Compliance: FM Approved and labeled perimeter security devices and equipment.

4. Standard Features:

- a. Xenon light with clear polycarbonate lens.
- b. Light Output: 115 cd, minimum.
- c. Flash Rate: 60 per minute.

2.5 SECURITY FASTENERS

A. Socket Flat Countersunk Head Fastener :

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Acument Global Technologies, Inc.; Acument Intellectual Properties, LLC]**
 - b. **[Safety Socket LLC]**
 - c. **[Tamper-Pruf Screws]**
 - d. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Acument Global Technologies, Inc.; Acument Intellectual Properties, LLC]**
 - b. **[Safety Socket LLC]**
 - c. **[Tamper-Pruf Screws]**
 - d. **<Insert manufacturer's name>**
- 3. Standard Features:
 - a. Operable only by tools produced for use on specific type of fastener by fastener manufacturer or other licensed fabricator. Drive system type, head style, material, and protective coating as required for assembly, installation, and strength.
 - b. Drive System Types: **[Pinned Torx-Plus][pinned Torx][or][pinned hex (Allen)]**.
 - c. Heat-treated alloy steel, **ASTM F835 (ASTM F835M)**.
 - d. Stainless steel, **ASTM F879 (ASTM F879M)**, Group 1 CW.

B. Socket Button Head Fastener :

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

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

- a. [Acument Global Technologies, Inc.; Acument Intellectual Properties, LLC]
 - b. [Safety Socket LLC]
 - c. [Tamper-Pruf Screws]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Acument Global Technologies, Inc.; Acument Intellectual Properties, LLC]
 - b. [Safety Socket LLC]
 - c. [Tamper-Pruf Screws]
 - d. <Insert manufacturer's name>
3. Standard Features:
- a. Operable only by tools produced for use on specific type of fastener by fastener manufacturer or other licensed fabricator. Drive system type, head style, material, and protective coating as required for assembly, installation, and strength.
 - b. Drive System Types: [Pinned Torx-Plus][pinned Torx][or][pinned hex (Allen)].
 - c. Heat-treated alloy steel, **ASTM F835 (ASTM F835M)**.
 - d. Stainless steel, **ASTM F879 (ASTM F879M)**, Group 1 CW.

C. Socket Head Cap Fastener :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Acument Global Technologies, Inc.; Acument Intellectual Properties, LLC]
 - b. [Safety Socket LLC]
 - c. [Tamper-Pruf Screws]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Acument Global Technologies, Inc.; Acument Intellectual Properties, LLC]
 - b. [Safety Socket LLC]
 - c. [Tamper-Pruf Screws]
 - d. <Insert manufacturer's name>
3. Standard Features:
- a. Operable only by tools produced for use on specific type of fastener by fastener manufacturer or other licensed fabricator. Drive system type, head style, material, and protective coating as required for assembly, installation, and strength.
 - b. Drive System Types: [Pinned Torx-Plus][pinned Torx][or][pinned hex (Allen)].
 - c. Heat-treated alloy steel, **ASTM A574 (ASTM A574M)**.
 - d. Stainless steel, **ASTM F837 (ASTM F837M)**, Group 1 CW.



2.6 SOURCE QUALITY CONTROL

- A. Electrostatic-Field and Buried, Ported Coaxial Cable Systems Electronics: Precondition at factory by subjecting modules to at least four days' operational burn-in at temperatures not less than **140 deg F (60 deg C)**.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of perimeter security.
- B. Examine roughing-in for embedded and built-in anchors to verify actual locations of perimeter security connections before perimeter security installation.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of perimeter security.
- D. Inspect built-in and cast-in anchor installations, before installing perimeter security, to verify that anchor installations comply with requirements. Prepare inspection reports.
 - 1. Remove and replace anchors where inspections indicate that they do not comply with requirements. Reinspect after repairs or replacements are made.
 - 2. Perform additional inspections to determine compliance of replaced or additional anchor installations. Prepare inspection reports.
- E. For material whose orientation is critical for its performance as a ballistic barrier, verify installation orientation.
- F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 SYSTEMS INTEGRATION

- A. Integrate perimeter security system with the following systems and equipment:
 - 1. Electronic door hardware.
 - 2. Elevators.
 - 3. Network lighting controls.
 - 4. Intercommunications and program systems.
 - 5. Public address and mass notification systems.
 - 6. Access control.
 - 7. Fire-alarm system.
 - 8. Intrusion detection system.
 - 9. Video surveillance.
 - 10. **<Insert applicable systems and equipment>**.

3.3 INSTALLATION OF AREA AND PERIMETER INTRUSION DETECTION

- A. Comply with UL 681 and NFPA 731.

- B. Equipment Mounting: Install master control unit on finished floor with tops of cabinets not more than **72 inch (1830 mm)** above the finished floor.
 - 1. Comply with requirements for seismic-restraint devices specified in Section 260548 "Vibration and Seismic Controls for Electrical Systems."
- C. Install wall-mounted equipment, with tops of cabinets not more than **72 inch (1830 mm)** above the finished floor.
 - 1. Comply with requirements for seismic-restraint devices specified in Section 260548 "Vibration and Seismic Controls for Electrical Systems."
- D. Connecting to Existing Equipment: Verify that existing perimeter security system is operational before making changes or connections.
 - 1. Connect new equipment to existing control panel in existing part of the building.
 - 2. Connect new equipment to existing monitoring equipment at the Supervising Station.
 - 3. Expand, modify, and supplement existing **[control][monitoring]** equipment as necessary to extend existing **[control][monitoring]** functions to the new points. New components must be capable of merging with existing configuration without degrading the performance of either system.
- E. Security Fasteners: Where accessible to public, install perimeter security components using security fasteners with head style appropriate for fabrication requirements, strength, and finish of adjacent materials except that a maximum of two different sets of tools must be required to operate security fasteners for Project. **[Provide stainless steel security fasteners in stainless steel materials.]**
- F. Wiring Method: Install power, signal, and data transmission wire and cable in metal raceways according to Section 260543 "Underground Ducts and Raceways for Electrical Systems" and Section 270528 "Pathways for Communications Systems." Minimum conduit size must be metric designator 13 (trade size 1/2). Control and data transmission wiring are not to share conduit with other building wiring systems.
- G. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Use lacing bars and distribution spools. Separate power-limited and non-power-limited conductors as recommended in writing by manufacturer. Install conductors parallel with or at right angles to sides and back of enclosure. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with perimeter security system to terminal blocks. Mark each terminal according to system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.
- H. Wires and Cables:
 - 1. Conductors: Size as recommended in writing by system manufacturer unless otherwise indicated.
 - 2. 120 V Power Wiring: Install according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables" unless otherwise indicated.
 - 3. Cable for Low-Voltage Control and Signal Circuits: Install unshielded, twisted-pair cable unless otherwise indicated or if manufacturer recommends shielded cable, according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
 - 4. Data and Television Signal Transmission Cables: Install according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- I. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.
- J. Install power supplies and other auxiliary components for detection devices at control units unless



otherwise indicated or required by manufacturer. Do not install such items near devices they serve.

- K. Stain-Sensitive Transducer Cable: Attached to fence at **12 inch (300 mm)** intervals with tie wraps.
- L. Electrostatic-Field System: Install field and sense wires on insulators and standoffs on a fence, wall, or roof. Provide intermediate supports recommended in writing by manufacturer as needed for specified performance.
- M. Buried, Ported Coaxial Cable: Transmitters may be located at one end of parallel coaxial cables, and preamplifier-sensor module may be located at opposite end. Install cable so shield is uniform throughout the length, without twisting or distorting cable during installation. Field-cut cables to exact zone length at the site. To attach data transmission cable to sensing cable, use heat-shrink splice kits approved by manufacturer. Provide sufficient overlap of detector cables to eliminate the possibility of entry between zones.

3.4 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with identification requirements in Section 260553 "Identification for Electrical Systems" and Section 270528 "Pathways for Communications Systems."
- B. Install instructions frame in a location visible from master control unit.

3.5 GROUNDING

- A. Ground the master control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to master control unit.
- B. Ground system components and conductor and cable shields to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
- C. Signal Ground Terminal: Locate at main equipment rack or cabinet. Isolate from power system and equipment grounding. Provide **[5 Ω]<Insert resistance>** ground. Measure, record, and report ground resistance.
- D. Install grounding electrodes of type, size, location, and quantity indicated. Comply with installation requirements in Section 260526 "Grounding and Bonding for Electrical Systems" and Section 270528 "Pathways for Communications Systems."

3.6 FIELD QUALITY CONTROL

- A. Administrant for Security Tests and Inspections:
 - 1. **[Owner][Tenant]** will engage qualified security testing and inspecting agency to administer and perform tests and inspections.
 - 2. Engage qualified security testing and inspecting agency to administer and perform tests and inspections.
 - 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
 - 4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].

- B. Acceptance Testing Preparation: After installation, align, adjust, and balance system and perform complete pretesting to determine compliance of system with requirements in the Contract Documents. Correct deficiencies observed in pretesting. Replace malfunctioning or damaged items with new ones and retest until satisfactory performance and conditions are achieved. Prepare forms for systematic recording of acceptance test results.
 - 1. Report of Pretesting: After pretesting is complete, provide a letter certifying that installation is complete and fully operable; include names and titles of witnesses to preliminary tests.
- C. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.
- D. Tests and Inspections: Comply with provisions in NFPA 731, Ch. 9, "Testing and Inspections."
 - 1. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.
 - 2. Test Methods: Perimeter security systems and other systems and equipment that are associated with detection and accessory equipment must be tested according to Table "Test Methods" and Table "Test Methods of Initiating Devices."
 - 3. Geophone System Tests: Test each zone at a minimum of two different locations. Test each zone as follows:
 - a. Horizontal Movement: Adjust sensitivity to screen out alarms from wind.
 - b. Vertical Climb: 100 percent detection required. Set count at three occurrences within 90-second window.
 - c. Cut Test: 100 percent detection required. Set count at two occurrences within 120-second window.
 - d. Set sensitivity to value as low as possible, consistent with reliable detection.
 - e. If performance tests fail, make adjustments to sensors to comply with requirements. Retest failing and adjacent zones to comply with test.
 - 4. Strain-Sensitive Cable System Tests: Adjust sensitivity and count control to value as low as possible, consistent with reliable detection.
 - 5. Microwave Perimeter Security System Tests: Adjust sensitivity to value as low as possible, consistent with reliable detection.
 - 6. Long-Range PIR System Tests: Adjust sensitivity and hold time between activity duration to value as low as possible, consistent with reliable detection.
- E. Documentation: Comply with provisions in NFPA 731, Ch. 4, "Documentation."
- F. Tag all equipment, stations, and other components at which tests have been satisfactorily completed.
- G. Nonconforming Work:
 - 1. Intrusion detection system will be considered defective if it does not pass tests and inspections.
- H. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.
- I. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.
 - 1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.



3.7 ADJUSTING

- A. Occupancy Adjustments: When requested within [12]<Insert number> months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to [two]<Insert number> visits to Project during other than normal occupancy hours for this purpose. [Visits for this purpose must be in addition to any required by warranty.]

3.8 DEMONSTRATION

- A. [Engage a factory-authorized service representative to train][Train] Owner's maintenance personnel to adjust, operate, and maintain the perimeter security system. Comply with documentation provisions in NFPA 731, Ch. 4, "Documentation and User Training."

END OF SECTION 28 16 11 00



28 - Electronic Safety and Security

Task	Specification	Specification Description
28 16 11 00	26 33 43 00a	Public Address Systems
28 16 11 00	27 41 23 00	Educational Intercommunications and Program Systems
28 16 11 00	28 10 00 00	Access Control
28 16 11 00	28 10 00 00a	Access Control System Hardware
28 16 11 00	28 31 00 00	Intrusion Detection
28 18 00 00	28 10 00 00	Access Control
28 18 00 00	28 10 00 00a	Access Control System Hardware
28 18 11 00	28 10 00 00	Access Control
28 18 11 00	28 10 00 00a	Access Control System Hardware



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SECTION 28 20 00 00 - VIDEO SURVEILLANCE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Standard cameras.
2. Submersible cameras.
3. Reinforced dome cameras.
4. Lenses.
5. Infrared illuminators.
6. Camera-supporting equipment.
7. Monitors.
8. Videotape recorders.
9. Digital video recorders.
10. Network video recorders.
11. Digital switchers.
12. IP video systems.
13. Video motion sensors (interior).
14. Control stations.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. Section 281300 "Access Control System Software and Database Management" to integrate access control system interface and control.
5. Section 283100 "Intrusion Detection" to integrate video surveillance used for intrusion detection.
6. Section 283121 "Area and Perimeter Intrusion Detection" to integrate video surveillance used for intrusion detection.
7. Section 285213 "Detention Monitoring and Control System and Interfaces" to integrate video surveillance with detention monitoring interface and control.

1.2 DEFINITIONS

- A. AGC: Automatic gain control.
- B. BNC: Bayonet Neill-Concelman - type of connector.
- C. B/W: Black and white.
- D. CCD: Charge-coupled device.
- E. FTP: File transfer protocol.

- F. IP: Internet protocol.
- G. LAN: Local area network.
- H. MPEG: Moving picture experts group.
- I. NTSC: National Television System Committee.
- J. PC: Personal computer.
- K. PTZ: Pan-tilt-zoom.
- L. RAID: Redundant array of independent disks.
- M. TCP: Transmission control protocol - connects hosts on the Internet.
- N. UPS: Uninterruptible power supply.
- O. WAN: Wide area network.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include dimensions and data on features, performance, electrical characteristics, ratings, and finishes.
 - 2. Include manufacturer's sample extended warranty language.
- B. Shop Drawings: For video surveillance. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Functional Block Diagram: Show single-line interconnections between components for signal transmission and control. Show cable types and sizes.
 - 3. Dimensioned plan and elevations of equipment racks, control panels, and consoles. Show access and workspace requirements.
 - 4. UPS: Sizing calculations.
 - 5. Wiring Diagrams: For power, signal, and control wiring.
- C. Design Data: Include an equipment list consisting of every piece of equipment by model number, manufacturer, serial number, location, and date of original installation. Add pretesting record of each piece of equipment, listing name of person testing, date of test, set points of adjustments, name and description of the view of preset positions, description of alarms, and description of unit output responses to an alarm.
- D. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Data: In addition to seismic qualification data specified in Section 260010 "Supplemental Requirements for Electrical," submit certificates for cameras, camera-supporting

equipment, accessories, and components, from manufacturer.

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

B. Manufacturer's published instructions.

C. Field Reports:

1. Manufacturer's field reports for field quality-control support.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For cameras, power supplies, infrared illuminators, monitors, videotape recorders, digital video recorders, video switches, and control-station components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Lists of spare parts and replacement components recommended to be stored at the site for ready access.

1.6 QUALIFICATIONS

A. Security Design Professional: Design professional with active Physical Security Professional (PSP) certification issued by American Society for Industrial Security (ASIS) and with documented experience managing installation of security systems in similar size and complexity.

B. Security Testing and Inspecting Agency: Entity possessing active credentials from qualified electrical testing laboratory recognized by authorities having jurisdiction.

1. On-site security testing supervisor must have **[ASIS][PSP]<Insert organization>** certification and documented training and experience with testing security equipment in accordance with **[ASIS]<Insert organization>** testing standards.

1.7 PROJECT CONDITIONS

A. Environmental Conditions: Capable of withstanding the requirements specified in Section 018116 "Facility Environmental Requirements" and the following environmental conditions without mechanical or electrical damage or degradation of operating capability:

1. Control Station: Rated for continuous operation in ambient temperatures of **60 to 85 deg F (16 to 29 deg C)** and a relative humidity of 20 to 80 percent, noncondensing.
2. Interior, Controlled Environment: System components, except central-station control unit, installed in **[air-conditioned][temperature-controlled]** interior environments are to be rated for continuous operation in ambient temperatures of **[36 to 122 deg F (2 to 50 deg C)]<Insert temperature range>** dry bulb and 20 to 90 percent relative humidity, noncondensing. Use UL 50E, Type 1 enclosures.
3. Interior, Uncontrolled Environment: System components installed in non-[air-

conditioned][temperature-controlled] interior environments are to be rated for continuous operation in ambient temperatures of **[0 to 122 deg F (minus 18 to plus 50 deg C)]<Insert temperature range>** dry bulb and 20 to 90 percent relative humidity, noncondensing. Use UL 50E, **[Type 3R][Type 4][Type 12][Type 12K]** enclosures.

4. Exterior Environment: System components installed in locations exposed to weather are to be rated for continuous operation in ambient temperatures of **[minus 30 to plus 122 deg F (minus 34 to plus 50 deg C)]<Insert temperature range>** dry bulb and 20 to 90 percent relative humidity, condensing. Rate for continuous operation when exposed to rain as specified in UL 50E, winds up to **85 mph (137 km/h)[and snow cover up to 24 inches (610 mm) thick]**. Use UL 50E, **[Type 3][Type 3R][Type 3S][Type 4][Type 4X]** enclosures.
5. Hazardous Environment: System components located in areas where fire or explosion hazards may exist because of flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers are to be rated, listed, and installed according to NFPA 70.
6. Corrosive Environment: System components subject to corrosive fumes, vapors, and wind-driven salt spray in coastal zones. Use UL 50E, **[Type 4X][Type 6P]** enclosures.
7. Security Environment: Camera housing for use in high-risk areas where surveillance equipment may be subject to physical violence.

1.8 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of cameras, equipment related to camera operation, and control-station equipment that fail in materials or workmanship within specified warranty period.

1. Warranty Period: **[Three]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM REQUIREMENTS

- A. Video-signal format must comply with NTSC standard, composite interlaced video. Composite video-signal termination must be 75 Ω .
- B. Surge Protection: Protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads. Include surge protection for external wiring of each conductor's entry connection to components.
 1. Minimum Protection for Power Connections 120 V and More: Auxiliary panel suppressors complying with requirements in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."
 2. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Connections: Comply with requirements in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits" as recommended by manufacturer for type of line being protected.
- C. Tamper Protection: Tamper switches on enclosures, control units, pull boxes, junction boxes, cabinets, and other system components are to initiate a tamper-alarm signal when unit is opened or partially disassembled. Control-station, control-unit alarm display is to identify tamper alarms and indicate locations.

2.2 PERFORMANCE REQUIREMENTS

- A. Seismic and Wind Performance: Installed assembly must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria."
 - 1. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events[**and unit must be fully operational after seismic events**]."
 - 2. Component Importance Factor (Ip): [1.0][1.5].
 - 3. Component Amplification Factor (ap): [1.0][2.5]<Insert value>.
 - 4. Component Response Modification Factor (Rp): [1.5][2.0][2.5][6.0]<Insert value>.
 - 5. Component Overstrength Factor (Ωo): [1.5][2.5]<Insert value>.
- B. Electrical Components, Devices, and Accessories: Listed and labeled in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with NECA 1.
- D. Comply with NFPA 70.
- E. Electronic data exchange between video surveillance system with an access-control system is to comply with SIA TVAC.

2.3 STANDARD CAMERAS

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - 1. [AXCESS International Inc.]
 - 2. [Axis Communications]
 - 3. [Bosch Security Systems, Inc.]
 - 4. [CBC (AMERICA) Corp]
 - 5. [COP-USA]
 - 6. [Crest Electronics, Inc]
 - 7. [Elbex Ltd.]
 - 8. [ELMO]
 - 9. [EverFocus Electronics Corporation]
 - 10. [Hitachi Cable America Inc.]
 - 11. [Honeywell Commercial Security; Honeywell International, Inc.]
 - 12. [Hunt Electronics USA, Inc]
 - 13. [Ikegami Electronics (USA) Inc]
 - 14. [Interlogix; Carrier Global Corporation]
 - 15. [JVC Americas Corp.]
 - 16. [Merit Li-Lin (USA) Corp.]
 - 17. [Panasonic Corporation of North America]
 - 18. [Pelco]
 - 19. [Pixera Corporation]
 - 20. [Safety Vision]
 - 21. [Samsung Opto-Electronics]
 - 22. [SANYO North America Corporation]
 - 23. [Telpix Electronics, Inc.]
 - 24. [Toshiba International Corporation]
 - 25. [Trinus Systems Inc.]
 - 26. [Tyco Security Products; brand of Johnson Controls International plc, Building Solutions]

- North America]
- 27. [Vicon Industries, Inc]
- 28. [Videology Imaging Solutions, Inc.]
- 29. [Viontech]
- 30. [VIVOTEK Inc.]
- 31. [Watec America Corporation]
- 32. <Insert manufacturer's name>

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

- 1. [AXCESS International Inc.]
- 2. [Axis Communications]
- 3. [Bosch Security Systems, Inc.]
- 4. [CBC (AMERICA) Corp]
- 5. [COP-USA]
- 6. [Crest Electronics, Inc]
- 7. [Elbex Ltd.]
- 8. [ELMO]
- 9. [EverFocus Electronics Corporation]
- 10. [Hitachi Cable America Inc.]
- 11. [Honeywell Commercial Security; Honeywell International, Inc.]
- 12. [Hunt Electronics USA, Inc]
- 13. [Ikegami Electronics (USA) Inc]
- 14. [Interlogix; Carrier Global Corporation]
- 15. [JVC Americas Corp.]
- 16. [Merit Li-Lin (USA) Corp.]
- 17. [Panasonic Corporation of North America]
- 18. [Pelco]
- 19. [Pixera Corporation]
- 20. [Safety Vision]
- 21. [Samsung Opto-Electronics]
- 22. [SANYO North America Corporation]
- 23. [Telpix Electronics, Inc.]
- 24. [Toshiba International Corporation]
- 25. [Trinus Systems Inc.]
- 26. [Tyco Security Products; brand of Johnson Controls International plc, Building Solutions North America]
- 27. [Vicon Industries, Inc]
- 28. [Videology Imaging Solutions, Inc.]
- 29. [Viontech]
- 30. [VIVOTEK Inc.]
- 31. [Watec America Corporation]
- 32. <Insert manufacturer's name>

C. B/W Camera:

- 1. Comply with UL 639.
- 2. Pickup Device: CCD interline transfer, 252,000 [512(H) by 492(V)]<Insert other> pixels.
- 3. Horizontal Resolution: 380 lines.
- 4. Signal-to-Noise Ratio: Not less than 46 dB.
- 5. With AGC, manually selectable on or off.
- 6. Sensitivity:
 - a. Usable images in low-light conditions: Able to deliver an image at a scene illumination of

- b. Peak-to-peak signal strength: Deliver 1-V peak-to-peak video signal at the minimum specified light level. Illumination for the test is to be with lamps rated at approximately 2200-K color temperature, and with camera AGC off.
 7. Manually selectable modes for backlight compensation or normal lighting.
 8. Scanning Synchronization: Determined by external synch over the coaxial cable. Camera is to revert to internally generated synchronization on loss of external synch signal.
 9. Motion Detector: Built-in digital.
- D. Color Camera:
1. Comply with UL 639.
 2. Pickup Device: CCD interline transfer, 380,000 [771(H) by 492(V)]<Insert other> pixels.
 3. Horizontal Resolution: 480 lines.
 4. Signal-to-Noise Ratio: Not less than 50 dB, with camera AGC off.
 5. With AGC, manually selectable on or off.
 6. Sensitivity:
 - a. Usable images in low-light conditions: Able to deliver an image at a scene illumination of <Insert light level> lux at f/1.4[, with camera AGC off].
 - b. Peak-to-peak signal strength: Deliver 1-V peak-to-peak video signal at the minimum specified light level. Illumination for the test is to be with lamps rated at approximately 2200-K color temperature, and with camera AGC off.
 7. Manually selectable modes for backlight compensation or normal lighting.
 8. Scanning Synchronization: Determined by external synch over the coaxial cable. Camera is to revert to internally generated synchronization on loss of external synch signal.
 9. White Balance: Auto-tracing white balance, with manually settable fixed balance option.
 10. Motion Detector: Built-in digital.
- E. Automatic Color Dome Camera: Assembled and tested as a manufactured unit, containing dome assembly, color camera, motorized pan and tilt, zoom lens, and receiver/driver.
1. Comply with UL 639.
 2. Pickup Device: CCD interline transfer, 380,000 [768(H) by 494(V)]<Insert other> pixels.
 3. Horizontal Resolution: 480 lines.
 4. Signal-to-Noise Ratio: Not less than 50 dB, with camera AGC off.
 5. With AGC, manually selectable on or off.
 6. Sensitivity:
 - a. Usable images in low-light conditions: Able to deliver an image at a scene illumination of <Insert light level> lux at f/1.4[, with camera AGC off].
 - b. Peak-to-peak signal strength: Deliver 1 V peak-to-peak video signal at the minimum specified light level. Illumination for the test is to be with lamps rated at approximately 2200 K color temperature, and with camera AGC off.
 7. Manually selectable modes for backlight compensation or normal lighting.
 8. Pan and Tilt: Direct-drive motor, 360-degree rotation angle, and 180-degree tilt angle. Pan-and-tilt speed is to be controlled by operator. Movement from preset positions is not to be less than 300 degrees per second.
 9. Preset Positioning: Eight user-definable scenes, each allowing 16-character titles. Controls are to include the following:
 - a. In "sequence mode," camera is to continuously sequence through preset positions, with dwell time and sequencing under operator control.



- b. Motion detection is to be available at each camera position.
- c. Up to four preset positions may be selected to be activated by an alarm. Each of the alarm positions may be programmed to output a response signal.

- 10. Scanning Synchronization: Determined by external synch over the coaxial cable. Camera is to revert to internally generated synchronization on loss of external synch signal.
- 11. White Balance: Auto-tracing white balance, with manually settable fixed balance option.
- 12. Motion Detector: Built-in digital.
- 13. Dome is to support multiplexed control communications using coaxial cable recommended by manufacturer.

2.4 SUBMERSIBLE CAMERAS

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

- 1. **[International Space Optics]**
- 2. **<Insert manufacturer's name>**

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

- 1. **[International Space Optics]**
- 2. **<Insert manufacturer's name>**

- C. Camera: Color, designed for underwater monitoring and for inspecting pipes and storm drains. Attributes as follows:

- 1. Infrared LEDs to provide illumination in zero-light conditions.
- 2. **60 ft (18.3 m)** factory-installed cable with BNC connector for video and a 2.1 mm jack for 12 V(dc) power supply.
- 3. An adjustable swivel mount and attachment base.
- 4. Pickup Device: CCD interline transfer, 290,000 **[500(H) by 580(V)]<Insert other>** pixels.
- 5. Horizontal Resolution: 380 lines.
- 6. Signal-to-Noise Ratio: Not less than 50 dB.
- 7. With AGC, from 4 to 39 dB.
- 8. Sensitivity: Camera is to provide usable images in low-light conditions, delivering an image at a scene illumination of 0.1 lux at f/2.0.
- 9. Scanning Synchronization: Internal.
- 10. White Balance: Auto-tracing white balance, for colors ranging from 2800 to 8200 K.

2.5 REINFORCED DOME CAMERAS

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

- 1. **[Axis Communications]**
- 2. **[Bosch Security Systems, Inc.]**
- 3. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's**

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

1. **[Axis Communications]**
2. **[Bosch Security Systems, Inc.]**
3. **<Insert manufacturer's name>**

C. Camera: Designed for high-abuse locations, with a weathertight **[semirecessed][surface]** mounting, impact-resistance polycarbonate dome, and heavy-gage, 6061 T6 aluminum body.

1. Suitable for exterior environment, rated for continuous operation in ambient temperatures of **minus 40 to plus 122 deg F (minus 40 to plus 50 deg C)** dry bulb and up to 85 percent relative humidity.
2. Pickup Device: CCD interline transfer, 290,000 **[510(H) by 492(V)]<Insert other>** pixels.
3. Horizontal Resolution: 350 lines.
4. Signal-to-Noise Ratio: Not less than 46 dB.
5. With AGC and automatic backlight compensation.
6. Sensitivity: Camera is to provide usable images in low-light conditions, delivering an image at a scene illumination of 6 lux at f/2.0.
7. Scanning Synchronization: Determined by external synch over the coaxial cable. Camera is to revert to internally generated synchronization on loss of external synch signal.
8. White Balance: Auto-tracing white balance.

2.6 LENSES

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

1. **[Bosch Security Systems, Inc.]**
2. **[CBC (AMERICA) Corp]**
3. **[COP-USA]**
4. **[Crest Electronics, Inc]**
5. **[Elbex Ltd.]**
6. **[Hitachi Cable America Inc.]**
7. **[Honeywell Commercial Security; Honeywell International, Inc.]**
8. **[Hunt Electronics USA, Inc]**
9. **[Interlogix; Carrier Global Corporation]**
10. **[International Space Optics]**
11. **[Panasonic Corporation of North America]**
12. **[Pelco]**
13. **[Samsung Opto-Electronics]**
14. **[SANYO North America Corporation]**
15. **[Tamron USA, Inc.]**
16. **[Telpix Electronics, Inc.]**
17. **[Tyco Security Products; brand of Johnson Controls International plc, Building Solutions North America]**
18. **[Vicon Industries, Inc]**
19. **[Videology Imaging Solutions, Inc.]**
20. **[Watec America Corporation]**
21. **<Insert manufacturer's name>**

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

1. **[Bosch Security Systems, Inc.]**

2. [CBC (AMERICA) Corp]
3. [COP-USA]
4. [Crest Electronics, Inc]
5. [Elbex Ltd.]
6. [Hitachi Cable America Inc.]
7. [Honeywell Commercial Security; Honeywell International, Inc.]
8. [Hunt Electronics USA, Inc]
9. [Interlogix; Carrier Global Corporation]
10. [International Space Optics]
11. [Panasonic Corporation of North America]
12. [Pelco]
13. [Samsung Opto-Electronics]
14. [SANYO North America Corporation]
15. [Tamron USA, Inc.]
16. [Telpix Electronics, Inc.]
17. [Tyco Security Products; brand of Johnson Controls International plc, Building Solutions North America]
18. [Vicon Industries, Inc]
19. [Videology Imaging Solutions, Inc.]
20. [Watec America Corporation]
21. <Insert manufacturer's name>

C. Description: Optical-quality coated lens, designed specifically for video-surveillance applications and matched to specified camera. Provide color-corrected lenses with color cameras.

1. Auto-Iris Lens: Electrically controlled iris with circuit set to maintain a constant video level in varying lighting conditions.
2. Fixed Lens: With calibrated focus ring.
3. Zoom Lens: Motorized, remote-controlled unit, rated as "quiet operating." Features include the following:
 - a. Electrical Leads: Filtered to minimize video signal interference.
 - b. Motor Speed: Variable.
 - c. Lens is to be available with preset positioning capability to recall the position of specific scenes.

2.7 POWER SUPPLIES

A. Low-voltage power supplies matched for voltage and current requirements of cameras and accessories, and of type as recommended by manufacturer of camera[, **infrared illuminator**,] and lens.

1. Enclosure: UL 50E, [Type 1][Type 3][Type 4X]<Insert type>.

2.8 INFRARED ILLUMINATORS

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

1. [Honeywell Commercial Security; Honeywell International, Inc.]
2. [International Space Optics]
3. [Merit Li-Lin (USA) Corp.]
4. [Viontech]

5. [VIVOTEK Inc.]
6. [Watec America Corporation]
7. <Insert manufacturer's name>

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

1. [Honeywell Commercial Security; Honeywell International, Inc.]
2. [International Space Optics]
3. [Merit Li-Lin (USA) Corp.]
4. [Viontech]
5. [VIVOTEK Inc.]
6. [Watec America Corporation]
7. <Insert manufacturer's name>

C. Description: Lighting fixtures that emit light only in the infrared spectrum, suitable for use with cameras indicated, for nighttime surveillance, without emitting visible light.

1. Field-Selectable Beam Patterns: Narrow, medium, and wide.
2. Rated Lamp Life: More than 8000 hours.
3. Power Supply: [12 V(ac/dc)][120 V(ac)].

D. Area Coverage: Illumination to **150 ft (50 m)** in a narrow beam pattern.

E. Exterior housings are to be suitable for same environmental conditions as the associated camera.

2.9 CAMERA-SUPPORTING EQUIPMENT

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

1. [Bosch Security Systems, Inc.]
2. [CBC (AMERICA) Corp]
3. [COP-USA]
4. [Crest Electronics, Inc]
5. [Elbex Ltd.]
6. [ELMO]
7. [EverFocus Electronics Corporation]
8. [Honeywell Commercial Security; Honeywell International, Inc.]
9. [Ikegami Electronics (USA) Inc]
10. [Interlogix; Carrier Global Corporation]
11. [Merit Li-Lin (USA) Corp.]
12. [Moog, Inc.]
13. [Panasonic Corporation of North America]
14. [Pelco]
15. [Samsung Opto-Electronics]
16. [SANYO North America Corporation]
17. [Telpix Electronics, Inc.]
18. [Tyco Security Products; brand of Johnson Controls International plc, Building Solutions North America]
19. [Vicon Industries, Inc]
20. [Video Mount Products]
21. [Viontech]
22. [Wren Associates Limited]

23. <Insert manufacturer's name>

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

1. [Bosch Security Systems, Inc.]
2. [CBC (AMERICA) Corp]
3. [COP-USA]
4. [Crest Electronics, Inc]
5. [Elbex Ltd.]
6. [ELMO]
7. [EverFocus Electronics Corporation]
8. [Honeywell Commercial Security; Honeywell International, Inc.]
9. [Ikegami Electronics (USA) Inc]
10. [Interlogix; Carrier Global Corporation]
11. [Merit Li-Lin (USA) Corp.]
12. [Moog, Inc.]
13. [Panasonic Corporation of North America]
14. [Pelco]
15. [Samsung Opto-Electronics]
16. [SANYO North America Corporation]
17. [Telpix Electronics, Inc.]
18. [Tyco Security Products; brand of Johnson Controls International plc, Building Solutions North America]
19. [Vicon Industries, Inc]
20. [Video Mount Products]
21. [Viontech]
22. [Wren Associates Limited]
23. <Insert manufacturer's name>

C. Minimum Load Rating: Rated for load in excess of the total weight supported times a minimum safety factor of two.

D. Pan Units: Motorized automatic-scanning units arranged to provide remote-controlled manual and automatic camera panning action, and equipped with matching mounting brackets.

1. Scanning Operation: Silent, smooth, and positive.
2. Stops: Adjustable without disassembly, to limit the scanning arc.

E. Pan-and-Tilt Units: Motorized units arranged to provide remote-controlled aiming of cameras with smooth and silent operation, and equipped with matching mounting brackets.

1. Panning Rotation: 0 to 355 degrees, with adjustable stops.
2. Tilt Movement: 90 degrees, plus or minus 5 degrees, with adjustable stops.
3. Speed: 12 degrees per second in both horizontal and vertical planes.
4. Wiring: Factory prewired for camera and zoom lens functions and pan-and-tilt power and control.
5. Built-in encoders or potentiometers for position feedback[, and thermostat-controlled heater].
6. Pan-and-tilt unit is to be available with preset positioning capability to recall the position of a specific scene.

F. Mounting Brackets for Fixed Cameras: Type matched to items supported and mounting conditions. Include manual pan-and-tilt adjustment.

G. Protective Housings for Fixed and Movable Cameras: Steel[or 6061 T6 aluminum] enclosures with internal camera mounting and connecting provisions that are matched to camera/lens combination and

mounting and installing arrangement of camera to be housed.

1. Tamper switch on access cover sounds an alarm signal when unit is opened or partially disassembled. Central-control unit is to identify tamper alarms and indicate location in alarm display. Tamper switches and central-control unit are specified in Section 283100 "Intrusion Detection."
2. Camera Viewing Window: **[Polycarbonate][Lexan]** window, aligned with camera lens.
3. Duplex Receptacle: Internally mounted.
4. Alignment Provisions: Camera mounting is to provide for field aiming of camera and permit removal and reinstallation of camera lens without disturbing camera alignment.
5. Built-in, thermostat-activated **[heater][and][blower]** units. Units are to be automatically controlled so the environmental limits of the camera equipment are not exceeded.
6. Sun shield is not to interfere with normal airflow around the housing.
7. Mounting bracket and hardware for wall or ceiling mounting of the housing. Bracket is to be of same material as the housing; mounting hardware is to be stainless steel.
8. Finish: Housing and mounting bracket are to be factory finished using manufacturer's standard finishing process suitable for the environment.
9. Enclosure Rating: **<Insert UL 50E Type designation><Insert Ingress Protection code designation>**.

2.10 MONITORS

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

1. **[Bosch Security Systems, Inc.]**
2. **[CBC (AMERICA) Corp]**
3. **[COP-USA]**
4. **[Crest Electronics, Inc]**
5. **[Elbex Ltd.]**
6. **[ELMO]**
7. **[EverFocus Electronics Corporation]**
8. **[Hitachi Cable America Inc.]**
9. **[Honeywell Commercial Security; Honeywell International, Inc.]**
10. **[Hunt Electronics USA, Inc]**
11. **[Ikegami Electronics (USA) Inc]**
12. **[Interlogix; Carrier Global Corporation]**
13. **[International Space Optics]**
14. **[JVC Americas Corp.]**
15. **[Merit Li-Lin (USA) Corp.]**
16. **[Panasonic Corporation of North America]**
17. **[Pelco]**
18. **[Samsung Opto-Electronics]**
19. **[SANYO North America Corporation]**
20. **[Tatung Company of America, Inc]**
21. **[Telpix Electronics, Inc.]**
22. **[Toshiba International Corporation]**
23. **[Trinus Systems Inc.]**
24. **[Tyco Security Products; brand of Johnson Controls International plc, Building Solutions North America]**
25. **[Vicon Industries, Inc]**
26. **<Insert manufacturer's name>**

- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's**

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

1. [Bosch Security Systems, Inc.]
2. [CBC (AMERICA) Corp]
3. [COP-USA]
4. [Crest Electronics, Inc]
5. [Elbex Ltd.]
6. [ELMO]
7. [EverFocus Electronics Corporation]
8. [Hitachi Cable America Inc.]
9. [Honeywell Commercial Security; Honeywell International, Inc.]
10. [Hunt Electronics USA, Inc]
11. [Ikegami Electronics (USA) Inc]
12. [Interlogix; Carrier Global Corporation]
13. [International Space Optics]
14. [JVC Americas Corp.]
15. [Merit Li-Lin (USA) Corp.]
16. [Panasonic Corporation of North America]
17. [Pelco]
18. [Samsung Opto-Electronics]
19. [SANYO North America Corporation]
20. [Tatung Company of America, Inc]
21. [Telpix Electronics, Inc.]
22. [Toshiba International Corporation]
23. [Trinus Systems Inc.]
24. [Tyco Security Products; brand of Johnson Controls International plc, Building Solutions North America]
25. [Vicon Industries, Inc]
26. <Insert manufacturer's name>

C. Monochrome:

1. Metal cabinet units designed for continuous operation.
2. Screen Size (Diagonal Dimension): <Insert dimension>.
3. Horizontal Resolution: [600]<Insert resolution> lines, minimum, at center.
4. Minimum Front Panel Devices and Controls: Power switch; power-on indicator; and brightness, horizontal-hold, vertical-hold, and contrast controls.
5. Mounting:
 - a. Adjustable tilting and training.
 - b. [Single, 14 inch (356 mm)][Dual, 9 inch (229 mm)], vertical, EIA 19 inch (483 mm) electronic equipment rack or cabinet complying with CEA 310-E.
6. Electrical: 120 V(ac), 60 Hz.

D. Color:

1. Metal cabinet units designed for continuous operation.
2. Screen Size (Diagonal Dimension): <Insert dimension>.
3. Horizontal Resolution: [300]<Insert resolution> lines.
4. Minimum Front Panel Devices and Controls: Power switch; power-on indicator; and brightness, contrast, color, and tint controls.
5. Degaussing: Automatic.
6. Mounting: [Single, 14 inch (356 mm)][Dual, 9 inch (229 mm)], vertical, EIA 19 inch (483 mm) electronic equipment rack or cabinet complying with CEA 310-E.

7. Electrical: 120 V(ac), 60 Hz.

2.11 VIDEOTAPE RECORDERS

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

1. **[Bosch Security Systems, Inc.]**
2. **[CBC (AMERICA) Corp]**
3. **[COP-USA]**
4. **[Crest Electronics, Inc]**
5. **[Elbex Ltd.]**
6. **[Honeywell Commercial Security; Honeywell International, Inc.]**
7. **[Ikegami Electronics (USA) Inc]**
8. **[Interlogix; Carrier Global Corporation]**
9. **[JVC Americas Corp.]**
10. **[Panasonic Corporation of North America]**
11. **[Pelco]**
12. **[Samsung Opto-Electronics]**
13. **[SANYO North America Corporation]**
14. **[Toshiba International Corporation]**
15. **[Tyco Security Products; brand of Johnson Controls International plc, Building Solutions North America]**
16. **[Vicon Industries, Inc]**
17. **[Videology Imaging Solutions, Inc.]**
18. **<Insert manufacturer's name>**

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

1. **[Bosch Security Systems, Inc.]**
2. **[CBC (AMERICA) Corp]**
3. **[COP-USA]**
4. **[Crest Electronics, Inc]**
5. **[Elbex Ltd.]**
6. **[Honeywell Commercial Security; Honeywell International, Inc.]**
7. **[Ikegami Electronics (USA) Inc]**
8. **[Interlogix; Carrier Global Corporation]**
9. **[JVC Americas Corp.]**
10. **[Panasonic Corporation of North America]**
11. **[Pelco]**
12. **[Samsung Opto-Electronics]**
13. **[SANYO North America Corporation]**
14. **[Toshiba International Corporation]**
15. **[Tyco Security Products; brand of Johnson Controls International plc, Building Solutions North America]**
16. **[Vicon Industries, Inc]**
17. **[Videology Imaging Solutions, Inc.]**
18. **<Insert manufacturer's name>**

- C. Description: Industrial, time-lapse type recorder, designed for continuous operation. Tape format is **1/2 inch (13 mm)** using industrial-grade, T-120 cassettes.

1. Horizontal Resolution: 400 lines, minimum.

2. Recording Heads: Rotary-scan type.
3. Integral Timer: Permits programming of recording operation for adjustable daily and weekly periods.
4. Time-Lapse Operating Modes: Multiple, covering 24 to 240 hours, minimum.
5. Other Operating Modes:
 - a. Manual play and recording at two- and six-hour speeds.
 - b. Forward and reverse high-speed search.
 - c. Reverse, slow, and single-frame play.
6. Alarm Recording: Operating mode is automatically switched from time-lapse to two- or six-hour recording mode when an externally generated alarm signal is received.
7. Audio Recording: 70 to 7000 Hz. Phono and microphone input; phono output.
8. Time and Date Generator: Records time and date legend in corner of recorded scenes.
9. Tape Counter: Displays tape position.
10. Manual Recording Lock: Key or keypad operated. Prevents unauthorized tampering or control changes during preset operation.
11. Signal-to-Noise Ratio: 45 dB for video output in standard play mode.
12. Mounting: Standard **19 inch (483 mm)** rack complying with CEA 310-E, or freestanding desktop.

2.12 DIGITAL VIDEO RECORDERS

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

1. **[AXCESS International Inc.]**
2. **[Bosch Security Systems, Inc.]**
3. **[CBC (AMERICA) Corp]**
4. **[COP-USA]**
5. **[Crest Electronics, Inc]**
6. **[Dedicated Microcomputers Limited]**
7. **[Elbex Ltd.]**
8. **[EverFocus Electronics Corporation]**
9. **[Hitachi Cable America Inc.]**
10. **[Honeywell Commercial Security; Honeywell International, Inc.]**
11. **[Ikegami Electronics (USA) Inc]**
12. **[Interlogix; Carrier Global Corporation]**
13. **[JVC Americas Corp.]**
14. **[Panasonic Corporation of North America]**
15. **[Pelco]**
16. **[Samsung Opto-Electronics]**
17. **[SANYO North America Corporation]**
18. **[Tyco Security Products; brand of Johnson Controls International plc, Building Solutions North America]**
19. **[Vicon Industries, Inc]**
20. **<Insert manufacturer's name>**

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

1. **[AXCESS International Inc.]**
2. **[Bosch Security Systems, Inc.]**
3. **[CBC (AMERICA) Corp]**

4. [COP-USA]
5. [Crest Electronics, Inc]
6. [Dedicated Microcomputers Limited]
7. [Elbex Ltd.]
8. [EverFocus Electronics Corporation]
9. [Hitachi Cable America Inc.]
10. [Honeywell Commercial Security; Honeywell International, Inc.]
11. [Ikegami Electronics (USA) Inc]
12. [Interlogix; Carrier Global Corporation]
13. [JVC Americas Corp.]
14. [Panasonic Corporation of North America]
15. [Pelco]
16. [Samsung Opto-Electronics]
17. [SANYO North America Corporation]
18. [Tyco Security Products; brand of Johnson Controls International plc, Building Solutions North America]
19. [Vicon Industries, Inc]
20. <Insert manufacturer's name>

C. Description: Digital, time-lapse type, full-frame and motion recorder, with removable hard drive.

1. Recording Time: 400 hours minimum.
2. Resolution: 720 by 480 lines, minimum.
3. Programming is to be from trackball and push buttons on face of the recorder, settings are to be displayed on any video monitor connected to the recorder. Programming is to include the following:
 - a. Motion analysis graph.
 - b. Password protection.
 - c. Alarm and timer controls.
 - d. Continuous recording option.
 - e. Time-lapse operating modes.
 - f. Search video by time, event, or motion.
4. Programming: SmartMedia card for software updating, image archiving, and image transfer to a PC.
5. Storage: [80 GB]<Insert size>, removable hard drive. Software is to permit hot-swapping drives.
6. Compression: [MPEG-2]<Insert type>.
7. Time and Date Generator: Records time (hr:min:sec) and date legend of each frame.
8. Audio Recording: 70 to 7000 Hz. Phono and microphone input; phono output.
9. Mounting: Standard 19 inch (483 mm) rack complying with CEA 310-E, or freestanding desktop.

2.13 NETWORK VIDEO RECORDERS

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

1. [AXCESS International Inc.]
2. [Bosch Security Systems, Inc.]
3. [CBC (AMERICA) Corp]
4. [COP-USA]
5. [Crest Electronics, Inc]
6. [Dedicated Microcomputers Limited]
7. [Elbex Ltd.]

8. [EverFocus Electronics Corporation]
9. [Hitachi Cable America Inc.]
10. [Honeywell Commercial Security; Honeywell International, Inc.]
11. [Ikegami Electronics (USA) Inc]
12. [Interlogix; Carrier Global Corporation]
13. [JVC Americas Corp.]
14. [Panasonic Corporation of North America]
15. [Pelco]
16. [Samsung Opto-Electronics]
17. [SANYO North America Corporation]
18. [Tyco Security Products; brand of Johnson Controls International plc, Building Solutions North America]
19. [Vicon Industries, Inc]
20. [VIVOTEK Inc.]
21. <Insert manufacturer's name>

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

1. [AXCESS International Inc.]
2. [Bosch Security Systems, Inc.]
3. [CBC (AMERICA) Corp]
4. [COP-USA]
5. [Crest Electronics, Inc]
6. [Dedicated Microcomputers Limited]
7. [Elbex Ltd.]
8. [EverFocus Electronics Corporation]
9. [Hitachi Cable America Inc.]
10. [Honeywell Commercial Security; Honeywell International, Inc.]
11. [Ikegami Electronics (USA) Inc]
12. [Interlogix; Carrier Global Corporation]
13. [JVC Americas Corp.]
14. [Panasonic Corporation of North America]
15. [Pelco]
16. [Samsung Opto-Electronics]
17. [SANYO North America Corporation]
18. [Tyco Security Products; brand of Johnson Controls International plc, Building Solutions North America]
19. [Vicon Industries, Inc]
20. [VIVOTEK Inc.]
21. <Insert manufacturer's name>

C. External storage or internal 250 to 1500 GB hard disk drive.

1. Video and audio recording over TCP/IP network.
2. Video recording of MPEG-2 and MPEG-4 streams.
3. Video recording up to 48 Mbps for internal storage and up to 100 Mbps for external storage.
4. Duplex Operation: Simultaneous recording and playback.
5. Continuous and alarm-based recording.
6. Full-Featured Search Capabilities: Search based on camera, time, or date.
7. Automatic data replenishment to ensure recording even if network is down.
8. Digital certification by watermarking.
9. Internal RAID storage or non-RAID storage of up to 1500 GB.
10. Capable of adding external RAID storage up to 7000 GB for models with no internal storage.
11. Full integration with LAN, Intranet, or Internet through standard Web browser or video

- management software.
- 12. Integrated Web server FTP server functionality.
- 13. Supports up to 16[, 32,] or [64]<Insert number> devices.

2.14 DIGITAL SWITCHERS

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

- 1. [AXCESS International Inc.]
- 2. [Bosch Security Systems, Inc.]
- 3. [CBC (AMERICA) Corp]
- 4. [Communications Specialties, Inc.]
- 5. [Convision Systems GmbH]
- 6. [COP-USA]
- 7. [Crest Electronics, Inc]
- 8. [Dedicated Microcomputers Limited]
- 9. [Elbex Ltd.]
- 10. [EverFocus Electronics Corporation]
- 11. [Honeywell Commercial Security; Honeywell International, Inc.]
- 12. [Hunt Electronics USA, Inc]
- 13. [Ikegami Electronics (USA) Inc]
- 14. [Interlogix; Carrier Global Corporation]
- 15. [JVC Americas Corp.]
- 16. [Merit Li-Lin (USA) Corp.]
- 17. [Panasonic Corporation of North America]
- 18. [Pelco]
- 19. [Samsung Opto-Electronics]
- 20. [SANYO North America Corporation]
- 21. [Telpix Electronics, Inc.]
- 22. [Toshiba International Corporation]
- 23. [Trinus Systems Inc.]
- 24. [Tyco Security Products; brand of Johnson Controls International plc, Building Solutions North America]
- 25. [Vicon Industries, Inc]
- 26. <Insert manufacturer's name>

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

- 1. [AXCESS International Inc.]
- 2. [Bosch Security Systems, Inc.]
- 3. [CBC (AMERICA) Corp]
- 4. [Communications Specialties, Inc.]
- 5. [Convision Systems GmbH]
- 6. [COP-USA]
- 7. [Crest Electronics, Inc]
- 8. [Dedicated Microcomputers Limited]
- 9. [Elbex Ltd.]
- 10. [EverFocus Electronics Corporation]
- 11. [Honeywell Commercial Security; Honeywell International, Inc.]
- 12. [Hunt Electronics USA, Inc]
- 13. [Ikegami Electronics (USA) Inc]
- 14. [Interlogix; Carrier Global Corporation]

15. [JVC Americas Corp.]
16. [Merit Li-Lin (USA) Corp.]
17. [Panasonic Corporation of North America]
18. [Pelco]
19. [Samsung Opto-Electronics]
20. [SANYO North America Corporation]
21. [Telpix Electronics, Inc.]
22. [Toshiba International Corporation]
23. [Trinus Systems Inc.]
24. [Tyco Security Products; brand of Johnson Controls International plc, Building Solutions North America]
25. [Vicon Industries, Inc]
26. <Insert manufacturer's name>

C. Quad Switch: For displaying images from four cameras on a single monitor. Provide color switcher if one or more cameras or monitors are in color.

1. Controls: Unit-mounted front panel.
2. Resolution: **[720 by 480]** lines <Insert resolution>.
3. Modes: Auto, manual, and alarm. In manual mode, each channel can also be viewed in single display mode. In the event of an alarm, alarming channel is to automatically switch to full screen. If several alarms are activated, channels in alarm are to be in auto-switching mode.
4. Channel Loss Alarm: Audible buzzer; occurrence details are to be recorded.
5. Time: Indicate date and time.
6. Timing of Auto-Switcher: 1 to 30 seconds, selectable.
7. Mounting: Standard **19 inch (483 mm)** rack complying with CEA 310-E, or freestanding desktop.

D. Manual Switch Bank: Low-loss, high-isolation, multiple-video switch to allow manual switching of multiple quad switches and cameras to a single output. Switches are to be illuminated.

E. Sequential Switchers: Automatically sequence outputs of multiple cameras to single monitor and videotape recorder.

1. Switching Time Interval: Continuously adjustable, 5 to 20 seconds minimum, with manual override.
2. Skip-Sequential-Hold Switch: One for each camera, with LED to indicate active camera.
3. Camera Identification Legend: Either on-screen message or label at skip-sequential switch.
4. Alarm Switching: In the event of an alarm, alarming channel is to automatically switch the monitor to full screen.
5. Mounting: Standard **19 inch (483 mm)** rack complying with CEA 310-E.

F. PTZ Controls: Arranged for multiple-camera control, with switches to select camera to be controlled.

1. Pan-and-Tilt Control: Joystick type.
2. Zoom Control: Momentary-contact, "in-out" push button.
3. Automatic-Scan Control: A push button for each camera with pan capability that places camera in automatic-scanning mode.

2.15 IP VIDEO SYSTEMS

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

1. [AXCESS International Inc.]
2. [Bosch Security Systems, Inc.]
3. [CBC (AMERICA) Corp]
4. [COP-USA]
5. [Crest Electronics, Inc]
6. [Dedicated Microcomputers Limited]
7. [Elbex Ltd.]
8. [EverFocus Electronics Corporation]
9. [Hitachi Cable America Inc.]
10. [Honeywell Commercial Security; Honeywell International, Inc.]
11. [Ikegami Electronics (USA) Inc]
12. [Interlogix; Carrier Global Corporation]
13. [JVC Americas Corp.]
14. [Panasonic Corporation of North America]
15. [Pelco]
16. [Salient Systems Inc.]
17. [Samsung Opto-Electronics]
18. [SANYO North America Corporation]
19. [Tyco Security Products; brand of Johnson Controls International plc, Building Solutions North America]
20. [Vicon Industries, Inc]
21. [VIVOTEK Inc.]
22. <Insert manufacturer's name>

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

1. [AXCESS International Inc.]
2. [Bosch Security Systems, Inc.]
3. [CBC (AMERICA) Corp]
4. [COP-USA]
5. [Crest Electronics, Inc]
6. [Dedicated Microcomputers Limited]
7. [Elbex Ltd.]
8. [EverFocus Electronics Corporation]
9. [Hitachi Cable America Inc.]
10. [Honeywell Commercial Security; Honeywell International, Inc.]
11. [Ikegami Electronics (USA) Inc]
12. [Interlogix; Carrier Global Corporation]
13. [JVC Americas Corp.]
14. [Panasonic Corporation of North America]
15. [Pelco]
16. [Salient Systems Inc.]
17. [Samsung Opto-Electronics]
18. [SANYO North America Corporation]
19. [Tyco Security Products; brand of Johnson Controls International plc, Building Solutions North America]
20. [Vicon Industries, Inc]
21. [VIVOTEK Inc.]
22. <Insert manufacturer's name>

- C. Description:

1. System is to provide high-quality delivery and processing of IP-based video, audio, and control data using standard Ethernet-based networks.
2. System is to have seamless integration of all video surveillance and control functions.



3. Graphical user interface software is to manage all IP-based video matrix switching and camera control functions, two-way audio communication, alarm monitoring and control, and recording and archive/retrieval management. IP system is to also be capable of integrating into larger system environments.
4. System design is to include all necessary compression software for high-performance, dual-stream, MPEG-2/MPEG-4 video. Unit is to provide connections for all video cameras, camera PTZ control data, bidirectional audio, discreet sensor inputs, and control system outputs.
5. All camera signals are to be compressed, encoded, and delivered onto the network for processing and control by the IP video-management software.
6. Camera system units are to be ruggedly built and designed for extreme adverse environments, complying with UL 50E Type environmental standards.
7. Encoder/decoder combinations are to place video, audio, and data network stream that can be managed from multiple workstations on the user's LAN or WAN.
8. All system interconnect cables, workstation PCs, PTZ joysticks, and network intermediate devices are to be provided for full performance of specified system.

2.16 VIDEO MOTION SENSORS (INTERIOR)

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 1. **[AXCESS International Inc.]**
 2. **[ICU Security, Inc]**
 3. **[Tyco Security Products; brand of Johnson Controls International plc, Building Solutions North America]**
 4. **[Visiontech]**
 5. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 1. **[AXCESS International Inc.]**
 2. **[ICU Security, Inc]**
 3. **[Tyco Security Products; brand of Johnson Controls International plc, Building Solutions North America]**
 4. **[Visiontech]**
 5. **<Insert manufacturer's name>**
- C. Device Performance: Detect changes in video signal within a user-defined protected zone. Video inputs are to be composite video as defined in SMPTE 170M. Provide an alarm output for each video input.
 1. Detect movement within protected zone of intruders wearing clothing with a reflectivity that differs from that of background scene by a factor of two. Reject all other changes in video signal.
 2. Modular design that allows for expansion or modification of number of inputs.
 3. Controls:
 - a. Size of detection zones.
 - b. Sensitivity of detection of each protected zone.
 4. Mounting: Standard **19 inch (483 mm)** rack complying with CEA 310-E.

2.17 CONTROL STATIONS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
1. **[AXCESS International Inc.]**
 2. **[Bosch Security Systems, Inc.]**
 3. **[CBC (AMERICA) Corp]**
 4. **[COP-USA]**
 5. **[Crest Electronics, Inc]**
 6. **[Elbex Ltd.]**
 7. **[Honeywell Commercial Security; Honeywell International, Inc.]**
 8. **[Interlogix; Carrier Global Corporation]**
 9. **[Panasonic Corporation of North America]**
 10. **[Pelco]**
 11. **[Samsung Opto-Electronics]**
 12. **[SANYO North America Corporation]**
 13. **[Tyco Security Products; brand of Johnson Controls International plc, Building Solutions North America]**
 14. **[Vicon Industries, Inc]**
 15. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[AXCESS International Inc.]**
 2. **[Bosch Security Systems, Inc.]**
 3. **[CBC (AMERICA) Corp]**
 4. **[COP-USA]**
 5. **[Crest Electronics, Inc]**
 6. **[Elbex Ltd.]**
 7. **[Honeywell Commercial Security; Honeywell International, Inc.]**
 8. **[Interlogix; Carrier Global Corporation]**
 9. **[Panasonic Corporation of North America]**
 10. **[Pelco]**
 11. **[Samsung Opto-Electronics]**
 12. **[SANYO North America Corporation]**
 13. **[Tyco Security Products; brand of Johnson Controls International plc, Building Solutions North America]**
 14. **[Vicon Industries, Inc]**
 15. **<Insert manufacturer's name>**
- C. Description: Heavy-duty, freestanding, modular, metal furniture units arranged to house electronic equipment. Coordinate component arrangement and wiring with components and wiring of other systems.
- D. Equipment Mounting: Standard **19 inch (483 mm)** rack complying with CEA 310-E.
- E. Normal System Power Supply: 120 V, 60 Hz, through a locked disconnect device and an isolation transformer in central-station control unit. Central-station control unit is to supply power to all components connected to it unless otherwise indicated.
- F. Power Continuity for Control Station: Batteries in power supplies of central-station control units and individual system components are to maintain continuous system operation during outages of both normal and backup ac system supply.



1. Batteries: Rechargeable, valve-regulated, recombinant, sealed, lead-acid type with nominal 10-year life expectancy. Capacity adequate to operate portions of system served including audible trouble signal devices for up to four hours and audible and visual alarm devices under alarm conditions for an additional 10 minutes.
2. Battery Charger: Solid-state, fully automatic, variable-charging-rate type. Charger is to recharge fully discharged battery within 24 hours.

G. Annunciation: Indicate change in system condition and switching of system or component to backup power.

2.18 SIGNAL TRANSMISSION COMPONENTS

- A. Cable: Coaxial cable elements have 75 Ω nominal impedance. Comply with requirements in Section 26519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Video Surveillance Coaxial Cable Connectors: BNC type, 75 Ω . Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine pathway elements intended for cables. Check raceways and other elements for compliance with space allocations, installation tolerance, hazards to camera installation, and other conditions affecting installation.
- B. Examine roughing-in for LAN, WAN, and IP network before device installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 WIRING

- A. Comply with requirements in Section 270528 "Pathways for Communications Systems."
- B. Wiring Method: Install cables in raceways unless otherwise indicated.
 1. Except raceways are not required in accessible indoor ceiling spaces and attics.
 2. Except raceways are not required in hollow gypsum board partitions.
 3. Conceal raceways and wiring except in unfinished spaces.
- C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.
- D. Splices, Taps, and Terminations: For power and control wiring, use numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- E. For communication wiring, comply with the following:

1. Section 271313 "Communications Copper Backbone Cabling."
2. Section 271323 "Communications Optical Fiber Backbone Cabling."
3. Section 271333 "Communications Coaxial Backbone Cabling."
4. Section 271513 "Communications Copper Horizontal Cabling."
5. Section 271523 "Communications Optical Fiber Horizontal Cabling."
6. Section 271533 "Communications Coaxial Horizontal Cabling."

- F. Grounding: Provide independent-signal circuit grounding recommended in writing by manufacturer.

3.3 INSTALLATION OF VIDEO SURVEILLANCE

- A. Install cameras and infrared illuminators level and plumb.
- B. Install cameras with **84 inch (2134 mm)** minimum clear space below cameras and their mountings. Change type of mounting to achieve required clearance.
- C. Set pan unit and pan-and-tilt unit stops to suit final camera position and to obtain the field of view required for camera. Connect all controls and alarms, and adjust.
- D. Install power supplies and other auxiliary components at control stations unless otherwise indicated.
- E. Install tamper switches on components indicated to receive tamper switches, arranged to detect unauthorized entry into system-component enclosures and mounted in self-protected, inconspicuous positions.
- F. Avoid ground loops by making ground connections only at the control station.
1. For 12 and 24 V(dc) cameras, connect the coaxial cable shields only at the monitor end.
- G. Identify system components, wiring, cabling, and terminals according to Section 260553 "Identification for Electrical Systems" and Section 270528 "Pathways for Communications Systems."

3.4 FIELD QUALITY CONTROL

- A. Administrant for Security Tests and Inspections:
1. **[Owner][Tenant]** will engage qualified security testing and inspecting agency to administer and perform tests and inspections.
 2. Engage qualified security testing and inspecting agency to administer and perform tests and inspections.
 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
 4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].
- B. Acceptance Testing Preparation:
1. **<Insert requirements>**.
- C. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.
- D. Tests and Inspections:



1. Inspection: Verify that units and controls are properly installed, connected, and labeled, and that interconnecting wires and terminals are identified.
2. Pretesting: Align and adjust system and pretest components, wiring, and functions to verify that they comply with specified requirements. Conduct tests at varying lighting levels, including day and night scenes as applicable. Prepare video-surveillance equipment for acceptance and operational testing as follows:
 - a. Prepare equipment list described in "Informational Submittals" Article.
 - b. Verify operation of auto-iris lenses.
 - c. Set back-focus of fixed focal length lenses. At focus set to infinity, simulate nighttime lighting conditions by using a dark glass filter of a density that produces a clear image. Adjust until image is in focus with and without the filter.
 - d. Set back-focus of zoom lenses. At focus set to infinity, simulate nighttime lighting conditions by using a dark glass filter of a density that produces a clear image. Additionally, set zoom to full wide angle and aim camera at an object **50 to 75 ft (17 to 23 m)** away. Adjust until image is in focus from full wide angle to full telephoto, with the filter in place.
 - e. Set and name all preset positions; consult Owner's personnel.
 - f. Set sensitivity of motion detection.
 - g. Connect and verify responses to alarms.
 - h. Verify operation of control-station equipment.
3. Test Schedule: Schedule tests after pretesting has been successfully completed and system has been in normal functional operation for at least 14 days. Provide a minimum of 10 days' notice of test schedule.
4. Operational Tests: Perform operational system tests to verify that system complies with Specifications. Include all modes of system operation. Test equipment for proper operation in all functional modes.

E. Nonconforming Work:

1. Video surveillance system will be considered defective if it does not pass tests and inspections.

F. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

G. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.

1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.

3.5 ADJUSTING

A. Occupancy Adjustments: When requested within **[12]<Insert number>** months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to **[two]<Insert number>** visits to Project during other-than-normal occupancy hours for this purpose. Tasks are to include, but are not limited to, the following:

1. Check cable connections.
2. Check proper operation of cameras and lenses. Verify operation of auto-iris lenses and adjust back-focus as needed.
3. Adjust all preset positions; consult Owner's personnel.
4. Recommend changes to cameras, lenses, and associated equipment to improve Owner's use of video surveillance system.

5. Provide a written report of adjustments and recommendations.

3.6 CLEANING

- A. Clean installed items using methods and materials recommended in writing by manufacturer.
- B. Clean video-surveillance-system components, including camera-housing windows, lenses, and monitor screens.

3.7 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain video-surveillance equipment.

END OF SECTION 28 20 00 00



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28 - Electronic Safety and Security

Task	Specification	Specification Description
28 21 00 00	28 20 00 00	Video Surveillance
28 21 31 00	26 09 13 00	Electrical Power Monitoring
28 21 31 00	28 20 00 00	Video Surveillance
28 21 31 00	28 31 00 00	Intrusion Detection



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SECTION 28 31 00 00 - INTRUSION DETECTION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Sensing devices.
2. Control devices.
3. Notification devices.
4. Security fasteners.

B. Related Sections:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for power cabling between master control units and field-mounted devices and control units.
5. Section 271313 "Communications Copper Backbone Cabling" for Category 5e, 6, and 7 backbone (riser-rated) cabling.
6. Section 271323 "Communications Optical Fiber Backbone Cabling" for multi- and single-mode backbone (riser-rated) optical fiber.
7. Section 271513 "Communications Copper Horizontal Cabling" for Category 5e, 6, and 7 horizontal (general use, riser-, and plenum-rated) cabling.
8. Section 271523 "Communications Optical Fiber Horizontal Cabling" for multi- and single-mode horizontal (general use, riser-, and plenum-rated) optical fiber.
9. Section 281300 "Access Control System Software and Database Management" for applications, interfaces, and workstations.
10. Section 283121 "Area and Perimeter Intrusion Detection" for outdoor intrusion detection devices, including lighting and communications associated with chain-link fence gates.
11. Section 282000 "Video Surveillance" for CCTV cameras that are used as devices for video motion detection.

1.2 DEFINITIONS

- A. CCTV: Closed-circuit television.
- B. PIR: Passive infrared.
- C. RFI: Radio-frequency interference.
- D. UPS: Uninterruptible power supply.
- E. Control Unit: System component that monitors inputs and controls outputs through various circuits.



- F. Master Control Unit: System component that accepts inputs from other control units and may also perform control-unit functions. The unit has limited capacity for the number of protected zones and is installed at an unattended location or at a location where it is not the attendant's primary function to monitor the security system.
- G. Monitoring Station: Facility that receives signals and has personnel in attendance at all times to respond to signals. A central station is a monitoring station that is listed.
- H. Protected Zone: A protected premises or an area within a protected premises that is provided with means to prevent an unwanted event.
- I. Standard Intruder: A person who weighs **100 lb (45 kg)** or less and whose height is **60 inch (1525 mm)** or less; dressed in a long-sleeved shirt, slacks, and shoes[**unless environmental conditions at the site require protective clothing**].
- J. Standard-Intruder Movement: Any movement, such as walking, running, crawling, rolling, or jumping, of a "standard intruder" in a protected zone.
- K. Systems Integration: The bringing together of components of several systems containing interacting components to achieve indicated functional operation of combined systems.
- L. Zone. A defined area within a protected premises. It is a space or area for which an intrusion must be detected and uniquely identified. The sensor or group of sensors must then be assigned to perform the detection, and any interface equipment between sensors and communication must link to master control unit.

1.3 ACTION SUBMITTALS

- A. Product Data:
 - 1. For each type of product.
 - a. Include manufacturer's sample extended warranty language.
- B. Shop Drawings: Detail assemblies of standard components that are custom assembled for specific application on this Project.
 - 1. Functional Block Diagram: Show single-line interconnections between components including interconnections between components specified in this Section and those furnished under other Sections. Indicate methods used to achieve systems integration. Indicate control, signal, and data communication paths and identify **[programmable logic controllers][networks][and]** control interface devices and media to be used. Describe characteristics of network and other data communication lines.
 - a. Indicate methods used to achieve systems integration.
 - b. Indicate control, signal, and data communication paths and identify PLCs, networks, control interface devices, and media to be used.
 - c. Describe characteristics of network and other data communication lines.
 - d. Describe methods used to protect against power outages and transient voltages including types and ratings of isolation and surge suppression devices used in data, communication, signal, control, and ac and dc power circuits.
 - 2. Raceway Riser Diagrams: Detail raceway runs required for intrusion detection[**and for systems integration**]. Include designation of devices connected by raceway, raceway type and size, and

- type and size of wire and cable fill for each raceway run.
 3. UPS: Sizing calculations.
 4. Site and Floor Plans: Indicate final outlet and device locations, routing of raceways, and cables inside and outside the building. **[Include room layout for master control-unit console, terminal cabinet, racks, and UPS.]**
 5. Master Control-Unit Console Layout: Show required artwork and device identification.
 6. Device Address List: Coordinate with final system programming.
 7. System Wiring Diagrams: Include system diagrams unique to Project. Show connections for all devices, components, and auxiliary equipment. Include diagrams for equipment and for system with all terminals and interconnections identified.
 8. Details of surge-protection devices and their installation.
 9. Sensor detection patterns and adjustment ranges.
- C. Design Data: Include method of operation and supervision of each component and each type of circuit. Show sequence of operations for manually and automatically initiated system or equipment inputs. Description must cover this specific Project; manufacturer's standard descriptions for generic systems are unacceptable.
- D. Samples for Initial Selection: For units with factory-applied color finishes.
- E. Samples for Verification: For each type of exposed finish required.
- F. Field quality-control reports.
1. Anchor inspection reports documenting inspections of built-in and cast-in anchors.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: In addition to qualification data specified in Section 260010 "Supplemental Requirements for Electrical" submit qualification data for **[Installer][intrusion detection systems integrator][testing agency]**.
- B. Manufacturer's published instructions.
- C. Field Reports:
1. Manufacturer's field reports for field quality-control support.
 2. Field Test Plans: Test plan and report defining all tests required to ensure that system meets technical, operational, and performance specifications within **[60 days]<Insert number>** of date of Contract award.
 3. Evaluation Reports: Examination reports documenting inspections of substrates, areas, and conditions.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For intrusion detection system to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
1. Data for each type of product, including features and operating sequences, both automatic and manual.
 2. Master control-unit hardware and software data.



1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Intrusion Detection Devices: Furnish quantity equal to **[five]<Insert number>** percent of the number of units of each type installed, but no fewer than one of each type.
 - 2. Fuses: **[Three]<Insert number>** of each kind and size.
 - 3. Tool Kit: Provide **[six]<Insert number>** sets of tools for use with security fasteners, each packaged in a compartmented kit configured for easy handling and storage.
 - 4. Security Fasteners: Furnish no fewer than **[1 box for every 50]<Insert numbers>** boxes or fraction thereof, of each type and size of security fastener installed.

1.7 QUALIFICATIONS

- A. Security Design Professional: Design professional with active Physical Security Professional (PSP) certification issued by American Society for Industrial Security (ASIS International) and with documented experience managing installation of security systems in similar size and complexity.
- B. Security Testing and Inspecting Agency: Entity possessing active credentials from qualified electrical testing laboratory recognized by authorities having jurisdiction.
 - 1. On-site security testing supervisor must have **[ASIS][PSP]<Insert organization>** certification and documented training and experience with testing security equipment in accordance with **[ASIS]<Insert organization>** testing standards.
- C. Intrusion Detection Systems Installer:
 - 1. An employer of workers, at least one of whom is a Certified Alarm Technician, Level 1.
 - 2. Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
 - 3. Layout Responsibility: Preparation of Shop Drawings[**and cabling administration Drawings**][, **cabling administration Drawings, and field testing program development**] by [an RCDD][a **Technician**].
 - 4. Installation Supervision: Installation must be under the direct supervision of **[Technician][Level 2 Commercial Installer]**, who must be present at all times when Work of this Section is performed at Project site.
- D. Intrusion Detection Systems Integrator: An experienced intrusion detection equipment supplier[**and Installer**] who has completed systems integration work for installations similar in material, design, and extent to that indicated for this Project, whose work has resulted in construction with a record of successful in-service performance.
 - 1. At least one of whom is a Certified Systems Integrator.

1.8 PROJECT CONDITIONS

- A. Environmental Conditions: Capable of withstanding the requirements specified in Section 018116 "Facility Environmental Requirements" and the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
 - 1. Altitude: Sea level to **[4000 ft (1220 m)]<Insert elevation>**.
 - 2. Master Control Unit: Rated for continuous operation in an ambient of **60 to 85 deg F (16 to 29**

- deg C) and a relative humidity of 20 to 80 percent, noncondensing.
3. Interior, Controlled Environment: System components, except master control unit, installed in [air-conditioned][temperature-controlled] interior environments must be rated for continuous operation in ambients of [36 to 122 deg F (2 to 50 deg C)]<Insert temperature range> dry bulb and 20 to 90 percent relative humidity, noncondensing.
4. Interior, Uncontrolled Environment: System components installed in [non-air-conditioned][non-temperature-controlled] interior environments must be rated for continuous operation in ambients of [0 to 122 deg F (minus 18 to plus 50 deg C)]<Insert temperature range> dry bulb and 20 to 90 percent relative humidity, noncondensing.
5. Exterior Environment: System components installed in locations exposed to weather must be rated for continuous operation in ambients of [minus 30 to plus 122 deg F (minus 34 to plus 50 deg C)]<Insert temperature range> dry bulb and 20 to 90 percent relative humidity, condensing. Comply with UL 294 and UL 639 for outdoor-use equipment. Rate for continuous operation when exposed to rain as specified in UL 50E, winds up to [85 mph (137 km/h)][and snow cover up to 24 inch (610 mm) thick].
6. Hazardous Environment: System components located in areas where fire or explosion hazards may exist because of flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers or flyings must be rated, listed, and installed according to NFPA 70.

1.9 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer and Installer agree to repair or replace components of intrusion detection devices and equipment that fail in materials or workmanship within specified warranty period.
 1. Warranty Period: [Two]<Insert number> years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. System Description: [Hardwired][Multiplexed], modular, microprocessor-based controls, intrusion sensors and detection devices, and communication links to perform monitoring, alarm, and control functions.
 1. Supervision: System components must be continuously monitored for normal, alarm, [supervisory], and trouble conditions. Indicate deviations from normal conditions at any location in system. Indication includes identification of device or circuit in which deviation has occurred and whether deviation is an alarm or malfunction.
 - a. Alarm Signal: Display at master control unit and actuate audible and visual alarm devices.
 - b. Trouble Condition Signal: Distinct from other signals, indicating that system is not fully functional. Trouble signal must indicate system problems such as battery failure, open or shorted transmission line conductors, or control-unit failure.
 - c. Supervisory Condition Signal: Distinct from other signals, indicating an abnormal condition as specified for the particular device or control unit.
 2. System Control:
 - a. Master control unit must directly monitor intrusion detection units and connecting wiring.
 - b. Master control unit must directly monitor intrusion detection devices[, perimeter detection units,], control units associated with perimeter detection units, and connecting wiring in a multiplexed distributed control system or as part of a network.

3. System must automatically reboot program without error or loss of status or alarm data after any system disturbance.
4. Operator Commands:
 - a. Help with System Operation: Display all commands available to operator. Help command, followed by a specific command, must produce a short explanation of the purpose, use, and system reaction to that command.
 - b. Acknowledge Alarm: To indicate that alarm message has been observed by operator.
 - c. Place Protected Zone in Access: Disable all intrusion-alarm circuits of a specific protected zone. Tamper circuits may not be disabled by operator.
 - d. Place Protected Zone in Secure: Activate all intrusion-alarm circuits of a protected zone.
 - e. Protected Zone Test: Initiate operational test of a specific protected zone.
 - f. System Test: Initiate system-wide operational test.
 - g. Print reports.
5. Timed Control at Master Control Unit: Allow automatically timed "secure" and "access" functions of selected protected zones.
6. Automatic Control of Related Systems: Alarm or supervisory signals from certain intrusion detection devices control the following functions in related systems:
 - a. Switch selected lights.
 - b. Shift elevator control to a different mode.
 - c. Open a signal path between certain intercommunication stations.
 - d. Shift sound system to "listening mode" and open a signal path to certain system speakers.
 - e. Switch signal to selected monitor from CCTV camera in vicinity of sensor signaling an alarm.
 - f. **<Insert description of automatic control required>.**
7. Printed Record of Events: Print a record of alarm, supervisory, and trouble events on system printer. Sort and report by protected zone, device, and function. When master control unit receives a signal, print a report of alarm, supervisory, or trouble condition. Report type of signal (alarm, supervisory, or trouble), protected zone description, date, and time of occurrence. Differentiate alarm signals from other indications. When system is reset, report reset event with the same information concerning device, location, date, and time. Commands must initiate the reporting of a list of current alarm, supervisory, and trouble conditions in system or a log of past events.
8. Response Time: **[Two]<Insert number>** seconds between actuation of any alarm and its indication at master control unit.
9. Circuit Supervision: Supervise all signal and data transmission lines, links with other systems, and sensors from master control unit. Indicate circuit and detection device faults with both protected zone and trouble signals, sound a distinctive audible tone, and illuminate an LED. Maximum permissible elapsed time between occurrence of a trouble condition and indication at master control unit is 20 seconds. Initiate an alarm in response to opening, closing, shorting, or grounding of a signal or data transmission line.
10. Programmed Secure-Access Control: System must be programmable to automatically change status of various combinations of protected zones between secure and access conditions at scheduled times. Status changes may be preset for repetitive, daily, and weekly; specially scheduled operations may be preset up to a year in advance. Manual secure-access control stations must override programmed settings.
11. Manual Secure-Access Control: Coded entries at manual stations must change status of associated protected zone between secure and access conditions.

- B. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

- C. Seismic and Wind Performance: Installed assembly must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria."
1. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events[**and unit must be fully operational after seismic events**]."
 2. Component Importance Factor (Ip): [1.0][1.5].
 3. Component Amplification Factor (ap): [1.0][2.5]<Insert value>.
 4. Component Response Modification Factor (Rp): [1.5][2.0][2.5][6.0]<Insert value>.
 5. Component Overstrength Factor (Ω_o): [1.5][2.5]<Insert value>.
- D. Compatibility: Detection devices and their communication features, connecting wiring, and master control unit must be selected and configured with accessories for full compatibility with the following equipment:
1. Door hardware specified in Section 087100 "Door Hardware."
 2. Door hardware specified in Section 087111 "Door Hardware (Descriptive Specification)."
 3. Elevators specified in Section 142100 "Electric Traction Elevators."
 4. Elevators specified in Section 142400 "Hydraulic Elevators."
 5. Lighting controls specified in Section 260923 "Lighting Control Devices."
 6. Lighting controls specified in Section 260943.16 "Addressable-Luminaire Lighting Controls" and Section 260943.23 "Relay-Based Lighting Controls."
 7. Intercom and program systems specified in Section 275123.20 "Commercial Intercommunications and Program Systems."
 8. Intercom and program systems specified in Section 275123.50 "Educational Intercommunications and Program Systems."
 9. Public address and mass notification systems specified in Section 275116 "Public Address Systems."
 10. Access control system specified in Section 281300 "Access Control System Software and Database Management."
 11. Fire alarm system specified in Section 284600 "Fire Detection and Alarm."
 12. Mass notification system specified in Section 284700 "Mass Notification."
 13. Perimeter security system specified in Section 283121 "Area and Perimeter Intrusion Detection."
 14. Video surveillance system specified in Section 282000 "Video Surveillance."
 15. **<Insert system or equipment>** specified in Section **<Insert Section number>** "**<Insert Section title>**."
- E. Surge Protection: Protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads. Include surge protection for external wiring of each conductor entry connection to components.
1. Minimum Protection for Power Lines 120 V and More: Auxiliary panel suppressors complying with requirements in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."
 2. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Lines: Listed and labeled by a qualified testing agency for compliance with NFPA 731.
- F. Interference Protection: Components must be unaffected by radiated RFI and electrical induction of 15 V/m over a frequency range of 10 to 10 000 MHz and conducted interference signals up to 0.25 V(rms) injected into power supply lines at 10 to 10 000 MHz.
- G. Tamper Protection: Tamper switches on detection devices, control units, annunciators, pull boxes, junction boxes, cabinets, and other system components must initiate a tamper-alarm signal when unit is opened or partially disassembled and when entering conductors are cut or disconnected. Master control-unit alarm display must identify tamper alarms and indicate locations.
- H. Self-Testing Devices: Automatically test themselves periodically, but not less than once per hour, to

verify normal device functioning and alarm initiation capability. Devices transmit test failure to master control unit.

- I. Antimasking Devices: Automatically check operation continuously or at intervals of a minute or less, and use signal-processing logic to detect blocking, masking, jamming, tampering, or other operational dysfunction. Devices transmit detection of operational dysfunction to master control unit as an alarm signal.
- J. Addressable Devices: Transmitter and receivers must communicate unique device identification and status reports to master control unit.
- K. Remote-Controlled Devices: Individually and remotely adjustable for sensitivity and individually monitored at master control unit for calibration, sensitivity, and alarm condition.
- L. Enclosures:
 - 1. Interior Sensors: Enclosures that protect against dust, falling dirt, and dripping noncorrosive liquids.
 - 2. Interior Electronics: UL 50E, Type 12.
 - 3. Exterior Electronics: UL 50E, Type 4X, **[fiberglass][stainless steel]**.
 - 4. Corrosion Resistant: UL 50E, Type 4X, **[PVC][stainless steel]**.
 - 5. Screw Covers: Where enclosures are readily accessible, secure with security fasteners of type appropriate for enclosure.
- M. Protective Coatings for Heat-Treated Alloy Steel:
 - 1. Zinc chromate, ASTM F1135, Grade 3 or Grade 4, for exterior applications and interior applications where indicated.
 - 2. Zinc phosphate with oil, ASTM F1137, Grade I, or black oxide unless otherwise indicated.

2.2 SENSING DEVICES

- A. Flush-Mounted Door or Window Switch :
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Aleph America Corporation]**
 - b. **[George Risk Industries]**
 - c. **[Honeywell Commercial Security; Honeywell International, Inc.]**
 - d. **[Honeywell International Inc.]**
 - e. **[Interlogix; Carrier Global Corporation]**
 - f. **[Optex Inc.]**
 - g. **[Potter Electric Signal Company, LLC]**
 - h. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Aleph America Corporation]**
 - b. **[George Risk Industries]**

- c. [Honeywell Commercial Security; Honeywell International, Inc.]
 - d. [Honeywell International Inc.]
 - e. [Interlogix; Carrier Global Corporation]
 - f. [Optex Inc.]
 - g. [Potter Electric Signal Company, LLC]
 - h. <Insert manufacturer's name>
3. Listing Criteria:
- a. Listed and labeled by a qualified electrical testing agency for compliance with UL 639.
 - b. Listed and labeled by a qualified electrical testing agency for compliance with SIA CP-01.
 - c. FM Global Compliance: FM Approved and labeled perimeter security devices and equipment.
4. Standard Features:
- a. Balanced-magnetic switch, complying with UL 634, installed on frame with integral overcurrent device to limit current to 80 percent of switch capacity.
 - b. Bias magnet and minimum of **[two][three]** encapsulated reed switches must resist compromise from introduction of foreign magnetic fields.
 - c. Unobtrusive and flush with surface of door or window frame.
 - d. Remote Test: Simulate movement of actuating magnet from master control unit.

B. Overhead Door Switch :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
- a. [Aleph America Corporation]
 - b. [George Risk Industries]
 - c. [Honeywell Commercial Security; Honeywell International, Inc.]
 - d. [Honeywell International Inc.]
 - e. [Interlogix; Carrier Global Corporation]
 - f. [Optex Inc.]
 - g. [Potter Electric Signal Company, LLC]
 - h. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. [Aleph America Corporation]
 - b. [George Risk Industries]
 - c. [Honeywell Commercial Security; Honeywell International, Inc.]
 - d. [Honeywell International Inc.]
 - e. [Interlogix; Carrier Global Corporation]
 - f. [Optex Inc.]
 - g. [Potter Electric Signal Company, LLC]
 - h. <Insert manufacturer's name>
3. Listing Criteria: Listed and labeled for outdoor locations.
4. Standard Features:
- a. Balanced-magnetic switch, complying with UL 634, installed on frame with integral

- overcurrent device to limit current to 80 percent of switch capacity.
- b. Bias magnet and minimum of **[two][three]** encapsulated reed switches must resist compromise from introduction of foreign magnetic fields.
- c. Has door-mounted magnet and floor-mounted switch unit.
- d. Remote Test: Simulate movement of actuating magnet from master control unit.

C. Wall-Mounted PIR Sensor :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Aleph America Corporation]**
 - b. **[Bosch Security Systems, Inc.]**
 - c. **[Crow Electronic Engineering, Inc]**
 - d. **[Digital Security Controls Ltd.]**
 - e. **[Honeywell International Inc.]**
 - f. **[Interlogix; Carrier Global Corporation]**
 - g. **[Visonic Inc]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Aleph America Corporation]**
 - b. **[Bosch Security Systems, Inc.]**
 - c. **[Crow Electronic Engineering, Inc]**
 - d. **[Digital Security Controls Ltd.]**
 - e. **[Honeywell International Inc.]**
 - f. **[Interlogix; Carrier Global Corporation]**
 - g. **[Visonic Inc]**
 - h. **<Insert manufacturer's name>**
3. Listing Criteria:
 - a. Listed and labeled by a qualified electrical testing agency for compliance with UL 639.
 - b. Listed and labeled by a qualified electrical testing agency for compliance with SIA CP-01.
 - c. Listed and labeled by a qualified electrical testing agency for compliance with SIA PIR-01.
 - d. FM Global Compliance: FM Approved and labeled perimeter security devices and equipment.
4. Standard Features:
 - a. Sensors detect intrusion by monitoring infrared wavelengths emitted from a human body within their protected zone and by being insensitive to general thermal variations.
 - b. Maximum Detection Range: 125 percent of indicated distance for individual units and not less than **50 ft (15 m).[Provide adjustable coverage pattern as indicated.]**
 - c. Sensitivity: Adjustable pattern coverage to detect a change in temperature of **2 deg F (1 deg C)** or less, and standard-intruder movement within sensor's detection patterns at any speed between **0.3 to 7.5 ft/s (0.09 to 2.3 m/s)** across two adjacent segments of detector's field of view.
 - d. Test Indicator: LED test indicator that is not visible during normal operation. When visible, indicator must light when sensor detects an intruder. Locate test enabling switch under

- sensor housing cover.
 - e. Remote Test: When initiated by master control unit, start a test sequence for each detector element that simulates standard-intruder movement within sensor's detection patterns, causing an alarm.
- D. Ceiling-Mounted PIR Sensor :
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Aleph America Corporation]**
 - b. **[Bosch Security Systems, Inc.]**
 - c. **[Crow Electronic Engineering, Inc]**
 - d. **[Digital Security Controls Ltd.]**
 - e. **[Honeywell International Inc.]**
 - f. **[Interlogix; Carrier Global Corporation]**
 - g. **[Visonic Inc]**
 - h. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Aleph America Corporation]**
 - b. **[Bosch Security Systems, Inc.]**
 - c. **[Crow Electronic Engineering, Inc]**
 - d. **[Digital Security Controls Ltd.]**
 - e. **[Honeywell International Inc.]**
 - f. **[Interlogix; Carrier Global Corporation]**
 - g. **[Visonic Inc]**
 - h. **<Insert manufacturer's name>**
 - 3. Listing Criteria:
 - a. Listed and labeled by a qualified electrical testing agency for compliance with UL 639.
 - b. Listed and labeled by a qualified electrical testing agency for compliance with SIA CP-01.
 - c. Listed and labeled by a qualified electrical testing agency for compliance with SIA PIR-01.
 - d. FM Global Compliance: FM Approved and labeled perimeter security devices and equipment.
 - 4. Standard Features:
 - a. Sensors detect intrusion by monitoring infrared wavelengths emitted from a human body within their protected zone and by being insensitive to general thermal variations.
 - b. Spot-Detection Pattern: Full 360-degree conical.
 - c. Pattern Size: **84 inch (2135 mm)** diameter at floor level for units mounted **96 inch (2440 mm)** above floor; **18 ft (5.5 m)** diameter at floor level for units mounted **25 ft (7.6 m)** above floor.
 - d. Sensitivity: Adjustable pattern coverage to detect a change in temperature of **2 deg F (1 deg C)** or less, and standard-intruder movement within sensor's detection patterns at any speed between **0.3 to 7.5 ft/s (0.09 to 2.3 m/s)** across two adjacent segments of detector's field of view.
 - e. Test Indicator: LED test indicator that is not visible during normal operation. When visible, indicator must light when sensor detects an intruder. Locate test enabling switch under

- sensor housing cover.
 - f. Remote Test: When initiated by master control unit, start a test sequence for each detector element that simulates standard-intruder movement within sensor's detection patterns, causing an alarm.

E. Microwave Intrusion Detector (Interior) :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Bosch Security Systems, Inc.]**
 - b. **[Crow Electronic Engineering, Inc]**
 - c. **[Digital Security Controls Ltd.]**
 - d. **[Interlogix; Carrier Global Corporation]**
 - e. **[Visonic Inc]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Bosch Security Systems, Inc.]**
 - b. **[Crow Electronic Engineering, Inc]**
 - c. **[Digital Security Controls Ltd.]**
 - d. **[Interlogix; Carrier Global Corporation]**
 - e. **[Visonic Inc]**
 - f. **<Insert manufacturer's name>**
3. Listing Criteria:
 - a. Listed and labeled by a qualified electrical testing agency for compliance with UL 639.
 - b. Listed and labeled by a qualified electrical testing agency for compliance with SIA CP-01.
 - c. FM Global Compliance: FM Approved and labeled perimeter security devices and equipment.
4. Standard Features:
 - a. Microwave transmitter establishes an electromagnetic field in an adjustable detection pattern and detects intrusion by monitoring changes in that pattern.
 - b. Sensitivity: Adjustable, able to detect standard-intruder movement within sensor's detection pattern at any speed between **0.3 to 7.5 ft/s (0.09 to 2.3 m/s)**. Sensor sensitivity adjustments must be accessible only when sensor housing is removed, and sensors must comply with 47 CFR 15.
 - c. Activation Indicator: LED indicator must not be visible during normal operation. Indicator must light when sensor detects a standard intruder. Locate test-enabling switch under sensor housing cover.
 - d. Remote Test: When initiated by master control unit, start a test sequence for each detector element that simulates standard-intruder movement within sensor's detection patterns, causing an alarm.

F. Acoustic-Type, Glass-Break Sensor :

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

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

- a. [Crow Electronic Engineering, Inc]
 - b. [Digital Security Controls Ltd.]
 - c. [Honeywell International Inc.]
 - d. [Interlogix; Carrier Global Corporation]
 - e. [International Electronics, Inc.]
 - f. [Potter Electric Signal Company, LLC]
 - g. [Visonic Inc]
 - h. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Crow Electronic Engineering, Inc]
 - b. [Digital Security Controls Ltd.]
 - c. [Honeywell International Inc.]
 - d. [Interlogix; Carrier Global Corporation]
 - e. [International Electronics, Inc.]
 - f. [Potter Electric Signal Company, LLC]
 - g. [Visonic Inc]
 - h. <Insert manufacturer's name>
3. Listing Criteria:
- a. Listed and labeled by a qualified electrical testing agency for compliance with UL 639.
 - b. Listed and labeled by a qualified electrical testing agency for compliance with SIA CP-01.
 - c. Listed and labeled by a qualified electrical testing agency for compliance with SIA GB-01.
 - d. FM Global Compliance: FM Approved and labeled perimeter security devices and equipment.
4. Standard Features:
- a. Detect unique, airborne acoustic energy spectrum caused by breaking glass.
 - b. Sensor Element: Microprocessor-based, digital device to detect breakage of plate, laminate, tempered, and wired glass while rejecting common causes of false alarms. Detection pattern must have at least a **20 ft (6 m)** range.
 - c. Hookup Cable: Factory installed, not less than **72 inch (1830 mm)**.
 - d. Activation Indicator: LED on sensor housing that lights when responding to vibrations, remaining on until manually reset at sensor control unit[**or at master control unit**].
 - e. Control Unit: Integral with sensor housing or in a separate assembly, locally adjustable by control under housing cover.
 - f. Glass-Break Simulator: A device to induce frequencies into protected glass pane that simulate breaking glass without causing damage to glass.

G. Piezoelectric-Type, Glass-Break Sensor :

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

- b. [Interlogix; Carrier Global Corporation]
 - c. [Potter Electric Signal Company, LLC]
 - d. [Visonic Inc]
 - e. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Honeywell International Inc.]
 - b. [Interlogix; Carrier Global Corporation]
 - c. [Potter Electric Signal Company, LLC]
 - d. [Visonic Inc]
 - e. <Insert manufacturer's name>
- 3. Listing Criteria:
 - a. Listed and labeled by a qualified electrical testing agency for compliance with UL 639.
 - b. Listed and labeled by a qualified electrical testing agency for compliance with SIA CP-01.
 - c. Listed and labeled by a qualified electrical testing agency for compliance with SIA GB-01.
 - d. FM Global Compliance: FM Approved and labeled perimeter security devices and equipment.
- 4. Standard Features:
 - a. Detect unique, high-frequency vibrations caused by breaking glass.
 - b. Sensor Element: Piezoelectric crystals in a housing designed to mount directly to glass surface with adhesive provided by element manufacturer.
 - c. Circular detection pattern, with at least a **60 inch (1525 mm)** radius on a continuous glass pane. Sensor element may not have an area larger than **4 inch² (25.80 cm²)**.
 - d. Hookup Cable: Factory installed, not less than **72 inch (1830 mm)**.
 - e. Activation Indicator: LED on sensor housing that lights when responding to vibrations, remaining on until manually reset at sensor control unit[**or at master control unit**].
 - f. Control Unit: Integral with sensor housing or in a separate assembly, locally adjustable by control under housing cover.
 - g. Glass-Break Simulator: A device to induce frequencies into protected glass pane that simulate breaking glass without causing damage to glass.

H. Vibration Sensor :

- 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Honeywell International Inc.]
 - b. [Interlogix; Carrier Global Corporation]
 - c. [Potter Electric Signal Company, LLC]
 - d. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Honeywell International Inc.]

- b. [Interlogix; Carrier Global Corporation]
 - c. [Potter Electric Signal Company, LLC]
 - d. <Insert manufacturer's name>
3. Listing Criteria:
- a. Listed and labeled by a qualified electrical testing agency for compliance with UL 639.
 - b. Listed and labeled by a qualified electrical testing agency for compliance with SIA CP-01.
 - c. Listed and labeled by a qualified electrical testing agency for compliance with SIA GB-01.
 - d. FM Global Compliance: FM Approved and labeled perimeter security devices and equipment.
4. Standard Features:
- a. A sensor control unit and piezoelectric crystal sensor elements that are designed to be rigidly mounted to structure being protected.
 - b. Detects high-frequency vibrations generated by use of such tools as oxyacetylene torches, oxygen lances, high-speed drills and saws, and explosives that penetrate a structure while not responding to other mechanical vibration.
 - c. Circular detection pattern, with at least a **72 inch (1830 mm)** radius on protected structure.
 - d. Hookup Cable: Factory installed, not less than **72 inch (1830 mm)**.
 - e. Control Unit: Integral with sensor housing or in a separate assembly, locally adjustable by control under housing cover.
 - f. Glass-Break Simulator: A device to induce frequencies to protected glass pane that simulate breaking glass without causing damage to glass.
- I. Photoelectric Sensor :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
- a. [Aleph America Corporation]
 - b. [Honeywell International Inc.]
 - c. [Interlogix; Carrier Global Corporation]
 - d. [Optex Inc.]
 - e. [Potter Electric Signal Company, LLC]
 - f. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. [Aleph America Corporation]
 - b. [Honeywell International Inc.]
 - c. [Interlogix; Carrier Global Corporation]
 - d. [Optex Inc.]
 - e. [Potter Electric Signal Company, LLC]
 - f. <Insert manufacturer's name>
3. Listing Criteria:
- a. Listed and labeled by a qualified electrical testing agency for compliance with UL 639.
 - b. Listed and labeled by a qualified electrical testing agency for compliance with SIA CP-01.
 - c. FM Global Compliance: FM Approved and labeled perimeter security devices and

equipment.

4. Standard Features:

- a. Detects interruption of a pulsed, infrared, light beam that links transmitter and receiver.
- b. Sensitivity: Detect standard-intruder movement within sensor's detection patterns at any speed of less than **7.5 ft/s (2.3 m/s)** though the beam.
- c. Allow installation of multiple sensors within same protected zone that will not interfere with each other.
- d. Activation Indicator: LED indicator may not be visible during normal operation. Indicator must light when sensor detects a standard intruder. Locate test enabling switch under sensor housing cover.
- e. Remote Test: When initiated by master control unit, start a test sequence for each detector element that simulates standard-intruder movement within sensor's detection patterns, causing an alarm.

J. Microwave-PIR Dual-Technology Sensor :

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

- a. **[Aleph America Corporation]**
- b. **[Honeywell International Inc.]**
- c. **[Interlogix; Carrier Global Corporation]**
- d. **[Visonic Inc]**
- e. **<Insert manufacturer's name>**

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

- a. **[Aleph America Corporation]**
- b. **[Honeywell International Inc.]**
- c. **[Interlogix; Carrier Global Corporation]**
- d. **[Visonic Inc]**
- e. **<Insert manufacturer's name>**

3. Listing Criteria:

- a. Listed and labeled by a qualified electrical testing agency for compliance with UL 639.
- b. Listed and labeled by a qualified electrical testing agency for compliance with SIA CP-01.
- c. Listed and labeled by a qualified electrical testing agency for compliance with SIA PIR-01.
- d. FM Global Compliance: FM Approved and labeled perimeter security devices and equipment.

4. Standard Features:

- a. Single unit combining a sensor that detects changes in microwave signals and a sensor that detects changes in ambient level of passive infrared emissions caused by standard-intruder movement within detection pattern.
- b. Alarm is transmitted when either sensor detects a standard intruder within a period of three to eight seconds from when the other sensor detects a standard intruder.
- c. Minimum Detection Pattern: A room **20 by 30 ft (6 by 9 m)**.

- d. PIR Sensor Sensitivity: Adjustable pattern coverage to detect a change in temperature of **2 deg F (1 deg C)** or less, and standard-intruder movement within sensor's detection patterns at any speed between **0.3 to 7.5 ft/s (0.09 to 2.3 m/s)** across two adjacent segments of detector's field of view.
- e. Microwave Sensor Sensitivity: Adjustable, able to detect standard-intruder movement within sensor's detection pattern at speeds within **0.3 to 7.5 ft/s (0.09 to 2.3 m/s)**.
- f. Sensor sensitivity adjustments must be accessible only when sensor housing is removed, and sensors must comply with 47 CFR 15.
- g. Activation Indicator: LED indicator may not be visible during normal operation. Indicator must light when sensor detects a standard intruder.
- h. Locate test enabling switch under sensor housing cover.
- i. Remote Test: When initiated by master control unit, start a test sequence for each detector element that simulates standard-intruder movement within sensor's detection patterns, causing an alarm.

K. Duress-Alarm Switch :

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Honeywell International Inc.]**
 - b. **[Interlogix; Carrier Global Corporation]**
 - c. **[Visonic Inc]**
 - d. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Honeywell International Inc.]**
 - b. **[Interlogix; Carrier Global Corporation]**
 - c. **[Visonic Inc]**
 - d. **<Insert manufacturer's name>**
- 3. Listing Criteria:
 - a. Listed and labeled by a qualified electrical testing agency for compliance with UL 639.
 - b. Listed and labeled by a qualified electrical testing agency for compliance with SIA CP-01.
 - c. FM Global Compliance: FM Approved and labeled perimeter security devices and equipment.
- 4. Standard Features:
 - a. A switch with a shroud over the activating lever that allows an individual to covertly send a duress signal to master control unit, with no visible or audible indication when activated.
 - b. Switch locks in activated position until reset with a key.
 - c. Minimum Switch Rating: 50,000 operations.
 - d. Foot Rail: Foot activated, floor mounting.
 - e. Push Button: Finger activated, suitable for mounting on horizontal or vertical surface.

L. Video Motion Sensor (Interior) :

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

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

- a. [Aleph America Corporation]
 - b. [Interlogix; Carrier Global Corporation]
 - c. [Visonic Inc]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Aleph America Corporation]
 - b. [Interlogix; Carrier Global Corporation]
 - c. [Visonic Inc]
 - d. <Insert manufacturer's name>
3. Listing Criteria:
- a. Listed and labeled by a qualified electrical testing agency for compliance with UL 639.
 - b. Listed and labeled by a qualified electrical testing agency for compliance with SIA CP-01.
 - c. FM Global Compliance: FM Approved and labeled perimeter security devices and equipment.
4. Standard Features:
- a. Detect changes in video signal within a user-defined protected zone. Provide an alarm output for each video input.
 - b. Detect movement within protected zone of standard intruders wearing clothing with a reflectivity that differs from that of background scene by a factor of 2. Reject all other changes in video signal.
 - c. Modular design that allows for expansion or modification of number of inputs.
 - d. Controls:
 - 1) Number of detection zones.
 - 2) Size of detection zones.
 - 3) Sensitivity of detection of each protected zone.
 - e. Mounting: Standard **19 inch (480 mm)** rack as described in EIA/ECA 310-E.

2.3 CONTROL DEVICES

A. Intrusion Detection Keypad and Display Module :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Bosch Security Systems, Inc.]
 - b. [Corby Industries, Inc.]
 - c. [Crow Electronic Engineering, Inc]
 - d. [DAQ Electronics, Inc]
 - e. [Digital Security Controls Ltd.]

- f. **[Edwards; Carrier Global Corporation]**
 - g. **[Honeywell International Inc.]**
 - h. **[Visonic Inc]**
 - i. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Bosch Security Systems, Inc.]**
 - b. **[Corby Industries, Inc.]**
 - c. **[Crow Electronic Engineering, Inc]**
 - d. **[DAQ Electronics, Inc]**
 - e. **[Digital Security Controls Ltd.]**
 - f. **[Edwards; Carrier Global Corporation]**
 - g. **[Honeywell International Inc.]**
 - h. **[Visonic Inc]**
 - i. **<Insert manufacturer's name>**
 - 3. Listing Criteria:
 - a. Listed and labeled by a qualified electrical testing agency for compliance with UL 639.
 - b. Listed and labeled by a qualified electrical testing agency for compliance with SIA CP-01.
 - c. FM Global Compliance: FM Approved and labeled perimeter security devices and equipment.
 - 4. Standard Features: Arranged for entering and executing commands for system-status changes and for displaying system-status and command-related data.
- B. Intrusion Detection Key-Operated Switch :
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Bosch Security Systems, Inc.]**
 - b. **[Corby Industries, Inc.]**
 - c. **[Crow Electronic Engineering, Inc]**
 - d. **[DAQ Electronics, Inc]**
 - e. **[Digital Security Controls Ltd.]**
 - f. **[Edwards; Carrier Global Corporation]**
 - g. **[Honeywell International Inc.]**
 - h. **[Visonic Inc]**
 - i. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Bosch Security Systems, Inc.]**
 - b. **[Corby Industries, Inc.]**
 - c. **[Crow Electronic Engineering, Inc]**
 - d. **[DAQ Electronics, Inc]**
 - e. **[Digital Security Controls Ltd.]**
 - f. **[Edwards; Carrier Global Corporation]**



- g. [Honeywell International Inc.]
- h. [Visonic Inc]
- i. <Insert manufacturer's name>

3. Listing Criteria:

- a. Listed and labeled by a qualified electrical testing agency for compliance with UL 639.
- b. Listed and labeled by a qualified electrical testing agency for compliance with SIA CP-01.
- c. FM Global Compliance: FM Approved and labeled perimeter security devices and equipment.

4. Standard Features: Changes protected zone between secure and access conditions.

C. Intrusion Detection Master Control Unit :

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

- a. [Bosch Security Systems, Inc.]
- b. [DAQ Electronics, Inc]
- c. [Digital Security Controls Ltd.]
- d. [Honeywell Commercial Security; Honeywell International, Inc.]
- e. [Honeywell International Inc.]
- f. [Interlogix; Carrier Global Corporation]
- g. [Visonic Inc]
- h. <Insert manufacturer's name>

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

- a. [Bosch Security Systems, Inc.]
- b. [DAQ Electronics, Inc]
- c. [Digital Security Controls Ltd.]
- d. [Honeywell Commercial Security; Honeywell International, Inc.]
- e. [Honeywell International Inc.]
- f. [Interlogix; Carrier Global Corporation]
- g. [Visonic Inc]
- h. <Insert manufacturer's name>

3. Listing Criteria:

- a. Listed and labeled by a qualified electrical testing agency for compliance with UL 639.
- b. Listed and labeled by a qualified electrical testing agency for compliance with **[UL 609][UL 1023][UL 1076]**.
- c. Listed and labeled by a qualified electrical testing agency for compliance with SIA CP-01.
- d. FM Global Compliance: FM Approved and labeled perimeter security devices and equipment.

4. Standard Features:

- a. Supervises sensors and detection subsystems and their connecting communication links, status control (secure or access) of sensors and detector subsystems, activation of alarms

and supervisory and trouble signals, and other indicated functions.

- 1) System software and programs must be held in flash electrically erasable programmable read-only memory (EEPROM), retaining the information through failure of primary and secondary power supplies.
 - 2) Include real-time clock for time annotation of events on event recorder and printer.
 - 3) Addressable initiation devices that communicate device identity and status.
 - 4) Control circuits for operation of mechanical equipment in response to an alarm.
- b. Construction: **[Freestanding equipment rack][Desk-mounted console]**, modular, with separate and independent alarm and supervisory system modules. **[Alarm-initiating protected zone boards must be plug-in cards.]** Arrangements that require removal of field wiring for module replacement are unacceptable.
- c. Console Controls and Displays: Arranged for interface between human operator at master control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.
- d. Annunciator and Display: LCD, **[one][two][three]** line(s) of **[40][80]** characters, minimum.
- e. Keypad: Arranged to permit entry and execution of programming, display, and control commands.
- f. Control-Unit Network: Automatic communication of alarm, status changes, commands, and other communications required for system operation. Communication must return to normal after partial or total network interruption such as power loss or transient event. Total or partial signaling network failures must identify the failure and record the failure at the annunciator display and at the system printer.
- g. Field Device Network: Communicate between the control unit and field devices of the system. Communications must consist of alarm, network status, and status and control of field-mounted processors. Each field-mounted device must be interrogated during each interrogation cycle.
- h. Operator Controls: Manual switches and push-to-test buttons that do not require a key to operate. Prevent resetting of alarm, supervisory, or trouble signals while alarm or trouble condition persists. Include the following:
- 1) Acknowledge alarm.
 - 2) Silence alarm.
 - 3) System reset.
 - 4) LED test.
 - 5) **<Insert operator functions>.**
- i. Timing Unit: Solid state, programmable, 365 days.
- j. Confirmation: Relays, contactors, and other control devices must have auxiliary contacts that provide confirmation signals to system for their on or off status. Software must interpret such signals, display equipment status, and initiate failure signals.
- k. Alarm Indication:
- 1) Audible signal sounds and an LED lights at master control unit identifying the **[protected zone][addressable detector]** originating the alarm. **[Annunciator panel displays a common alarm light and sounds an audible tone.]**
 - 2) Audible signal sounds and a plain-language identification of the **[protected zone][addressable detector]** originating the alarm appears on **[LED][or][LCD]** display at master control unit. **[Annunciator panel displays a common alarm light and sounds an audible tone.]**
 - 3) Audible signal sounds and a plain-language identification of the **[protected zone][addressable detector]** originating the alarm appears on **[LED][LCD][or][cathode-ray-tube]** display at master control unit. **[Annunciator panel alarm light and audible tone identify protected zone signaling an alarm.]**

- 4) Alarm activation sounds a [bell][siren][strobe][bell or siren and strobe].
- l. Protected Zones: Quantity of alarm and supervisory zones as indicated, with capacity for expanding number of protected zones by a minimum of [25]<Insert number> percent.
- m. Power Supply Circuits: Master control units must provide power for remote power-consuming detection devices. Circuit capacity must be adequate for at least a [25]<Insert number> percent increase in load.
- n. UPS: Comply with Section 263353 "Static Uninterruptible Power Supply." UPS must be sized to provide a minimum of six hours of master control-unit operation.
- o. Cabinet: Lockable, steel enclosure arranged so operations required for testing, normal operation, and maintenance are performed from front of enclosure. If more than a single cabinet is required to form a complete control unit, provide exactly matching modular enclosures. Accommodate all components and allow ample gutter space for field wiring. Identify each enclosure by an engraved, laminated, phenolic-resin nameplate. Lettering on enclosure nameplate may not be less than 1 inch (25 mm) high. Identify, with permanent labels, individual components and modules within cabinets.
- p. Transmission to Monitoring Station: A communications device to automatically transmit alarm, supervisory, and trouble signals to the monitoring station, operating over a standard voice grade telephone leased line. Comply with UL 1635.
- q. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble) and date and time of occurrence. Differentiate alarm signals from all other printed indications. Also print system reset event, including same information for device, location, date, and time. Commands initiate the printing of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.

2.4 NOTIFICATION DEVICES

A. Intrusion Detection Alarm Bell :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Alarm Controls; Hanchett Entry Systems, Inc.; ASSA ABLOY Group]
 - b. [Cooper Wheelock; brand of Eaton]
 - c. [Edwards; Carrier Global Corporation]
 - d. [Honeywell International Inc.]
 - e. [Potter Electric Signal Company, LLC]
 - f. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Alarm Controls; Hanchett Entry Systems, Inc.; ASSA ABLOY Group]
 - b. [Cooper Wheelock; brand of Eaton]
 - c. [Edwards; Carrier Global Corporation]
 - d. [Honeywell International Inc.]
 - e. [Potter Electric Signal Company, LLC]
 - f. <Insert manufacturer's name>
3. Listing Criteria:

- a. Listed and labeled by a qualified electrical testing agency for compliance with UL 639.
 - b. Listed and labeled by a qualified electrical testing agency for compliance with SIA CP-01.
 - c. FM Global Compliance: FM Approved and labeled perimeter security devices and equipment.
 4. Standard Features:
 - a. **10 inch (254 mm)** in diameter, rated to produce a minimum sound output of 84 dB at **10 ft (3 m)** from master control unit.
 - b. Enclosure: Weather-resistant steel box equipped with tamper switches on cover and on back of box.
- B. Intrusion Detection Alarm Klaxon :
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Alarm Controls; Hanchett Entry Systems, Inc.; ASSA ABLOY Group]**
 - b. **[Cooper Wheelock; brand of Eaton]**
 - c. **[Edwards; Carrier Global Corporation]**
 - d. **[Honeywell International Inc.]**
 - e. **[Potter Electric Signal Company, LLC]**
 - f. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Alarm Controls; Hanchett Entry Systems, Inc.; ASSA ABLOY Group]**
 - b. **[Cooper Wheelock; brand of Eaton]**
 - c. **[Edwards; Carrier Global Corporation]**
 - d. **[Honeywell International Inc.]**
 - e. **[Potter Electric Signal Company, LLC]**
 - f. **<Insert manufacturer's name>**
 3. Listing Criteria:
 - a. Listed and labeled by a qualified electrical testing agency for compliance with UL 639.
 - b. Listed and labeled by a qualified electrical testing agency for compliance with SIA CP-01.
 - c. FM Global Compliance: FM Approved and labeled perimeter security devices and equipment.
 4. Standard Features:
 - a. Weatherproof motor-driven hooter.
 - b. Rated to produce minimum sound output of 120 dB at **3 ft (1 m)**, plus or minus 3 dB, at frequency of 470 Hz.
 - c. Rated for intermittent use; two minutes on and five minutes off.
 - d. Designed for use in industrial areas and in high-noise, severe-weather marine environments.
- C. Intrusion Detection Alarm Siren :
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the**



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

- a. [Alarm Controls; Hanchett Entry Systems, Inc.; ASSA ABLOY Group]
- b. [Cooper Wheelock; brand of Eaton]
- c. [Edwards; Carrier Global Corporation]
- d. [Honeywell International Inc.]
- e. [Potter Electric Signal Company, LLC]
- f. <Insert manufacturer's name>

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

- a. [Alarm Controls; Hanchett Entry Systems, Inc.; ASSA ABLOY Group]
- b. [Cooper Wheelock; brand of Eaton]
- c. [Edwards; Carrier Global Corporation]
- d. [Honeywell International Inc.]
- e. [Potter Electric Signal Company, LLC]
- f. <Insert manufacturer's name>

3. Listing Criteria:

- a. Listed and labeled by a qualified electrical testing agency for compliance with UL 639.
- b. Listed and labeled by a qualified electrical testing agency for compliance with SIA CP-01.
- c. FM Global Compliance: FM Approved and labeled perimeter security devices and equipment.

4. Standard Features:

- a. 30 W speaker with siren driver, rated to produce a minimum sound output of 103 dB at 10 ft (3 m) from master control unit.
- b. Enclosure: Weather-resistant steel box with tamper switches on cover and on back of box.

D. Intrusion Detection Alarm Strobe :

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

- a. [Alarm Controls; Hanchett Entry Systems, Inc.; ASSA ABLOY Group]
- b. [Cooper Wheelock; brand of Eaton]
- c. [Edwards; Carrier Global Corporation]
- d. [Honeywell International Inc.]
- e. [Potter Electric Signal Company, LLC]
- f. <Insert manufacturer's name>

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

- a. [Alarm Controls; Hanchett Entry Systems, Inc.; ASSA ABLOY Group]
- b. [Cooper Wheelock; brand of Eaton]

- c. **[Edwards; Carrier Global Corporation]**
- d. **[Honeywell International Inc.]**
- e. **[Potter Electric Signal Company, LLC]**
- f. **<Insert manufacturer's name>**

3. Listing Criteria:

- a. Listed and labeled by a qualified electrical testing agency for compliance with UL 639.
- b. Listed and labeled by a qualified electrical testing agency for compliance with UL 1638.
- c. Listed and labeled by a qualified electrical testing agency for compliance with SIA CP-01.
- d. FM Global Compliance: FM Approved and labeled perimeter security devices and equipment.

4. Standard Features:

- a. Xenon light with clear polycarbonate lens.
- b. Light Output: 115 cd, minimum.
- c. Flash Rate: 60 per minute.

2.5 SECURITY FASTENERS

A. Socket Flat Countersunk Head Fastener :

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Acument Global Technologies, Inc.; Acument Intellectual Properties, LLC]**
 - b. **[Safety Socket LLC]**
 - c. **[Tamper-Pruf Screws]**
 - d. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Acument Global Technologies, Inc.; Acument Intellectual Properties, LLC]**
 - b. **[Safety Socket LLC]**
 - c. **[Tamper-Pruf Screws]**
 - d. **<Insert manufacturer's name>**
- 3. Standard Features:
 - a. Operable only by tools produced for use on specific type of fastener by fastener manufacturer or other licensed fabricator. Drive system type, head style, material, and protective coating as required for assembly, installation, and strength.
 - b. Drive System Types: **[Pinned Torx-Plus][pinned Torx][or][pinned hex (Allen)]**.
 - c. Heat-treated alloy steel, **ASTM F835 (ASTM F835M)**.
 - d. Stainless steel, **ASTM F879 (ASTM F879M)**, Group 1 CW.

B. Socket Button Head Fastener :

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

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

- a. **[Acument Global Technologies, Inc.; Acument Intellectual Properties, LLC]**
 - b. **[Safety Socket LLC]**
 - c. **[Tamper-Pruf Screws]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[Acument Global Technologies, Inc.; Acument Intellectual Properties, LLC]**
 - b. **[Safety Socket LLC]**
 - c. **[Tamper-Pruf Screws]**
 - d. **<Insert manufacturer's name>**
3. Standard Features:
- a. Operable only by tools produced for use on specific type of fastener by fastener manufacturer or other licensed fabricator. Drive system type, head style, material, and protective coating as required for assembly, installation, and strength.
 - b. Drive System Types: **[Pinned Torx-Plus][pinned Torx][or][pinned hex (Allen)]**.
 - c. Heat-treated alloy steel, **ASTM F835 (ASTM F835M)**.
 - d. Stainless steel, **ASTM F879 (ASTM F879M)**, Group 1 CW.

C. Socket Head Cap Fastener :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Acument Global Technologies, Inc.; Acument Intellectual Properties, LLC]**
 - b. **[Safety Socket LLC]**
 - c. **[Tamper-Pruf Screws]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Acument Global Technologies, Inc.; Acument Intellectual Properties, LLC]**
 - b. **[Safety Socket LLC]**
 - c. **[Tamper-Pruf Screws]**
 - d. **<Insert manufacturer's name>**
3. Standard Features:
 - a. Operable only by tools produced for use on specific type of fastener by fastener manufacturer or other licensed fabricator. Drive system type, head style, material, and protective coating as required for assembly, installation, and strength.
 - b. Drive System Types: **[Pinned Torx-Plus][pinned Torx][or][pinned hex (Allen)]**.
 - c. Heat-treated alloy steel, **ASTM A574 (ASTM A574M)**.
 - d. Stainless steel, **ASTM F837 (ASTM F837M)**, Group 1 CW.



PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of intrusion detection.
- B. Examine roughing-in for embedded and built-in anchors to verify actual locations of intrusion detection connections before intrusion detection installation.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of intrusion detection.
- D. Inspect built-in and cast-in anchor installations, before installing intrusion detection, to verify that anchor installations comply with requirements. Prepare inspection reports.
 - 1. Remove and replace anchors where inspections indicate that they do not comply with requirements. Reinspect after repairs or replacements are made.
 - 2. Perform additional inspections to determine compliance of replaced or additional anchor installations. Prepare inspection reports.
- E. For material whose orientation is critical for its performance as a ballistic barrier, verify installation orientation.
- F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 SYSTEM INTEGRATION

- A. Integrate intrusion detection system with the following systems and equipment:
 - 1. Electronic door hardware.
 - 2. Elevators.
 - 3. Network lighting controls.
 - 4. Intercommunications and program systems.
 - 5. Public address and mass notification systems.
 - 6. Access control.
 - 7. Fire-alarm system.
 - 8. Perimeter security system.
 - 9. Video surveillance.
 - 10. **<Insert applicable systems and equipment>.**

3.3 INSTALLATION OF INTRUSION DETECTION

- A. Comply with UL 681 and NFPA 731.
- B. Equipment Mounting: Install master control unit on finished floor with tops of cabinets not more than **72 inch (1830 mm)** above the finished floor.
 - 1. Comply with requirements for seismic-restraint devices specified in Section 260548 "Vibration and Seismic Controls for Electrical Systems."
- C. Install wall-mounted equipment, with tops of cabinets not more than **72 inch (1830 mm)** above the

finished floor.

1. Comply with requirements for seismic-restraint devices specified in Section 260548 "Vibration and Seismic Controls for Electrical Systems."
- D. Connecting to Existing Equipment: Verify that existing perimeter security system is operational before making changes or connections.
1. Connect new equipment to existing control panel in existing part of the building.
 2. Connect new equipment to existing monitoring equipment at the Supervising Station.
 3. Expand, modify, and supplement existing **[control][monitoring]** equipment as necessary to extend existing **[control][monitoring]** functions to the new points. New components must be capable of merging with existing configuration without degrading the performance of either system.
- E. Security Fasteners: Where accessible to inmates, install intrusion detection components using security fasteners with head style appropriate for fabrication requirements, strength, and finish of adjacent materials except that a maximum of two different sets of tools must be required to operate security fasteners for Project. **[Provide stainless-steel security fasteners in stainless-steel materials.]**
- F. Wiring Method:
1. Install wiring in metal raceways according to Section 270528 "Pathways for Communications Systems." Conceal raceway except in unfinished spaces and as indicated. Minimum conduit size must be metric designator 13 (trade size 1/2). Control and data transmission wiring may not share conduit with other building wiring systems.
 2. Install wiring in metal raceways according to Section 270528 "Pathways for Communications Systems," except in accessible indoor ceiling spaces and in interior hollow gypsum board partitions where cable may be used. Conceal raceways and wiring except in unfinished spaces and as indicated. Minimum conduit size must be metric designator 13 (trade size 1/2). Control and data transmission wiring may not share conduit with other building wiring systems.
 3. Cable, concealed in accessible ceilings, walls, and floors when possible.
- G. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Use lacing bars and distribution spools. Separate power-limited and non-power-limited conductors as recommended in writing by manufacturer. Install conductors parallel with or at right angles to sides and back of enclosure. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with intrusion system to terminal blocks. Mark each terminal according to system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.
- H. Wires and Cables:
1. Conductors: Size as recommended in writing by system manufacturer unless otherwise indicated.
 2. 120 V Power Wiring: Install according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables" unless otherwise indicated.
 3. Control and Signal Transmission Conductors: Install unshielded, twisted-pair cable unless otherwise indicated or if manufacturer recommends shielded cable, according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
 4. Data and Television Signal Transmission Cables: Install according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- I. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

- J. Install power supplies and other auxiliary components for detection devices at control units unless otherwise indicated or required by manufacturer. Do not install such items near devices they serve.
- K. Identify components with engraved, laminated-plastic or metal nameplate for master control unit and each terminal cabinet, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 260553 "Identification for Electrical Systems" and Section 270528 "Pathways for Communications Systems."

3.4 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with identification requirements in Section 260553 "Identification for Electrical Systems" and Section 270528 "Pathways for Communications Systems."
- B. Install instructions frame in a location visible from master control unit.

3.5 GROUNDING

- A. Ground the master control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to master control unit.
- B. Ground system components and conductor and cable shields to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
- C. Signal Ground Terminal: Locate at main equipment rack or cabinet. Isolate from power system and equipment grounding. Provide **[5 Ω]<Insert resistance>** ground. Measure, record, and report ground resistance.
- D. Install grounding electrodes of type, size, location, and quantity indicated. Comply with installation requirements in Section 260526 "Grounding and Bonding for Electrical Systems" and Section 270528 "Pathways for Communications Systems."

3.6 FIELD QUALITY CONTROL

- A. Administrant for Security Tests and Inspections:
 - 1. **[Owner][Tenant]** will engage qualified security testing and inspecting agency to administer and perform tests and inspections.
 - 2. Engage qualified security testing and inspecting agency to administer and perform tests and inspections.
 - 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
 - 4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].
- B. Acceptance Testing Preparation: After installation, align, adjust, and balance system and perform complete pretesting to determine compliance of system with requirements in the Contract Documents. Correct deficiencies observed in pretesting. Replace malfunctioning or damaged items with new ones and retest until satisfactory performance and conditions are achieved. Prepare forms for systematic recording of acceptance test results.
 - 1. Report of Pretesting: After pretesting is complete, provide a letter certifying that installation is



complete and fully operable; include names and titles of witnesses to preliminary tests.

- C. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.
- D. Tests and Inspections: Comply with provisions in NFPA 731, Ch. 9, "Testing and Inspections."
 - 1. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.
 - 2. Test Methods: Intrusion detection systems and other systems and equipment that are associated with detection and accessory equipment must be tested according to Table "Test Methods" and Table "Test Methods of Initiating Devices."
- E. Documentation: Comply with provisions in NFPA 731, Ch. 4, "Documentation."
- F. Tag all equipment, stations, and other components for which tests have been satisfactorily completed.
- G. Nonconforming Work:
 - 1. Intrusion detection system will be considered defective if it does not pass tests and inspections.
- H. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.
- I. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.
 - 1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.

3.7 ADJUSTING

- A. Occupancy Adjustments: When requested within **[12]<Insert number>** months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to **[three]<Insert number>** visits to Project during other-than-normal occupancy hours for this purpose. **[Visits for this purpose must be in addition to any required by warranty.]**

3.8 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain the intrusion detection system. Comply with documentation provisions in NFPA 731, Ch. 4, "Documentation and User Training."

END OF SECTION 28 31 00 00



SECTION 28 40 00 00 - EMERGENCY RESPONDER COMMUNICATIONS ENHANCEMENT SYSTEM ERCES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Emergency responder communications enhancement system (ERCES) equipment.

B. Products Installed, but Not Furnished, under This Section:

1. **<Insert products identified in "Existing Products to be Modified" Article or "Existing Products to be Removed and Re-Installed" Article>.**

C. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. **[Section 013100 "Project Management and Coordination"] <Insert Section number and title>** specifies preinstallation conference procedures.
5. Section 078413 "Penetration Firestopping" specifies materials and methods for sealing penetrations of rated walls and partitions referenced by this Section.
6. Section 260526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding referenced by this Section.
7. Section 260529 "Hangers and Supports for Electrical Systems" specifies hangers, supports, and concrete bases referenced by this Section.
8. Section 260548 "Vibration and Seismic Controls for Electrical Systems" specifies vibration isolation and seismic **[and wind]** control devices referenced by this Section.
9. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs referenced by this Section.
10. Section 270528 "Pathways for Communications Systems" specifies additional requirements for raceway materials, routing, locations, and identification of communications equipment and cabling.
11. Section 284600 "Fire Detection and Alarm" specifies fire-alarm cabling and interfacing ERCES with fire-alarm systems.

1.2 ALLOWANCES

- A. See Section 012100 "Allowances" for description of allowances affecting items specified in this Section.

1.3 UNIT PRICES

- A. See Section 012200 "Unit Prices" for description of unit prices affecting items specified in this Section.



1.4 ALTERNATES

- A. See Section 012300 "Alternates" for description of alternates affecting items specified in this Section.

1.5 DEFINITIONS

- A. Backbone: Primary segment of ERCES between donor antenna and distribution cabling.
- B. BDA: Bi-directional amplifier.
- C. DAS: Distributed antenna system.
- D. Downlink: The signal from a base station to portable radios.
- E. ERCES: Emergency responder communications enhancement system(s).
- F. FCC: Federal Communications Commission.
- G. GROL: General Radiotelephone Operator License (FCC).
- H. IB-PSC: In-building public safety communications.
- I. LTE: Long-term evolution (mobile device technology standard).
- J. NICET: National Institute for Certification in Engineering Technologies, a division of the National Society of Professional Engineers (NSPE).
- K. RF: Radio frequency.
- L. UHF: Ultra-high frequency.
- M. Uplink: The signal from a portable radio to the base station.

1.6 DELEGATED DESIGN SERVICES

- A. Delegated Design Professionals:
 - 1. Engage qualified RF design professional to design ERCES.
 - 2. Engage qualified electrical professional engineer to design power distribution for ERCES.
 - 3. Engage qualified structural professional engineer to design poles, foundations, hangers, and supports for ERCES.
 - 4. Engage qualified fire-alarm system designer for supervision of ERCES components by the building fire-alarm system.

1.7 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at **[the Project site]** <Insert location>.
- B. Preinstallation Coordination Meeting(s): Conduct meeting(s) **[as videoconference]** [or] **[at the Project site]** <Insert location> before <Insert construction activity>.

1. Attendees: Installers, fabricators, representatives of manufacturers, and administrators for field tests and inspections. Notify Architect[, **Construction Manager**] [, and **Owner's Commissioning Authority**] of scheduled meeting dates.

1.8 ACTION SUBMITTALS

- A. Product Data: For each type of product. In addition to information identified in Section 013300 "Submittal Procedures," submit the following:

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Include operating characteristics, electrical characteristics, and furnished accessories.
3. **<Insert product-specific submittal data requirement>**.
4. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing agency, certifying product's compliance with specified listing criteria.
 - a. If listed manufacturer differs from selling manufacturer, indicate relationship between entities on submittal. Clearly indicate which entity warrants product performance and fitness for purpose.
 - b. Listing criteria identified in approval letter must match specified listing criteria. UL label indicating approval of equipment's enclosure is not considered approval of equipment for intended application.
 - c. Product identification in approval letter must match product branding and model numbers in submittal. Approval letters for discontinued or superseded products are unacceptable for submitted product.
5. Include manufacturer's sample extended warranty language.
6. Product Certificates: Include product certificate stating compliance with NFPA 72, NFPA 1225, and specified requirements, signed by manufacturer or fabricator.
7. **<Insert requirements>**.

- B. Shop Drawings: Prepare and submit the following:

1. ERCES Drawings, Diagrams, and Supporting Documents:
 - a. Project general notes.
 - b. Include plans, elevations, sections, details, and attachments to other Work.
 - c. Device layout.
 - d. Block diagrams and cable/conduit routing.
 - e. Cable type identification.
 - f. Pathway class and survivability identification.
 - g. System communications details.
 - h. System sequence of operations.
 - i. System mounting details.
 - j. Roof attachment and penetration details.
 - k. Secondary power calculations.
 - l. Critical Areas Coverage: Fire command center, fire pump room, exit stairs/passageways, elevators, elevator lobbies, sprinkler standpipe closets and sectional valves locations, and other areas deemed critical by authorities having jurisdiction.
2. Include lightning protection with donor antenna installation as required by adopted codes and standards and in accordance with manufacturers' instructions. **<Insert additional requirements for drawing content or format>**.



- C. Delegated Design Submittals: Include analysis data signed by delegated design professional(s) responsible for their preparation. Include FCC GROL license or IB-PSC certification information.
- D. Field quality-control reports.

1.9 INFORMATIONAL SUBMITTALS

- A. Manufacturer's published instructions.
- B. Baseline Radio Signal Strength and Quality Testing Report:
 - 1. Detailed report indicating NFPA 1225 plotted interior radio signal strength or delivered audio quality score throughout building critical and general areas with construction of interior partitions and doors completed, but without ERCES installed.
 - 2. Approval from authorities having jurisdiction to omit ERCES installation within building areas where baseline radio signal strength testing demonstrates that minimum required radio signal strength values are provided within these areas.
- C. System Record of Inspection and Testing: Record copy of completed system acceptance testing. **[Format must be approved by authorities having jurisdiction.]**
- D. Field Reports:
 - 1. Manufacturer's field reports for field quality-control support.
 - 2. Manufacturer's field reports for system startup support.
 - 3. Field reports for voltage monitoring and adjusting.
 - 4. Field reports for infrared scanning.
 - 5. Field reports for software and firmware upgrades.

1.10 CLOSEOUT SUBMITTALS

- A. Warranty documentation.
- B. Maintenance service agreement.
- C. Software and firmware service agreement.

1.11 REGULATORY AGENCY APPROVALS

- A. Submittals for ERCES requiring approval by authorities having jurisdiction must be signed by qualified FCC GROL licensee, NICET IB-PSC design technician, or life-safety professional engineer responsible for their preparation. **[Obtain approval by authorities having jurisdiction prior to submitting for action by Architect] [Submit for action by Architect prior to submitting for approval by authorities having jurisdiction].**
- B. Submittals for ERCES must include written authorization from the frequency license holder to operate the two-way emergency responder communications enhancement system identified in the submittal.

1.12 QUALIFICATIONS

- A. In-Building Public Safety Communications (IB-PSC) Technician Trainee: Having at least six months of experience and possessing active NICET IB-PSC Level I certification. Able to install passive and active ERCES equipment under direct supervision.
- B. In-Building Public Safety Communications (IB-PSC) Associate Engineering Technician: Having at least two years of experience and possessing active NICET IB-PSC Level II certification. Able to conduct surveys, to install, to commission, and to maintain ERCES systems under limited supervision.
- C. In-Building Public Safety Communications (IB-PSC) Engineering Technician: Having at least five years of experience and possessing active NICET IB-PSC Level III certification. Able to interpret and evaluate surveys, to layout, and to manage ERCES systems without supervision.
- D. In-Building Public Safety Communications (IB-PSC) Design Technician: Having at least two years of IB-PSC design experience and possessing active NICET IB-PSC Design Technician certification. Able to prepare shop drawing plans and details for ERCES in accordance with Project requirements, manufacturer's published instructions, site survey data, and design tools.
- E. General Radiotelephone Operator License (GROL) Designer: Having an active FCC Registration Number (FRN). Able to prepare shop drawing plans and details for ERCES in accordance with Project requirements, manufacturer's published instructions, site survey data, and design tools.
- F. Communications Cable Installer: Entity possessing active qualifications specified in Section 014000 "Quality Requirements" and the following:
 - 1. Training and manufacturer certification to install, splice, and terminate communications cabling.
 - 2. Installation Supervisor: BICSI Technician (TECH) certification.
 - 3. Copper Installers: **[30 percent] <Insert quantity>** of employees possess BICSI Copper Installer 2 (INSTC) certification. Remaining employees possess BICSI Installer 1 (INST1) certification.
 - 4. Fiber Installers: **[30 percent] <Insert quantity>** of employees possess BICSI Optical Fiber Installer 2 (INSTF) certification. Remaining employees possess BICSI Installer 1 (INST1) certification.
- G. Communications Testing and Inspecting Agency: Entity possessing active credentials from qualified electrical testing laboratory recognized by authorities having jurisdiction.
 - 1. On-site communications testing supervisor must have **[BICSI Technician (TECH)] <Insert certification program>** certification and documented training, and be experienced with testing communications equipment in accordance with **[BICSI] <Insert code enforced by authorities having jurisdiction>** testing standards.
- H. Life-Safety Professional Engineer: Professional engineer possessing active qualifications specified in Section 014000 "Quality Requirements," with expertise in life-safety systems.

1.13 WARRANTY FOR ERCES

- A. Special Installer Extended Warranty: Installer warrants that fabricated and installed ERCES perform in accordance with specified requirements and agrees to repair or replace components or products that fail to perform as specified within extended-warranty period.



1. Extended-Warranty Period: **[Two] [Three] [Four]** <Insert number> years from date of Substantial Completion; full coverage for labor, materials, and equipment.
- B. Special Manufacturer Extended Warranty: Manufacturer warrants that ERCES perform in accordance with specified requirements and agrees to provide repair or replacement of components or products that fail to perform as specified within extended-warranty period.
 1. Initial Extended-Warranty Period: **[Three] [Four] [Five]** <Insert number> years from date of Substantial Completion; **[full] [prorated]** coverage for labor, materials, and equipment.
 2. Follow-On Extended-Warranty Period: **[Eight]** <Insert number> years from date of Substantial Completion; **[full] [prorated]** coverage for materials only, free on board **[origin] [destination]**, freight prepaid.

PART 2 - PRODUCTS

2.1 EXISTING PRODUCTS TO BE MODIFIED

- A. Basis for Pricing: <Insert name of manufacturer and model number or series for existing product>.
- B. Description: <Insert description of existing product, including special features, options, and finishes that may impact the Work>.
- C. Accessories: <Insert accessories included with existing product>.

2.2 EXISTING PRODUCTS TO BE REMOVED AND RE-INSTALLED

- A. Basis for Pricing: <Insert name of manufacturer and model number or series for existing product>.
- B. Description: <Insert description of existing product, including special features, options, and finishes that may impact the Work>.
- C. Accessories: <Insert accessories included with existing product>.

2.3 PERFORMANCE REQUIREMENTS

- A. Description: The emergency responder communications enhancement system consists of one or more of the following: donor antenna, backbone riser cable, bi-directional amplifier (BDA), coupler, splitter, power divider, and distribution antenna. <Insert brief description of actual system, assembly, or equipment to be installed>.
- B. Performance Criteria:
 1. Regulatory Requirements:
 - a. Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

- b. Unless otherwise indicated in Contract Documents, products must comply with NFPA 1, NFPA 70, NFPA 72, NFPA 1225, **[NFPA 101,] [ICC IBC,] [ICC IFC,]** and local regulations enforced by authorities having jurisdiction.
 - c. Performance objectives include downlink signal sufficient to provide a minimum of DAQ 3.0 (delivered audio quality) for voice communications using either narrowband, analog, or digital P25 signals or wideband LTE digital signals throughout the coverage area. Recommended design to DAQ 3.4 for safety factor.
 - d. Uplink signal should be sufficient to provide a minimum of DAQ 3.0 (delivered audio quality) for voice communications using either narrowband, analog, or digital P25 signals or widespread LTE digital signals.
 2. General Characteristics: ERCES to be installed inside of buildings using approved materials, electrical and radio components, and accepted installation practices. Where required, ensure that systems meet NFPA survivability requirements through the use of fire barrier construction, fireproofing materials, listed cabling, and environmentally rated enclosures. Buildings fully protected by an automatic sprinkler system in accordance with NFPA 13 do not require fire-resistance rating of the backbone cables or backbone cable components.
 3. Provide at least two independent and reliable primary and secondary power sources for all RF-emitting devices and other electronic components of the system.
 4. To maintain proper alignment with the donor site, permanently affix donor antennas on the building or mount on a moveable sled with visible signage. Where donor antennas exist, maintain isolation between the donor antenna and all inside antennas to a minimum of 20 dB above system gain. The antenna installation must meet applicable codes for weather protection of the building envelope. Additionally, systems must be protected by lightning protection complying with NFPA 1225.
 - a. **<Insert additional performance requirements for the Project>.**
- C. Seismic and Wind Performance: Installed assembly must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:
 1. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events[**and unit must be fully operational after seismic events**].
 2. Component Importance Factor (I_p): **[1.0] [1.5]**.
 3. Component Amplification Factor (a_p): **[1.0] [2.5] <Insert value>.**
 4. Component Response Modification Factor (R_p): **[1.5] [2.0] [2.5] [6.0] <Insert value>.**
 5. Component Overstrength Factor (Ω_o): **[1.5] [2.5] <Insert value>.**

2.4 PASSIVE AND ACTIVE SYSTEMS

- A. Description: A distributed antenna system (DAS) is one element of an ERCES and does not include an RF signal source such as a BDA or radio base station. The RF distribution part of the system may be either a passive DAS or an active DAS. A passive DAS includes a BDA feeding a coax distribution antenna system through splitters where none of the elements (coax, splitters, antennas) are powered. An active DAS uses powered components to distribute RF signals. A fiber DAS is an example of an active DAS; the head-end device converts RF signals into optical wavelengths sent over the fiber cables. Remote components convert the optical wavelengths back into RF signals and amplify them for broadcast over the distribution antenna system. The head-end device and remote components are powered devices.



2.5 EMERGENCY RESPONDER COMMUNICATIONS ENHANCEMENT SYSTEM (ERCES) EQUIPMENT

- A. Description: This category includes in-building ERCES equipment to improve wireless communication. This FCC-certified enhancement system is inclusive of BDAs, transmission lines, cables, power supplies, antennas, and other ancillary equipment that allow radio signals to pass to and from interior of structure for facilitating radio communications using emergency responder radio frequencies.
- B. In-Building ERCES Bi-Directional Amplifiers **<Insert drawing designation>**:
 1. **<Double click here to find, evaluate, and insert list of manufacturers and products.>**
 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. ERCES: UL CCN UTMH; including UL 2524 and NFPA 1225.
 3. Standard Features:
 - a. Primary Power Supply: **[120 V(ac)] [240 V(ac)] <Insert voltage>** supplied from a dedicated branch circuit, permanently connected, protected from overvoltage, and NFPA 72 compliant.
 - b. Secondary Power Supply: Provide one of the following:
 - 1) **[24 V(dc)] <Insert voltage>** supplied from a storage battery with capacity of 12 h at 100 percent system operation capacity.
 - 2) Power source with capacity of 12 h at 100 percent system operation capacity approved by authorities having jurisdiction.
 - 3) 2 h battery supplemented by a generator power system with capacity to support system load for 12 h.
 - c. Monitor the integrity of power sources in accordance with NFPA 1225.
 - d. Supervision: Provide auxiliary contacts for remote status supervision by **[protected premises fire-alarm system] [mass notification system] <Insert system>**.
 - 1) Signal booster failure.
 - 2) Antenna malfunction.
 - 3) Loss of normal AC power.
 - 4) Low battery voltage.
 - 5) Battery charger failure.
 - 6) **<Insert system status supervision>**.
 - e. Monitor system integrity in accordance with Ch. 10 of NFPA 72. Monitor integrity of the communications link between the **[protected premises fire-alarm system] [mass notification system] <Insert system>** and the in-building ERCES. Where approved by authorities having jurisdiction, a single supervisory input is permitted to the **[protected premises fire-alarm system] [mass notification system] <Insert system>**.
 - f. Cabinet Enclosures: UL 50E, **[Type 4] [Type 3R]**. Protect battery systems with a Type 3R or higher-rated cabinet. Protect repeater, transmitter, receiver, signal booster components, optical-to-RF converters, and external filters with a Type 4 or Type 4X enclosure.
 - g. Mounting: **[Surface] <Insert type>** mount.
 - h. Finish: **[Factory-finish red enamel] <Insert finish>**.
 4. Options:

- a. Remote Indicator Panel: As required. Install remote indicator panel within the fire command center or at a location designated by authorities having jurisdiction, and in accordance with approved shop drawings showing location, mounting height, and wiring detail. The indicator panel must display the following:
 - 1) Presence of primary AC power.
 - 2) Loss of primary AC power.
 - 3) Battery charger failure.
 - 4) Low-battery capacity.
 - 5) Signal source malfunction.
 - 6) Active RF-emitting device malfunction.
 - 7) Active system component malfunction.
 - b. Emergency Power-Off (EPO) Switch: As required. The EPO switch interrupts power to the ERCES on direction from authorities having jurisdiction or frequency license holder.
- C. In-Building ERCES Distributed Antennas **<Insert drawing designation>**:
1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
 2. Standard Features:
 - a. Type: **[Wide-band omnidirectional] [and] [multi-band] [single-band]**.
 - b. Mounting: Low-profile **[ceiling]** **<Insert type>** mount.
- D. In-Building ERCES Donor Antennas **<Insert drawing designation>**:
1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
 2. Standard Features:
 - a. Configuration: Factory-assembled and -tuned directional UHF Yagi antenna.
 - b. Mounting: **[Stainless steel]** **<Insert type>** mounting hardware.
 - c. Finish: **[Welded] [or] [seamless]** corrosion-resistant aluminum construction.
 - d. Wind Velocity Rating: **[Comply with minimum ICC IBC requirements]** **<Insert requirements>**.
- E. RF Antenna Cable Couplers and Splitters **<Insert drawing designation>**:
1. Description: Physical hardware elements connecting the donor antenna cables to the distributed antennas, mounting hardware, and building elements.
 2. <Double click here to find, evaluate, and insert list of manufacturers and products.>
 3. Standard Features:
 - a. Configuration: Nominal **[0.5 inch (13 mm)]** **<Insert diameter>**, **[50 Ω]** **<Insert impedance>**, N-Type, weatherproof, medium-size, RF couplers, and splitters for coaxial cables.
 - b. Bandwidth: **[As required by in-building emergency radio enhancement system performance requirements]** **<Insert requirement>**.
 - c. Gain (dB) Rating: **[As required by in-building emergency radio enhancement system performance requirements]** **<Insert requirement>**.
 - d. Environmental Rating: **[Type 4 and][IP65]** **<Insert IP code>**.
- F. Remote Indicator Panel **<Insert drawing designation>**:
1. <Double click here to find, evaluate, and insert list of manufacturers and products.>



2. Standard Features:

- a. Primary Power Supply: **[24 V(dc)] [120 V(ac)]** generally powered from the ERCES power supply as auxiliary nominal 28 V(dc). **<Insert voltage>**.
- b. Secondary Power Supply: Provide one of the following:
 - 1) **[24 V(dc)] <Insert voltage>** storage battery with capacity for 12 h at 100 percent system operation capacity.
 - 2) Power source with capacity for 12 h at 100 percent system operation capacity approved by authorities having jurisdiction.
 - 3) 2 h battery supplemented by standby generator power system with capacity to support system load for 12 h.
- c. Configuration: Zone indicator panel with LED indicators[, **piezoelectric sounder**,] and switches for lamp test and alarm silence.
- d. LED Indicators: Green indicator for primary power in normal state; red indicators for each individual fault status required to be indicated by authorities having jurisdiction.
- e. Enclosure: **[16-gauge steel] <Insert material>** with factory-applied red enamel finish.

PART 3 - EXECUTION

3.1 INSTALLATION OF EMERGENCY RESPONDER COMMUNICATIONS ENHANCEMENT SYSTEM (ERCES)

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:
 1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
 2. Electrical Maintenance: NFPA 70B.
 3. Electrical Safety: NFPA 70E.
 4. Temporary Electric Power Work: NECA NEIS 200.
 5. Commissioning of Electrical Systems: NECA NEIS 90.
 6. Commissioning of Active and Passive Fire Protection Features: NFPA 3 and NFPA 4.
 7. Hot Work: NFPA 51B.
 8. Fire-Alarm and Premises Security Work: NFPA 72, NFPA 731, NFPA 1225, and NECA NEIS 305.
 9. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
 10. Communications Work: BICSI N1.
 11. Work in ITE Rooms: NFPA 75.
 12. Work in Health Care Facilities: NFPA 99 and Article 517 of NFPA 70.
 13. Life-Safety and Means-of-Egress Work: NFPA 101.
 14. Emergency and Standby Power Work: NFPA 110, NFPA 111, and NECA NEIS 416.
 15. Work in Confined Spaces: NFPA 350.
 16. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
 17. Evaluation of Unlabeled Electrical Equipment: NFPA 791.
 18. Work in Museums, Libraries, Places of Worship, and Historic Structures: NFPA 909 and NFPA 914.
 19. Fire-Alarm Circuits and Pathways: Ch. 12 of NFPA 72 and Article 760 of NFPA 70.
 20. Consult Architect for resolution of conflicting requirements.
- C. Special Installation Techniques:

1. Installation for Survivability:
 - a. Install cables in accordance with Ch. 7 and 8 of NFPA 70.
 - b. Provide mechanical protection of work and raceways for coax cables in accordance with Article 820 of NFPA 70.
 - c. Backbone cables and cable components installed in buildings that are fully protected by an automatic sprinkler system in accordance with NFPA 13 do not require fire-resistance rating.
 - d. Protect backbone cables and cable components installed in nonsprinklered buildings, in buildings that are partially protected by an automatic sprinkler system, or in high-rise buildings from attack by fire in accordance with one of the following:
 - 1) Provide cable with listed fire-resistance rating in accordance with the following criteria:
 - a) Where the primary structural frame of a building is required to have a fire-resistance rating of 2 h or more, or is classified as heavy-timber construction, provide minimum 2 h fire-resistance rated cable.
 - b) Where the primary structural frame of a building is required to have a fire-resistance rating of less than 2 h, provide minimum 1 h fire-resistance rated cable.
 - c) Where the primary structural frame of a building does not require a fire-resistance rating, fire-resistance rated cable is not required.
 - 2) Provide protected enclosure or area with fire-resistance rating in accordance with the following criteria:
 - a) Where the primary structural frame of a building is required to have a fire-resistance rating of 2 h or more, or is classified as heavy-timber construction, provide minimum 2 h fire-resistance rated enclosure or area.
 - b) Where the primary structural frame of a building is required to have a fire-resistance rating of less than 2 h, provide minimum 1 h fire-resistance rated enclosure or area.
 - c) Where the primary structural frame of a building does not require a fire resistance rating, fire-resistance rated enclosure or area is not required.
 - e. Where the backbone cables and distribution antenna cables are run in a fire-resistant enclosure or protected area, both of the following shall apply, except as permitted in Section 18.12.3.6 of NFPA 1225:
 - 1) Provide connection between backbone cable and distribution antenna cables within an enclosure or protected area in accordance with Section 18.12.3.4 of NFPA 1225, Section 18.12.3.4.
 - 2) Provide firestop assembly for passage of the distribution antenna cable in and out of the enclosure or protected area with equivalent rating to enclosure or protected area.
 - f. If both the backbone cables and cable components are fire rated in accordance with Section 18.12.3.4 of NFPA-1225, connection of the distribution antenna cable may be made outside enclosure or protected area.
2. Antenna Wiring Methods:
 - a. Coaxial Cabling:



- 1) Riser Coaxial Cable: Type CATVR, nominal **[0.5 inch (13 mm)]** **<Insert diameter>**, **[50 Ω]** **<Insert impedance>** coaxial jacketed cable with corrugated **[copper]** **[or]** **[aluminum]** outer conductor.
- 2) Plenum Coaxial Cable: Type CATVP, nominal **[0.5 inch (13 mm)]** **<Insert diameter>**, **[50 Ω]** **<Insert impedance>** coaxial jacketed cable with corrugated **[copper]** **[or]** **[aluminum]** outer conductor.
- 3) Plenum Radiating Coaxial Cable: Type CATVP, nominal **[0.5 inch (13 mm)]** **<Insert diameter>**, **[50 Ω]** **<Insert impedance>** radiating coaxial jacketed cable with corrugated **[copper]** **[or]** **[aluminum]** outer conductor.
- 4) Connectors: Nominal **[0.5 inch (13 mm)]** **<Insert diameter>**, **[50 Ω]** **<Insert impedance>** N-Type, weatherproof, medium-size, RF connectors for coaxial cables.

3. Determine in-building service antenna locations based on baseline radio signal strength testing.
4. Request approval from authorities having jurisdiction to omit emergency responder radio coverage system from areas of building where baseline radio signal strength testing demonstrates that minimum required radio signal strength values are achieved without radio coverage system.
5. Install outdoor donor antenna with clear view to donor site with minimum **[2 ft (0.6 m)]** vertical clearance above nearby obstacles.
6. **<Insert more stringent installation requirements that supplement or supersede listed standards and manufacturer's published instructions>**.

D. Interfaces with Other Work:

1. Coordinate with Section 284600 "Fire Detection and Alarm" for interfaces with fire-alarm system.
2. Identification: Provide labels for ERCES and associated electrical equipment.
 - a. Identify field-installed conductors, interconnecting wiring, and components.
 - b. Label each enclosure with engraved metal or laminated-plastic nameplate.
 - c. Provide warning signs and arc-flash hazard warning labels for electrical equipment.
3. Coordinate installation of new products for **<Insert system or product group/category>** with existing conditions.
 - a. **<Insert requirements for transition between new and existing>**.
4. Coordinate with **<Insert Section number and title>** for **<Insert description of interfacing related Work>**.
 - a. **<Insert requirements for transition between this Section and related Work>**.

E. Systems Integration:

1. **<Insert requirements for integration with other systems>**.

3.2 FIELD QUALITY CONTROL OF ERCES

A. Administrant for Communications Tests and Inspections:

1. **[Owner]** **[Tenant]** will engage qualified communications testing and inspecting agency to administer and perform tests and inspections.

2. Engage qualified communications testing and inspecting agency to administer and perform tests and inspections.
 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
 4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].
- B. Administrant for Fire-Alarm Tests and Inspections:
1. **[Owner] [Tenant]** will engage qualified fire-alarm testing and inspecting agency to administer and perform tests and inspections.
 2. Engage qualified fire-alarm testing and inspecting agency to administer and perform tests and inspections.
 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
 4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].
- C. Acceptance Testing Preparation:
1. Notify the Owner and authorities having jurisdiction no later than ten working days in advance of scheduled acceptance testing of the installed system.
 2. Notify the frequency license holder no later than ten working days in advance of scheduled testing of the installed system. Receive written authorization from the frequency license holder to activate active RF components on scheduled date.
 3. Provide Owner and authorities having jurisdiction with a written test plan no later than seven working days prior to conducting acceptance tests.
- D. Field tests and inspections must be witnessed by **[Architect] [Tenant] [authorities having jurisdiction] <Insert names or titles of witnesses>**.
- E. Tests and Inspections:
1. Perform manufacturer's recommended tests and inspections.
 2. Perform standard field tests and inspections as required by NFPA 72 for fire-alarm supervision of ERCES components.
 3. Perform standard field tests and inspections as required by NFPA 1225.
 4. Building Owner to have the ERCES inspected and tested annually or where structural changes occur, including additions or remodels.
 5. Baseline radio signal strength testing.
 6. **<Insert detailed description of additional tests and inspections required>**.
- F. Nonconforming Work:
1. ERCES will be considered defective if it does not pass tests and inspections.
 2. Remove and replace defective units and retest.
- G. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.
- H. Manufacturer Services: Engage factory-authorized service representative to **[support] [supervise]** field tests and inspections.
1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.



3.3 SYSTEM STARTUP

- A. Perform startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's published instructions.
 - 2. **<Insert startup steps if any>.**
- B. Manufacturer Services: Engage factory-authorized service representative to **[support]** **[supervise]** system startup.
 - 1. Manufacturer's Field Reports for System Startup Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.

3.4 CLOSEOUT ACTIVITIES

- A. Training:
 - 1. **[With assistance from factory-authorized service representatives, train]** **[Train]** Owner's maintenance personnel on the following topics:
 - a. How to adjust, operate, and maintain ERCES components.
 - b. **<Insert system or equipment>.**
 - 2. **[Provide video recordings of training sessions to Owner]** **[Allow Owner to record training sessions]**.

3.5 PROTECTION

- A. After installation, protect ERCES equipment from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

3.6 MAINTENANCE

- A. Maintenance Service Agreement: Beginning at Substantial Completion, verify that maintenance service agreement includes **[three-month]** **[six-month]** **[nine-month]** **[one-year]** **<Insert duration>** period for full maintenance by **[skilled employees of ERCES Installer]** **[manufacturer's authorized service representative]**. Include **[monthly]** **[quarterly]** **[semiannual]** **[annual]** preventive maintenance, repair or replacement of worn or defective components, cleaning, and adjusting as required for proper ERCES operation. Verify that parts and supplies are manufacturer's authorized replacement parts and supplies.
- B. Software and Firmware Service Agreement:
 - 1. Technical Support: Beginning at Substantial Completion, verify that software and firmware service agreement includes software and firmware support for **[two years]** **<Insert duration>.**
 - 2. Upgrade Service: At Substantial Completion, update software and firmware to latest version. Install and program software and firmware upgrades that become available within **[two years]**



<Insert duration> from date of Substantial Completion.[Verify that upgrading software includes operating system and new or revised licenses for using software.]

- a. Upgrade Notice: Not less than **[30 days]** **<Insert duration>**; to allow Owner to schedule and access the system**[and to upgrade computer equipment if necessary.]**
3. Field Reports for Software and Firmware Upgrades: Prepare and submit report after each update, documenting upgrades installed.

END OF SECTION 28 40 00 00



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28 - Electronic Safety and Security

Task	Specification	Specification Description
28 41 00 00	28 40 00 00	Emergency Responder Communications Enhancement System ERCES
28 41 15 00	28 40 00 00	Emergency Responder Communications Enhancement System ERCES
28 42 00 00	28 40 00 00	Emergency Responder Communications Enhancement System ERCES
28 42 11 00	28 40 00 00	Emergency Responder Communications Enhancement System ERCES
28 42 15 00	28 40 00 00	Emergency Responder Communications Enhancement System ERCES
28 43 00 00	28 40 00 00	Emergency Responder Communications Enhancement System ERCES



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SECTION 28 46 00 00 - FIRE DETECTION AND ALARM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fire-alarm system control units.
2. Dedicated function control units.
3. Fire-alarm remote annunciators.
4. Fire-alarm auxiliary power supplies.
5. Fire-alarm audio amplifiers.
6. Fire-alarm terminal cabinets.
7. Manual fire-alarm boxes.
8. Heat-sensing fire detectors.
9. Smoke-sensing fire detectors.
10. Radiant energy-sensing fire detectors.
11. Combination, multi-criteria, and multi-sensor detectors.
12. Carbon monoxide detectors.
13. Sprinkler waterflow alarm-initiating devices.
14. Audible notification appliances.
15. Visual notification appliances.
16. Combination audible/visual notification appliances.
17. Firefighters' two-way, in-building wired telephone communications system.
18. Fire-alarm supervised control module interfaces for fire safety functions.
19. Fire-alarm supervisory signal-initiating devices.
20. Fire-alarm digital alarm communicator transmitters.
21. Fire-alarm radio alarm transmitters.
22. Fire-alarm record documentation cabinets.
23. Passive graphic maps.
24. Fire-alarm cables.

B. Products Installed, but Not Furnished, under This Section:

1. **<Insert products identified in "Existing Products to be Modified" or "Existing Products to be Removed and Re-Installed" Article>.**

C. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. Section 078413 "Penetration Firestopping" specifies materials and methods for sealing penetrations of rated walls and partitions referenced by this Section.
5. **[Section 087100 "Door Hardware"] [Section 087111 "Door Hardware (Descriptive Specification)"] [Section 087113 "Power Door Operators"] [Section 087813 "All-Glass-Entrance Hardware"]** specifies door hardware control interfaces referenced by this Section.
6. **[Section 142100 "Electric Traction Elevators"] [Section 142113 "Electric Traction Freight**

Elevators"][Section 142123.16 "Machine Room-Less Electric Traction Passenger Elevators"]**[Section 142400 "Hydraulic Elevators"]**[Section 142413 "Hydraulic Freight Elevators"]**[Section 142600 "Limited-Use/Limited-Application Elevators"]** specifies elevator control interfaces referenced by this Section.

7. Section 143100 "Escalators" specifies escalator control interfaces referenced by this Section.
8. Section 143200 "Moving Walks" specifies moving walk control interfaces referenced by this Section.
9. Section 230923 "Direct Digital Control (DDC) System for HVAC" specifies HVAC control interfaces referenced by this Section.
10. Section 260529 "Hangers and Supports for Electrical Systems" specifies hangers, supports, and concrete bases referenced by this Section.
11. Section 260533.13 "Conduits for Electrical Systems" specifies raceway types installed by this Section.
12. Section 260548 "Vibration and Seismic Controls for Electrical Systems" specifies vibration isolation and seismic **[and wind]** control devices referenced by this Section.
13. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs installed by this Section.
14. Section 260923 "Lighting Control Devices" specifies emergency lighting control interfaces referenced by this Section.
15. Section 262816 "Enclosed Switches and Circuit Breakers" specifies shunt-trip control interfaces referenced by this Section.
16. Section 270528 "Pathways for Communications Systems" specifies additional requirements for raceway materials, routing, locations, and identification of communications equipment and cabling.
17. Section 275119 "Sound Masking Systems" specifies sound masking system equipment referenced by this Section.
18. Section 284700 "Mass Notification" specifies mass notification system interfaces referenced by this Section.
19. Section 284800 "Emergency Response Systems" specifies **[ERCES]****[and]****[two-way emergency communications systems for rescue assistance]** referenced by this Section.

1.2 REFERENCES

A. Abbreviations and Acronyms for Electrical Terms and Units of Measure:

1. AWG: American wire gauge; see ASTM B258.
2. BAS: Building automation system.
3. BMS: Building management system.
4. cd: Candela, the SI fundamental unit of luminous intensity.
5. DACR: Digital alarm communicator receiver.
6. DACT: Digital alarm communicator transmitter.
7. dB(A-weighted) or dB(A): Decibel acoustical sound pressure level with A-weighting applied in accordance with IEC 61672-1.
8. EMP: Electrical maintenance program (operation and maintenance); electromagnetic pulse (transient analysis).
9. EPS: Emergency power supply.
10. EPSS: Emergency power supply system.
11. ERCES: Emergency responder communications enhancement system.
12. ESS: Energy storage system.
13. FACU: Fire-alarm control unit.
14. FAS: Fire-alarm system.
15. IDC: Initiating device circuit.
16. IP: Internet Protocol.
17. IR: Infrared.

18. LAN: Local area network.
19. LCD: Liquid-crystal display.
20. LED: Light-emitting diode.
21. Li-ion: Lithium-ion.
22. NAC: Notification appliance circuit.
23. N.C.: Normally closed.
24. Ni-Cd: Nickel-cadmium.
25. Ni-MH: Nickel-metal hydride.
26. N.O.: Normally open.
27. PC: Personal computer.
28. PLFA: Power-limited fire alarm.
29. PoE: Power over Ethernet.
30. POTS: Plain old telephone service. See "public switched telephone network" definition.
31. PSTN: Public switched telephone network.
32. RAT: Radio alarm transmitter.
33. SLC: Signaling-line circuit.
34. TR: Tamper resistant.
35. UL: (standards) UL Standards & Engagement Inc.; (product categories) UL Solutions, Inc.
36. UL CCN: UL Category Control Number.
37. UPS: Uninterruptible power supply.
38. VoIP: Voice over Internet Protocol.
39. VPN: Virtual private network.
40. VRLA: Valve regulated lead acid; also called "sealed lead acid (SLA)" or "valve regulated sealed lead acid."
41. WAN: Wide area network.
42. WR: Weather resistant.

B. Abbreviations and Acronyms for Electrical Raceway Types:

1. EMT: Electrical metallic tubing.
2. EMT-A: Aluminum electrical metallic tubing.
3. EMT-S: Steel electrical metallic tubing.
4. EMT-SS: Stainless steel electrical metallic tubing.
5. ERMCA: Aluminum electrical rigid metal conduit.
6. ERMCS: Steel electrical rigid metal conduit.
7. ERMCS-G: Galvanized-steel electrical rigid metal conduit.
8. ERMCS-PVC: PVC-coated-steel electrical rigid metal conduit.
9. ERMCS-SS: Stainless steel electrical rigid metal conduit.
10. FMC: Flexible metal conduit.
11. FMC-A: Aluminum flexible metal conduit.
12. FMC-S: Steel flexible metal conduit.
13. IMC: Steel electrical intermediate metal conduit.
14. LFMC: Liquidtight flexible metal conduit.
15. LFMC-A: Aluminum liquidtight flexible metal conduit.
16. LFMC-S: Steel liquidtight flexible metal conduit.
17. LFMC-SS: Stainless steel liquidtight flexible metal conduit.
18. LFNC: Liquidtight flexible nonmetallic conduit.
19. LFNC-A: Layered (Type A) liquidtight flexible nonmetallic conduit.
20. LFNC-B: Integral (Type B) liquidtight flexible nonmetallic conduit.
21. LFNC-C: Corrugated (Type C) liquidtight flexible nonmetallic conduit.
22. PVC: Rigid PVC conduit.
23. PVC-40: Schedule 40 rigid PVC conduit.
24. PVC-80: Schedule 80 rigid PVC conduit.
25. RGS: See ERMCS-G.
26. RMC: See ERMCA raceway types above.

C. Abbreviations and Acronyms for Electrical Single-Conductor and Multiple-Conductor Cable Types:

1. CI: Circuit integrity cable.
2. FPL: Power-limited fire-alarm cable.
3. FPLP: Power-limited fire-alarm plenum cable.
4. FPLR: Power-limited fire-alarm riser cable.
5. MC-FPL/FPLR/FPLP: Metal-clad cable containing FPL, FPLR, or FPLP.
6. NPLF: Non-power-limited fire-alarm circuit cable.
7. NPLFP: Non-power-limited fire-alarm circuit cable for environmental air spaces.
8. NPLFR: Non-power-limited fire-alarm circuit riser cable.
9. OFC: Conductive optical fiber general-purpose cable.
10. OFCG: Conductive optical fiber general-purpose cable.
11. OFCP: Conductive optical fiber plenum cable.
12. OFCR: Conductive optical fiber riser cable.
13. OFN: Nonconductive optical fiber general-purpose cable.
14. OFNG: Nonconductive optical fiber general-purpose cable.
15. OFNP: Nonconductive optical fiber plenum cable.
16. OFNR: Nonconductive optical fiber riser cable.

D. Definitions:

1. Cable: In accordance with NIST NBS Circular 37 and IEEE standards, in the United States for the purpose of interstate commerce, the definition of "cable" is (1) a conductor with insulation, or a stranded conductor with or without insulation (single-conductor cable); or (2) a combination of conductors insulated from one another (multiple-conductor cable).
2. Conductor: In accordance with NIST NBS Circular 37 and IEEE standards, in the United States for the purpose of interstate commerce, the definition of "conductor" is (1) a wire or combination of wires not insulated from one another, suitable for carrying an electric current; (2) (National Electrical Safety Code) a material, usually in the form of wire, cable, or bar, suitable for carrying an electric current; or (3) (general) a substance or body that allows a current of electricity to pass continuously along it.
3. Conduit: A structure containing one or more duct raceways.
4. Designated Seismic System: An architectural, electrical, or mechanical system and its components for which the component importance factor is greater than 1.0 when determined in accordance with Section 018123 "Facility Seismic and Wind Criteria."
5. Direct Buried: Installed underground without encasement in concrete or other protective material.
6. Duct Bank: An arrangement of conduit providing one or more continuous duct raceways between two points.
7. Duct Raceway: A single enclosed raceway for conductors or cable.
8. Emergency Systems: Those systems legally required and classed as emergency by municipal, state, federal, or other codes, or by any governmental agency having jurisdiction that are designed to ensure continuity of lighting, electrical power, or both, to designated areas and equipment in the event of failure of the normal supply for safety to human life.
9. Public Switched Telephone Network (PSTN): Analog telephone technology that uses twisted pair cables from a telephone-provider central office for the transmission medium. "PSTN" refers to the telephone network; "POTS" refers to the individual subscriber line.
10. Voice over Internet Protocol (VoIP): Digital telephone packet technology that uses the internet for its transmission medium.
11. Wire: In accordance with NIST NBS Circular 37 and IEEE standards, in the United States for the purpose of interstate commerce, the definition of "wire" is a slender rod or filament of drawn metal. A group of small wires used as a single wire is properly called a "stranded wire." A wire or stranded wire covered with insulation is properly called an "insulated wire" or a "single-conductor cable." Nevertheless, when the context indicates that the wire is insulated, the term "wire" will be understood to include the insulation.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Coordination Meeting(s): For fire-alarm system coordination with **[sound-masking system][paging system][and][mass notification system]**. Conduct meeting(s) **[as videoconference][or][at Project site]<Insert location>** before **<Insert construction activity>**.
- Attendees: Installers, fabricators, representatives of manufacturers, and administrators for field tests and inspections. Notify Architect[, **Construction Manager**], and **Owner's Commissioning Authority** of scheduled meeting dates.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product. In addition to information identified in Section 013300 "Submittal Procedures," submit the following:
- Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing agency, certifying product's compliance with specified listing criteria.
 - If listed manufacturer differs from selling manufacturer, indicate relationship between entities on submittal. Clearly indicate which entity warrants product performance and fitness for purpose.
 - Listing criteria identified in approval letter must match specified listing criteria. UL label indicating approval of equipment's enclosure is not considered approval of equipment for intended application.
 - Product identification in approval letter must match product branding and model numbers in submittal. Approval letters for discontinued or superseded products are not acceptable for submitted product.
 - Include manufacturer's sample extended warranty language.
 - <Insert requirements>**.
- B. Shop Drawings: Prepare and submit the following:
- Cover sheet indicating protected premises name and location and Owner information, name of installer, device legend and symbols **[in accordance with NFPA 170][acceptable to the authorities having jurisdiction]**, and date of issue and any revision dates.
 - Floor Plans:
 - Floor or level identification.
 - Point of compass (indication of north).
 - Graphic scale.
 - All walls and doors.
 - All partitions extending to within 15 percent of the ceiling height.
 - Room and area descriptions.
 - Acoustically distinguishable spaces.
 - Minimum required illumination levels.
 - System devices/component locations.
 - Locations of the system's primary power disconnecting means.
 - Locations of monitor/control interfaces to other systems.
 - System riser locations.
 - Type and number of system components/devices on each circuit, on each floor or level.
 - Type and quantity of conductors[**and conduit**] for each circuit.
 - Identification of any ceiling over **10 ft (3.0 m)** in height where automatic fire detection is being proposed.
 - Details of ceiling geometries, including beams and solid joists, where automatic fire

- q. detection is being proposed.
 - r. Acoustic properties of spaces, where known.
 - r. Pathway class designations, including the location of any end-of-line supervisory or power devices that are required by the pathway class.
 - s. Pathway survivability level designations.
 - 3. Wiring Diagrams:
 - a. System riser diagrams coordinated with the floor plans and indicating the following information:
 - 1) General arrangement of the system in building cross-section.
 - 2) Number of risers.
 - 3) Type and number of circuits in each riser.
 - 4) Type and number of system components/devices on each circuit, on each floor or level.
 - 5) Number of conductors for each circuit.
 - 6) Pathway class designation, including the location of any end-of-line supervisory or power devices that are required by the pathway class.
 - 7) Pathway survivability level designations.
 - b. Control unit diagrams for all control equipment, power supplies, battery chargers, and annunciators indicating the following information:
 - 1) Identification of control equipment depicted.
 - 2) Location(s) of control equipment.
 - 3) All field wiring terminals and terminal identifications.
 - 4) All circuits connected to field wiring terminals and circuit identifications.
 - 5) All indicators and manual controls.
 - 6) Field connections to supervising station signaling equipment[, **releasing equipment,**] and emergency safety control interfaces.
 - c. Typical fire-alarm component schematic wiring diagrams for all initiating devices, notification appliances[, **remote indicators,**][**remote test stations,**][**end-of-line and power supervisory devices,**] and annunciators.
 - 4. Fire-Alarm Input/Output Sequence: Include a narrative description or input/output matrix of operation to describe the fire-alarm system sequence of operation.
 - 5. Details:
 - a. Component installation details.
 - b. Custom graphic annunciator layout.
 - 6. Calculations:
 - a. Battery calculations.
 - b. Voltage-drop calculations.
 - c. Speaker circuit calculations.
 - d. Spare capacity circuit calculations.
- C. Field quality-control reports.

1.5 INFORMATIONAL SUBMITTALS

- A. Manufacturer's published instructions.
- B. Field Reports:
 - 1. Manufacturer's field reports for field quality-control support.
 - 2. Manufacturer's field reports for system startup support.
 - 3. Field reports for [software][and][firmware] upgrades.

1.6 CLOSEOUT SUBMITTALS

- A. Warranty documentation.
- B. Maintenance service agreement.
- C. Software and firmware service agreement.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Spare parts.
- B. Special tools.

1.8 REGULATORY AGENCY APPROVALS

- A. Submittals for fire detection and alarm system requiring approval by authorities having jurisdiction must be signed by qualified NICET FAS[**senior**] engineering technician or life-safety professional engineer responsible for their preparation.[**Obtain approval by authorities having jurisdiction prior to submitting for action by Architect.**][**Submit for action by Architect prior to submitting for approval by authorities having jurisdiction.**]

1.9 QUALIFICATIONS

- A. Fire-Alarm Systems (FAS) Technician Trainee: Having at least six months of experience and possessing active NICET FAS Level I certification. Able to perform limited tasks under direct supervision.
- B. Fire-Alarm Systems (FAS) Associate Engineering Technician: Having at least two years of experience and possessing active NICET FAS Level II certification. Able to review drawings, specifications, codes, and standards; to conduct basic installation activities; and to perform basic troubleshooting.
- C. Fire-Alarm Systems (FAS) Engineering Technician: Having at least five years of experience and possessing active NICET FAS Level III certification. Able to perform system layout activities, supervise Level I and Level II technicians, provide submittal packages, and interact with authorities having jurisdiction.
- D. Fire-Alarm Systems (FAS) Senior Engineering Technician: Having at least 10 years of experience and possessing active NICET FAS Level IV certification. Able to manage multiple projects at once, interpret codes and standards, conduct training, and serve as liaison between authorities having jurisdiction, owners, engineers, and contractors.



- E. Inspection and Testing of Fire-Alarm Systems (I&TFAS) Technician I: Possessing active NICET I&TFAS Level I certification. Able to perform periodic inspections and tests of basic fire-alarm systems and prepare related records and reports.
- F. Inspection and Testing of Fire-Alarm Systems (I&TFAS) Technician II: Possessing active NICET I&TFAS Level II certification. Able to plan, perform, and coordinate periodic inspections and tests of complex fire-alarm systems (including one or more of suppression interfaces, networked control units, smoke control interfaces, air sampling systems, multi-zone voice evacuation systems, or high-rise applications) and prepare related records and reports.
- G. Life-Safety Professional Engineer: Professional engineer possessing active qualifications specified in Section 014000 "Quality Requirements," with expertise in life-safety systems.
- H. Fire-Alarm Cable Installer: Entity possessing active qualifications specified in Section 014000 "Quality Requirements" with training and manufacturer certification to install, splice, and terminate fire-alarm cabling.
 - 1. On-site fire-alarm cable installation supervisor must possess active NICET FAS[**Senior**] Engineering Technician certification.
- I. Fire-Alarm Testing Agency: Entity possessing active credentials from qualified electrical testing laboratory recognized by authorities having jurisdiction.
 - 1. On-site fire-alarm testing supervisor must possess active NICET I&TFAS Technician **[I][II]** certification.

1.10 WARRANTY FOR FIRE DETECTION AND ALARM SYSTEMS

- A. Special Installer Extended Warranty: Installer warrants that installed fire detection and alarm system performs in accordance with specified requirements and agrees to repair or replace system components or products that fail to perform as specified within extended-warranty period. Warranty must convey to Owner upon acceptance of the Work.
 - 1. Extended-Warranty Period: **[Two][Three][Four]<Insert number>** years from date of Substantial Completion; full coverage for labor, materials, and equipment.
- B. Special Manufacturer Extended Warranty: Manufacturer warrants that fire detection and alarm system components perform in accordance with specified requirements and agrees to repair or replace system components or products that fail to perform as specified within extended-warranty period. Warranty must convey to Owner upon acceptance of the Work.
 - 1. Initial Extended-Warranty Period: **[Three][Four][Five]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for labor, materials, and equipment.
 - 2. Follow-On Extended-Warranty Period: **[Eight]<Insert number>** years from date of Substantial Completion; **[full][prorated]** coverage for materials **[that failed because of transient voltage surges]** only, free on board **[origin][destination]**, freight prepaid.



PART 2 - PRODUCTS

2.1 EXISTING PRODUCTS TO BE MODIFIED

- A. Basis for Pricing: **<Insert name of manufacturer and model number or series for existing product>.**
- B. Description: **<Insert description of existing product, including special features, options, and finishes that may impact the Work>.**
- C. Accessories: **<Insert accessories included with existing product>.**

2.2 EXISTING PRODUCTS TO BE REMOVED AND RE-INSTALLED

- A. Basis for Pricing: **<Insert name of manufacturer and model number or series for existing product>.**
- B. Description: **<Insert description of existing product, including special features, options, and finishes that may impact the Work>.**
- C. Accessories: **<Insert accessories included with existing product>.**

2.3 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70 or NFPA 72, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- B. System Description: Noncoded, **[UL-certified][FM Global-placarded][addressable][conventional]** system with multiplexed signal transmission and **[voice][horn]-and-strobe** notification for evacuation.
- C. System Inputs:
 - 1. Fire-alarm signal initiation must be by one or more of the following devices **[and systems]**:
 - a. Manual fire-alarm boxes.
 - b. Heat detectors.
 - c. Smoke detectors.
 - d. Flame detectors.
 - e. Duct smoke detectors.
 - f. Air-sampling smoke-detection system.
 - g. Carbon monoxide detectors.
 - h. Combustible gas detectors.
 - i. Automatic sprinkler system water flow.
 - j. Preaction system alarm.
 - k. Fire-extinguishing system operation.
 - l. Fire standpipe system.
 - m. Dry-pipe sprinkler system pressure flow switch.
 - n. Fire pump is running.
 - o. **<Insert alarm-initiating devices and systems>.**
 - 2. Supervisory signal initiation must be by one or more of the following devices and actions:
 - a. Valve supervisory switch.

- b. High- or low-air pressure switch of dry-pipe or preaction sprinkler system.
- c. Alert and Action signals of air-sampling smoke-detection systems.
- d. Duct smoke detectors.
- e. Elevator shunt-trip control circuit supervision.
- f. Independent fire-detection and fire-suppression systems.
- g. Fire pump is running.
- h. Fire pump has lost power.
- i. Power to the fire pump has phase reversal.
- j. Zones or individual devices have been disabled.
- k. FACU has lost communication with network.
- l. Hose cabinet door is open.
- m. **<Insert supervisory signal-initiating devices and actions>.**

3. System trouble signal initiation must be by one or more of the following devices and actions:

- a. Open circuits, shorts, and grounds in designated circuits.
- b. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
- c. Loss of communication with addressable sensor, input module, relay, control module, remote annunciator, or ethernet module.
- d. Loss of primary power at FACU.
- e. Ground or single break in internal circuits of FACU.
- f. Abnormal AC voltage at FACU.
- g. Break in standby battery circuitry.
- h. Failure of battery charging.
- i. Abnormal position of switch at FACU or remote annunciator.
- j. Voice signal amplifier failure.
- k. **<Insert trouble signal-initiating devices and actions>.**

4. Carbon monoxide alarm signal initiation must be by the following devices **and systems**:

- a. Carbon monoxide detectors.

D. System Outputs:

1. Fire-alarm signal must initiate the following actions:

- a. Continuously operate alarm notification appliances[, **including voice evacuation notices**].
- b. Identify alarm and specific initiating device at FACU[, **connected network control panels, off-premises network control panels,**][**and remote annunciators**].
- c. Transmit alarm signal to remote alarm receiving station.
- d. Unlock electric door locks in designated egress paths.
- e. Release fire and smoke doors held open by magnetic door holders.
- f. Activate voice/alarm communication system.
- g. Switch HVAC equipment controls to fire-alarm mode.
- h. Activate smoke-control system (smoke management) at firefighters' smoke-control system panel.
- i. Activate stairwell[**and elevator-shaft**] pressurization systems.
- j. Close smoke dampers in air ducts of designated air-conditioning duct systems.
- k. Activate preaction system.
- l. Recall elevators to designated or alternate recall levels only upon activation of smoke detectors in respective elevator lobbies, machine rooms, or hoistways.
- m. Activate elevator power shunt trip only upon activation of associated heat detector.
- n. Activate emergency lighting control.
- o. Activate emergency shutoffs for gas and fuel supplies[, **except for shutoffs serving**

- p. **legally required life-safety systems such as emergency generators and fire pumps].**
 - q. Record events in system memory.
 - r. Indicate device in alarm on graphic annunciator.
 - r. **<Insert signal-initiating actions>.**
- 2. System supervisory signal must initiate the following actions:
 - a. Initiate supervisory notification appliances.
 - b. Identify specific device initiating event at FACU[, **connected network control panels, off-premises network control panels,][and remote annunciators].**
 - c. After time delay of **[200 seconds]<Insert time>**, transmit trouble or supervisory signal to remote alarm receiving station.
 - d. Transmit system status to building management system.
 - e. Display system status on graphic annunciator.
- 3. Carbon monoxide alarm signal must initiate the following actions:
 - a. Initiate carbon monoxide notification appliances and sound temporal-4 signal.
 - b. Identify specific device initiating event at FACU[, **connected network control panels, off-premises network control panels,][and remote annunciators].**
 - c. Transmit carbon monoxide alarm signal to remote alarm receiving station.

2.4 FIRE-ALARM SYSTEM CONTROL UNITS

- A. Description: A component of the fire-alarm system, provided with primary and secondary power sources, which receives signals from initiating devices or other fire-alarm control units, and processes these signals to determine part or all of the required fire-alarm system output functions.
- B. UL UOJZ - Addressable Fire-Alarm System Control Units :
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Bosch Security Systems, Inc.]**
 - b. **[Fike Corporation]**
 - c. **[Fire-Lite Alarms; Honeywell International, Inc.]**
 - d. **[Firecom, Inc.]**
 - e. **[Gamewell-FCI; Honeywell International, Inc.]**
 - f. **[Keltron Corporation]**
 - g. **[Kidde Commercial Fire & Life Safety Systems]**
 - h. **[Kidde; Carrier Global Corporation]**
 - i. **[Kingfisher Company, Inc.]**
 - j. **[Notifier; Honeywell International, Inc.]**
 - k. **[Potter Electric Signal Company, LLC]**
 - l. **[Siemens Industry, Inc.; Fire Safety Division]**
 - m. **[Silent Knight; Honeywell International, Inc.]**
 - n. **[Simplex; brand of Johnson Controls International plc, Building Solutions North America]**
 - o. **[Tyco Security Products and Solutions; brand of Johnson Controls]**
 - p. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the

following:

- a. **[Bosch Security Systems, Inc.]**
 - b. **[Fike Corporation]**
 - c. **[Fire-Lite Alarms; Honeywell International, Inc.]**
 - d. **[Firecom, Inc.]**
 - e. **[Gamewell-FCI; Honeywell International, Inc.]**
 - f. **[Keltron Corporation]**
 - g. **[Kidde Commercial Fire & Life Safety Systems]**
 - h. **[Kidde; Carrier Global Corporation]**
 - i. **[Kingfisher Company, Inc.]**
 - j. **[Notifier; Honeywell International, Inc.]**
 - k. **[Potter Electric Signal Company, LLC]**
 - l. **[Siemens Industry, Inc.; Fire Safety Division]**
 - m. **[Silent Knight; Honeywell International, Inc.]**
 - n. **[Simplex; brand of Johnson Controls International plc, Building Solutions North America]**
 - o. **[Tyco Security Products and Solutions; brand of Johnson Controls]**
 - p. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Electrical Control Units for Fire-Protective Signaling Systems: UL CCN UOJZ, including UL 864 and NFPA 72.
 5. Standard Features:
 - a. Product Reference Standards: Ch. 23 of NFPA 72.
 - b. **[Voice][Non-voice]**/alarm communications.
 - c. Indication of which communication zones have been silenced.
 - d. Provide selective silencing of alarm notification appliances by building communication zone.
 - e. Real-time clock for time annotation of events on the event recorder **[and printer]**.
 - f. Communication between the FACU and remote circuit interface panels, annunciators, and displays.
 - g. The FACU must be listed for connection to a central station signaling system service.
 - h. Provide non-volatile memory for system database, logic, operating system, and event history.
 - i. The system must not require manual input to initialize in the event of a complete power-down condition.
 - j. Alphanumeric display and system controls.
 - k. Minimum of **[two][four]<Insert number>[Class A][Class X][Class B]** signaling-line circuits **[with expansion capability to add circuits]**.
 - l. Minimum of **[two][four]<Insert number>[Class A][Class B]** notification appliance circuits **[with expansion capability to add circuits]**.
 - m. Synchronization of notification appliance circuits.
 6. Other Available Features Required by Project:
 - a. Printer interface.
 - b. Smoke-alarm verification.

C. UL UOJZ - Conventional Fire-Alarm System Control Units :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Bosch Security Systems, Inc.]**
 - b. **[Edwards; Carrier Global Corporation]**
 - c. **[Gamewell-FCI; Honeywell International, Inc.]**
 - d. **[Notifier; Honeywell International, Inc.]**
 - e. **[Siemens Industry, Inc.; Fire Safety Division]**
 - f. **[Silent Knight; Honeywell International, Inc.]**
 - g. **[Simplex; brand of Johnson Controls International plc, Building Solutions North America]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Bosch Security Systems, Inc.]**
 - b. **[Edwards; Carrier Global Corporation]**
 - c. **[Gamewell-FCI; Honeywell International, Inc.]**
 - d. **[Notifier; Honeywell International, Inc.]**
 - e. **[Siemens Industry, Inc.; Fire Safety Division]**
 - f. **[Silent Knight; Honeywell International, Inc.]**
 - g. **[Simplex; brand of Johnson Controls International plc, Building Solutions North America]**
 - h. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Electrical Control Units for Fire-Protective Signaling Systems: UL CCN UOJZ, including UL 864 and NFPA 72.
5. Standard Features:
 - a. Product Reference Standards: Ch. 23 of NFPA 72.
 - b. Communication between devices and control panel is limited and has only three states: Standby, Fault, and Fire.
 - c. Minimum of **[four][eight]<Insert number>** conventional zones to supervise initiating device circuits.
 - d. Built-in alarm and trouble relays.
 - e. Capable of being interfaced to supervise third-party systems or equipment via dry contact closure.
 - f. Synchronization of notification appliance circuits.
6. Other Available Features Required by Project:
 - a. Printer interface.



2.5 DEDICATED FUNCTION CONTROL UNITS

- A. Description: A protected premises fire-alarm control unit specifically listed for supervising a single function, such as releasing service that is part of a fire-suppression system and which provides control outputs to release a fire-suppression agent based on either automatic or manual input.
- B. UL SYZV - Addressable Non-Extinguishing and Non-Water-Based Releasing Device Control Unit :
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Johnson Controls, Inc.]**
 - b. **[Silent Knight; Honeywell International, Inc.]**
 - c. **[Simplex; brand of Johnson Controls International plc, Building Solutions North America]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Johnson Controls, Inc.]**
 - b. **[Silent Knight; Honeywell International, Inc.]**
 - c. **[Simplex; brand of Johnson Controls International plc, Building Solutions North America]**
 - d. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Releasing Device Control Units for Fire-Protective Signaling Systems: UL CCN SYZV, including UL 864 and NFPA 72.
 5. Standard Features:
 - a. Product Reference Standards: Ch. 23 of NFPA 72.
 - b. Built-in alarm, trouble, supervisory, and security relays.
 - c. Minimum of **[two][four]<Insert number>[Class A][Class X][Class B]** signaling-line circuits **[with expansion capability to add circuits]**.
 - d. Auto programming and walk test reports.
 - e. Manual sensitivity adjustments.
 - f. Maintenance alerts.
 - g. Battery charger supports.
 - h. Non-alarm points for lower-priority functions.
 6. Other Available Features Required by Project:
 - a. Printer interface.
 - b. Synchronization of notification appliance circuits.
- C. UL SYZV - Conventional Non-Extinguishing and Non-Water-Based Releasing Device Control Unit :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **<Insert, in separate subparagraphs, manufacturer's name>.**
2. Source Limitations: Obtain products from single manufacturer.
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Releasing Device Control Units for Fire-Protective Signaling Systems: UL CCN SYZV, including UL 864 and NFPA 72.
4. Standard Features:
 - a. Product Reference Standards: Ch. 23 of NFPA 72.
 - b. Built-in alarm and trouble relays.
 - c. Minimum of **[two][four]<Insert number>[Class A][Class B]** initiating device circuits **[with expansion capability to add circuits]**.
 - d. Maintenance alerts.
 - e. Battery charger supports.
5. Other Available Features Required by Project:
 - a. Printer interface.
 - b. Synchronization of notification appliance circuits.

2.6 FIRE-ALARM REMOTE ANNUNCIATORS

- A. Description: A unit containing one or more indicator lamps, alphanumeric displays, or other equivalent means in which each indication provides status information about a fire-alarm system device, circuit, condition, or location.
- B. UL UOXX - Fire-Alarm System Remote Annunciators :
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Bosch Security Systems, Inc.]**
 - b. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Bosch Security Systems, Inc.]**
 - b. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product



categories:

- a. Control Unit Accessories for Fire-Protective Signaling Systems: UL CCN UOXX, including UL 864 and NFPA 72.

5. Standard Features:

- a. Product Reference Standards: Ch. 23 of NFPA 72.
- b. Compatibility with fire-alarm control unit for alphanumeric display and LED indicating lights.
- c. Provide controls to acknowledge, silence, reset and test functions for alarm, supervisory, and trouble signals.

2.7 FIRE-ALARM AUXILIARY POWER SUPPLIES

- A. Description: An auxiliary source of low-voltage electrical operating power for fire-alarm system equipment, including the circuits and terminations connecting it to the equipment being powered. Auxiliary power supplies are often referred to as remote power supplies, booster power supplies, or notification appliance power supplies.

B. UL UOXX - Fire-Alarm Auxiliary Power Supplies :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **<Insert, in separate subparagraphs, manufacturer's name>.**
2. Source Limitations: Obtain products from single manufacturer.
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Control Unit Accessories for Fire-Protective Signaling Systems: UL CCN UOXX, including UL 864 and NFPA 72.
4. Standard Features:
 - a. Product Reference Standards: Chs. 10 and 23 of NFPA 72.
 - b. Minimum of **[two][four]<Insert number>** 24 V(dc) auxiliary power circuits.
5. Other Available Features Required by Project:
 - a. Synchronization of notification appliance circuits.
 - b. Addressable-type notification appliance power supply, which connects directly to a signaling-line circuit.

2.8 FIRE-ALARM AUDIO AMPLIFIERS

- A. Description: A component of in-building fire emergency voice/alarm communications systems that takes a low-level audio input and amplifies the power output to distribute to fire-alarm loudspeakers. Amplifiers can be an integral component of the fire-alarm control unit or can be remotely located in a separate

cabinet within the building.

B. UL UEAY2 - Fire-Alarm Audio Amplifiers :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Cooper Wheelock; brand of Eaton]**
 - b. **[Extron Electronics]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Cooper Wheelock; brand of Eaton]**
 - b. **[Extron Electronics]**
 - c. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Amplifiers for Fire-Protective Signaling Systems: UL CCN UEAY2, including UL 1711, UL 1480, UL 1480A, UL 864, and NFPA 72.
5. Standard Features:
 - a. Product Reference Standards: Chs. 18, 23, and 24 of NFPA 72.
 - b. Supervised high-fidelity audio for emergency voice evacuation fire-alarm systems.
 - c. Frequency Response: 275 Hz - 6.5 kHz.
 - d. Speaker Outputs: **[25 V][70 V]** power limited.
 - e. Minimum of **[four][eight]<Insert number>[Class A][Class B]** speaker output circuits.
6. Other Available Features Required by Project:
 - a. Minimum of **[four][eight]<Insert number>[Class A][Class B]** synchronized strobe power circuits.
 - b. **[Four][Eight]<Insert number>** digitally pre-recorded voice messages.
 - c. Push-to-Talk (PTT) microphone.

2.9 FIRE-ALARM TERMINAL CABINETS

- A. Description: A cabinet with hinged, lockable cover clearly labeled and intended for termination of fire-alarm conductors at junction points. Screw-type terminal blocks are provided within the terminal cabinet for conductor splices.
- B. UL UOXX - Fire-Alarm Terminal Cabinet :
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the**

following]:

- a. [Space Age Electronics, Inc.]
 - b. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Space Age Electronics, Inc.]
 - b. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
- a. System Control Unit Accessories: UL CCN UOXX, including UL 864 and NFPA 72.
5. Standard Features:
- a. Labeled "FIRE ALARM TERMINAL CABINET."
 - b. Interior field identification labels.
 - c. Sized accordingly to contain required number of termination points.
 - d. Accessible by authorized personnel only.

2.10 MANUAL FIRE-ALARM BOXES

- A. Description: A manually operated device used to initiate a fire-alarm signal. Manual fire-alarm boxes come in both conventional or addressable models and may require a single-action (pull down) or double-action (push in and pull down) to initiate a fire-alarm signal. These initiating devices are sometimes referred to as manual fire-alarm stations, pull stations, or call points.
- B. UL UNIU - Single-Action Manual Fire-Alarm Boxes :
 - 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Ansul; brand of Johnson Controls International plc, Building Solutions North America]
 - b. [Edwards; Carrier Global Corporation]
 - c. [Firecom, Inc.]
 - d. [Gamewell-FCI; Honeywell International, Inc.]
 - e. [Kidde; Carrier Global Corporation]
 - f. [Kingfisher Company, Inc.]
 - g. [Notifier; Honeywell International, Inc.]
 - h. [Potter Electric Signal Company, LLC]
 - i. [Safety Technology International, Inc.]
 - j. [Security Door Controls]
 - k. [Siemens Industry, Inc.; Fire Safety Division]
 - l. [Simplex; brand of Johnson Controls International plc, Building Solutions North America]

- m. [System Sensor; Honeywell International, Inc.]
 - n. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Ansul; brand of Johnson Controls International plc, Building Solutions North America]
 - b. [Edwards; Carrier Global Corporation]
 - c. [Firecom, Inc.]
 - d. [Gamewell-FCI; Honeywell International, Inc.]
 - e. [Kidde; Carrier Global Corporation]
 - f. [Kingfisher Company, Inc.]
 - g. [Notifier; Honeywell International, Inc.]
 - h. [Potter Electric Signal Company, LLC]
 - i. [Safety Technology International, Inc.]
 - j. [Security Door Controls]
 - k. [Siemens Industry, Inc.; Fire Safety Division]
 - l. [Simplex; brand of Johnson Controls International plc, Building Solutions North America]
 - m. [System Sensor; Honeywell International, Inc.]
 - n. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
- a. Non-Coded Fire-Alarm Boxes: UL CCN UNIU, including UL 38 and NFPA 72.
5. Standard Features:
- a. Product Reference Standards: Ch. 17 of NFPA 72.
 - b. Colored red with raised letters providing operating instructions.
 - c. [Surface][Recessed]<Insert mounting arrangement> mounted.
 - d. Station Reset: [Key][Wrench] operated switch.
 - e. Material: [Polycarbonate][Metal].
- C. UL UNIU - Double-Action Manual Fire-Alarm Boxes :
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
- a. [Ansul; brand of Johnson Controls International plc, Building Solutions North America]
 - b. [Edwards; Carrier Global Corporation]
 - c. [Firecom, Inc.]
 - d. [Gamewell-FCI; Honeywell International, Inc.]
 - e. [Kidde; Carrier Global Corporation]
 - f. [Kingfisher Company, Inc.]
 - g. [Notifier; Honeywell International, Inc.]
 - h. [Potter Electric Signal Company, LLC]
 - i. [Safety Technology International, Inc.]

- j. [Security Door Controls]
 - k. [Siemens Industry, Inc.; Fire Safety Division]
 - l. [Simplex; brand of Johnson Controls International plc, Building Solutions North America]
 - m. [System Sensor; Honeywell International, Inc.]
 - n. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Ansul; brand of Johnson Controls International plc, Building Solutions North America]
 - b. [Edwards; Carrier Global Corporation]
 - c. [Firecom, Inc.]
 - d. [Gamewell-FCI; Honeywell International, Inc.]
 - e. [Kidde; Carrier Global Corporation]
 - f. [Kingfisher Company, Inc.]
 - g. [Notifier; Honeywell International, Inc.]
 - h. [Potter Electric Signal Company, LLC]
 - i. [Safety Technology International, Inc.]
 - j. [Security Door Controls]
 - k. [Siemens Industry, Inc.; Fire Safety Division]
 - l. [Simplex; brand of Johnson Controls International plc, Building Solutions North America]
 - m. [System Sensor; Honeywell International, Inc.]
 - n. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
- a. Non-Coded Fire-Alarm Boxes: UL CCN UNIU, including UL 38 and NFPA 72.
5. Standard Features:
- a. Product Reference Standards: Chs. 10 and 17 of NFPA 72.
 - b. Colored red with raised letters providing operating instructions.
 - c. [Surface][Recessed]<Insert mounting arrangement> mounted.
 - d. Station Reset: [Key][Wrench] operated switch.
 - e. Material: [Polycarbonate][Metal].
- D. Accessories:
- 1. Factory-fabricated clear plastic enclosure[with battery-operated sounder].
 - 2. Weatherproof protective shield for conventional manual fire-alarm boxes located outdoors.

2.11 HEAT-SENSING FIRE DETECTORS

- A. Description: A fire detector that detects either abnormally high temperatures or rate-of-temperature rise, or both.
- B. UL UQGS - Fixed-Temperature Heat Detectors :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Edwards; Carrier Global Corporation]
 - b. [Fire-Lite Alarms; Honeywell International, Inc.]
 - c. [Gamewell-FCI; Honeywell International, Inc.]
 - d. [Honeywell International Inc.]
 - e. [Johnson Controls, Inc.]
 - f. [Kidde; Carrier Global Corporation]
 - g. [Notifier; Honeywell International, Inc.]
 - h. [Siemens Industry, Inc.; Fire Safety Division]
 - i. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Edwards; Carrier Global Corporation]
 - b. [Fire-Lite Alarms; Honeywell International, Inc.]
 - c. [Gamewell-FCI; Honeywell International, Inc.]
 - d. [Honeywell International Inc.]
 - e. [Johnson Controls, Inc.]
 - f. [Kidde; Carrier Global Corporation]
 - g. [Notifier; Honeywell International, Inc.]
 - h. [Siemens Industry, Inc.; Fire Safety Division]
 - i. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Heat-Detecting-Type Automatic Fire Detectors: UL CCN UQGS, including UL 521 and NFPA 72.
5. Standard Features:
 - a. Product Reference Standards: Ch. 17 of NFPA 72.
 - b. Actuated by temperature that exceeds fixed temperature of [135 deg F (57 deg C)][155 deg F (68 deg C)][190 deg F (88 deg C)][220 deg F (104 deg C)] regardless of rate of temperature rise.
 - c. [Conventional][Addressable]-type initiating device.
 - d. Detector must have functional humidity range of 10 to 90 percent.

C. UL UQGS - Rate-Compensated Heat Detectors :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Edwards; Carrier Global Corporation]
 - b. [Gamewell-FCI; Honeywell International, Inc.]
 - c. [Honeywell International Inc.]

- d. [Johnson Controls, Inc.]
 - e. [Notifier; Honeywell International, Inc.]
 - f. [Simplex; brand of Johnson Controls International plc, Building Solutions North America]
 - g. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Edwards; Carrier Global Corporation]
 - b. [Gamewell-FCI; Honeywell International, Inc.]
 - c. [Honeywell International Inc.]
 - d. [Johnson Controls, Inc.]
 - e. [Notifier; Honeywell International, Inc.]
 - f. [Simplex; brand of Johnson Controls International plc, Building Solutions North America]
 - g. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
- a. Heat-Detecting-Type Automatic Fire Detectors: UL CCN UQGS, including UL 521 and NFPA 72.
5. Standard Features:
- a. Product Reference Standards: Ch. 17 of NFPA 72.
 - b. Outer metal construction and inner metal components, which eliminate nuisance alarms due to thermal lag.
 - c. Actuated by temperature that exceeds fixed temperature of [135 deg F (57 deg C)][155 deg F (68 deg C)][190 deg F (88 deg C)][220 deg F (104 deg C)] regardless of rate of temperature rise.

D. UL UQGS - Spot-Type Heat Detectors :

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
- a. [Edwards; Carrier Global Corporation]
 - b. [Fire-Lite Alarms; Honeywell International, Inc.]
 - c. [Gamewell-FCI; Honeywell International, Inc.]
 - d. [Honeywell International Inc.]
 - e. [Johnson Controls, Inc.]
 - f. [Kidde; Carrier Global Corporation]
 - g. [Notifier; Honeywell International, Inc.]
 - h. [Siemens Industry, Inc.; Fire Safety Division]
 - i. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the

following:

- a. **[Edwards; Carrier Global Corporation]**
 - b. **[Fire-Lite Alarms; Honeywell International, Inc.]**
 - c. **[Gamewell-FCI; Honeywell International, Inc.]**
 - d. **[Honeywell International Inc.]**
 - e. **[Johnson Controls, Inc.]**
 - f. **[Kidde; Carrier Global Corporation]**
 - g. **[Notifier; Honeywell International, Inc.]**
 - h. **[Siemens Industry, Inc.; Fire Safety Division]**
 - i. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Heat-Detecting-Type Automatic Fire Detectors: UL CCN UQGS, including UL 521 and NFPA 72.
 5. Standard Features:
 - a. Product Reference Standards: Ch. 17 of NFPA 72.
 - b. Field programmable.
 - c. Resettable from the control unit.
 - d. Removable from the base assembly without the use of tools and without disturbing the wiring connections.
 - e. Actuated by temperature that exceeds fixed temperature of **[135 deg F (57 deg C)][155 deg F (68 deg C)][190 deg F (88 deg C)][220 deg F (104 deg C)]** regardless of rate of temperature rise.
 - f. **[Conventional][Addressable]**-type initiating device.
 - g. Detector must have functional humidity range of 10 to 90 percent.

E. UL UQGS - Line-Type Heat Detectors :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[The Protectowire Co., Inc.]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[The Protectowire Co., Inc.]**
 - b. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Heat-Detecting-Type Automatic Fire Detectors: UL CCN UQGS, including UL 521 and

NFPA 72.

5. Standard Features:

- a. Product Reference Standards: Ch. 17 of NFPA 72.
- b. Cable Type: **[Standard digital heat-sensitive cable][Confirmed temperature initiation cable][Fiber-optic cable with low-smoke zero-halogen jacket].**
- c. Actuated by temperature that exceeds fixed temperature of **[135 deg F (57 deg C)][155 deg F (68 deg C)][190 deg F (88 deg C)][220 deg F (104 deg C)]** regardless of rate of temperature rise.
- d. **[Conventional][Programmable]**-type initiating device supervised by **[addressable input module][intelligent sub-panel].**

F. Accessories:

1. Heat detector protective guard.

2.12 SMOKE-SENSING FIRE DETECTORS

- A. Description: A device that detects visible or invisible particles of combustion and initiates an action. Types of smoke-sensing fire detectors include spot-type detectors, air-sampling detectors, projected beam-type detectors, duct detectors, multi-criteria detectors, and video image smoke detectors.

B. UL UROX - Spot-Type Smoke Detectors :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Edwards; Carrier Global Corporation]**
 - b. **[Fire-Lite Alarms; Honeywell International, Inc.]**
 - c. **[Gamewell-FCI; Honeywell International, Inc.]**
 - d. **[Honeywell International Inc.]**
 - e. **[Johnson Controls, Inc.]**
 - f. **[Kidde; Carrier Global Corporation]**
 - g. **[Notifier; Honeywell International, Inc.]**
 - h. **[Siemens Industry, Inc.; Fire Safety Division]**
 - i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Edwards; Carrier Global Corporation]**
 - b. **[Fire-Lite Alarms; Honeywell International, Inc.]**
 - c. **[Gamewell-FCI; Honeywell International, Inc.]**
 - d. **[Honeywell International Inc.]**
 - e. **[Johnson Controls, Inc.]**
 - f. **[Kidde; Carrier Global Corporation]**
 - g. **[Notifier; Honeywell International, Inc.]**
 - h. **[Siemens Industry, Inc.; Fire Safety Division]**
 - i. **<Insert manufacturer's name>**

3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Detectors Designed for Smoke Particles: UL CCN UROX, including UL 268 and NFPA 72.
 5. Standard Features:
 - a. Product Reference Standards: Ch. 17 of NFPA 72.
 - b. Field programmable.
 - c. Resettable from the control unit.
 - d. Removable from the base assembly without the use of tools and without disturbing the wiring connections.
 - e. Sensing Type: **[Photoelectric][Ionization]**.
- C. UL UROX - Air Sampling-Type Smoke Detectors :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Gamewell-FCI; Honeywell International, Inc.]**
 - b. **[Honeywell International Inc.]**
 - c. **[Notifier; Honeywell International, Inc.]**
 - d. **[Siemens Industry, Inc.; Fire Safety Division]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Gamewell-FCI; Honeywell International, Inc.]**
 - b. **[Honeywell International Inc.]**
 - c. **[Notifier; Honeywell International, Inc.]**
 - d. **[Siemens Industry, Inc.; Fire Safety Division]**
 - e. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Detectors Designed for Smoke Particles: UL CCN UROX, including UL 268 and NFPA 72.
 5. Standard Features:
 - a. Product Reference Standards: Ch. 17 of NFPA 72.
 - b. Piping system and fan to transport particles of combustion to detector chamber.
 - c. Detectors must communicate with FACU via addressable smoke detector installed in housing[, **monitored dry contact closures**][, **and interface modules**].
 - d. Pipe length and hole sizes must be in accordance with manufacturer's published instructions[**and airflow balancing calculations performed using approved calculation software**].
 - e. Detector and Aspirator: Housed in mounting box and arranged such that air is drawn from

- detection area and sample passes through detector chamber.
- f. Detector must transmit faults to the FACU.

6. Other Available Features Required by Project:

- a. <Insert available feature>.

D. UL UROX - Projected Beam-Type Smoke Detectors :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Fire-Lite Alarms; Honeywell International, Inc.]**
 - b. **[Honeywell International Inc.]**
 - c. **[Notifier; Honeywell International, Inc.]**
 - d. **[Siemens Industry, Inc.; Fire Safety Division]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Fire-Lite Alarms; Honeywell International, Inc.]**
 - b. **[Honeywell International Inc.]**
 - c. **[Notifier; Honeywell International, Inc.]**
 - d. **[Siemens Industry, Inc.; Fire Safety Division]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Detectors Designed for Smoke Particles: UL CCN UROX, including UL 268 and NFPA 72.
5. Standard Features:
 - a. Product Reference Standards: Ch. 17 of NFPA 72.
 - b. Detector Address: Accessible from FACU and able to identify detector's location within system and its sensitivity setting.
 - c. Operator at FACU, having designated access level, must be able to manually access the following for each detector: primary status, device type, present average value, present sensitivity selected, and sensor range.

E. UL UROX - Duct Smoke Detectors :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Edwards; Carrier Global Corporation]**
 - b. **[Fire-Lite Alarms; Honeywell International, Inc.]**

- c. [Gamewell-FCI; Honeywell International, Inc.]
 - d. [Honeywell International Inc.]
 - e. [Johnson Controls, Inc.]
 - f. [Kidde; Carrier Global Corporation]
 - g. [Notifier; Honeywell International, Inc.]
 - h. [Siemens Industry, Inc.; Fire Safety Division]
 - i. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Edwards; Carrier Global Corporation]
 - b. [Fire-Lite Alarms; Honeywell International, Inc.]
 - c. [Gamewell-FCI; Honeywell International, Inc.]
 - d. [Honeywell International Inc.]
 - e. [Johnson Controls, Inc.]
 - f. [Kidde; Carrier Global Corporation]
 - g. [Notifier; Honeywell International, Inc.]
 - h. [Siemens Industry, Inc.; Fire Safety Division]
 - i. <Insert manufacturer's name>
 3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Detectors Designed for Smoke Particles: UL CCN UROX, including UL 268 and NFPA 72.
 5. Standard Features:
 - a. Product Reference Standards: Ch. 17 of NFPA 72.
 - b. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to FACU.
 - c. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
 - d. Integral Visual-Indicating Light: LED type, indicating detector has operated.
 - e. Detectors must be four- or two-wire type.
 - f. Detector address must be accessible from fire-alarm control unit and must be able to identify the detector's location within the system and its sensitivity setting.
 - g. Operator at FACU, having designated access level, must be able to manually access the following for each detector: primary status, device type, present average value, present sensitivity selected, and sensor range.

F. UL UROX - Video Image Smoke Detectors :

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

following:

- a. **[SigniFire, Fike Corp.]**
 - b. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Detectors Designed for Smoke Particles: UL CCN UROX, including UL 268 and NFPA 72.
 5. Standard Features:
 - a. Product Reference Standards: Ch. 17 of NFPA 72.
 - b. Unit dedicated to task of video fire detection should not be running any additional software, as it can compromise its detection.
 - c. Camera viewing must use graphic user interface with independent video codecs to provide continuous analysis of video images.
 - d. Smoke must be detected by monitoring of small areas of change within image and passing these pixel changes to processor for analysis.
 - e. Unit must employ algorithms to process video information from up to four cameras simultaneously.
 - f. Unit must achieve 25 Hz frame rate for each of four channels.
 - g. Outputs: Minimum of 16 alarm outputs that may be individually assigned to combination of zones or sectors. These outputs must not be linked to any particular camera, allowing for zonal and image association.
 - h. Through output logic matrix, operator must have ability to customize systems output to alarm conditions and, therefore, allow easy integration within "house" fire-alarm system.

2.13 RADIANT ENERGY-SENSING FIRE DETECTORS

- A. Description: A device that detects radiant energy, such as ultraviolet, visible, or infrared, that is emitted as a product of combustion reaction and obeys the laws of optics. Common types of radiant energy-sensing fire detectors include video image flame detectors.
- B. UL UIAZ - Video Image Flame Detectors :
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Fike Corporation]**
 - b. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Fike Corporation]**
 - b. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain products from single manufacturer.

4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Automatic Fire Detectors for Use in Hazardous Locations: UL CCN UIAZ, including UL 268 and NFPA 72.
5. Standard Features:
 - a. Product Reference Standards: Ch. 17 of NFPA 72.
 - b. Unit dedicated to task of video fire detection should not be running any additional software, as it can compromise its detection.
 - c. Camera viewing must use graphic user interface with independent video codecs to provide continuous analysis of video images.
 - d. Unit must employ algorithms to process video information from up to four cameras simultaneously.
 - e. Unit must achieve 25 Hz frame rate for each of four channels.
 - f. Outputs: Minimum of 16 alarm outputs that may be individually assigned to combination of zones or sectors. These outputs must not be linked to any particular camera, allowing for zonal and image association.
 - g. Through output logic matrix, operator must have ability to customize systems output to alarm conditions and, therefore, allow easy integration within "house" fire-alarm system.

2.14 COMBINATION, MULTI-CRITERIA, AND MULTI-SENSOR DETECTORS

- A. Description: A device that contains multiple sensors that separately respond to physical stimulus such as heat, smoke, or fire gases, or employs more than one sensor to sense the same stimulus. This sensor is capable of generating only one alarm signal from the sensor employed in the design either independently or in combination. The sensor output signal is mathematically evaluated to determine when an alarm signal is warranted. The evaluation can be performed either at the detector or at the control unit. This detector can have a single listing that establishes the primary function of the detector, or can have listings for each sensing method employed.
- B. UL UROX - Multi-Criteria Detector :
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **<Insert, in separate subparagraphs, manufacturer's name>.**
 2. Source Limitations: Obtain products from single manufacturer.
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Detectors Designed for Smoke Particles: UL CCN UROX, including UL 268 and NFPA 72.
 4. Standard Features:
 - a. Product Reference Standards: Ch. 17 of NFPA 72.
 - b. Field programmable.
 - c. Resettable from the control unit.
 - d. Removable from the base assembly without the use of tools and without disturbing the



- wiring connections.
- e. Smoke Sensing Type: **[Photoelectric][Ionization]**.
- f. Heat Sensing Type: Fixed temperature **[and combination rate-of-rise]**.

2.15 CARBON MONOXIDE DETECTORS

- A. Description: A device that detects the presence of a specific carbon monoxide concentration.
- B. UL FTAM - Carbon Monoxide Detectors :
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Digital Monitoring Products]**
 - b. **[Fire-Lite Alarms; Honeywell International, Inc.]**
 - c. **[Gamewell-FCI; Honeywell International, Inc.]**
 - d. **[Honeywell International Inc.]**
 - e. **[Johnson Controls, Inc.]**
 - f. **[Notifier; Honeywell International, Inc.]**
 - g. **[Potter Electric Signal Company, LLC]**
 - h. **[Simplex; brand of Johnson Controls International plc, Building Solutions North America]**
 - i. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Digital Monitoring Products]**
 - b. **[Fire-Lite Alarms; Honeywell International, Inc.]**
 - c. **[Gamewell-FCI; Honeywell International, Inc.]**
 - d. **[Honeywell International Inc.]**
 - e. **[Johnson Controls, Inc.]**
 - f. **[Notifier; Honeywell International, Inc.]**
 - g. **[Potter Electric Signal Company, LLC]**
 - h. **[Simplex; brand of Johnson Controls International plc, Building Solutions North America]**
 - i. **<Insert manufacturer's name>**
 - 3. Source Limitations: Obtain products from single manufacturer.
 - 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Detectors and Sensors Designed to Detect Gases and Vapors: UL CCN FTAM, including UL 2075 and NFPA 72.
 - 5. Standard Features:
 - a. Product Reference Standards: Ch. 17 of NFPA 72.
 - b. Detector sends trouble alarm when nearing end of life or experiencing power supply problems or internal faults.

- c. Detector sounder base emits Temporal-4 signal.
- d. Testable by introducing test carbon monoxide into sensing cell.

2.16 SPRINKLER WATERFLOW ALARM-INITIATING DEVICES

- A. Description: An initiating device used to monitor the flow of water in a wet-pipe or dry-pipe sprinkler system for the purpose of initiating an alarm signal. These devices employ operating mechanisms that include paddle operation, pressure operation, or mechanical operation.
- B. UL USQT - Sprinkler Waterflow Alarm-Initiating Device :
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **<Insert, in separate subparagraphs, manufacturer's name>.**
 - 2. Source Limitations: Obtain products from single manufacturer.
 - 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Extinguishing System Attachments: UL CCN USQT, including UL 346 and NFPA 72.
 - 4. Standard Features:
 - a. Product Reference Standards: Ch. 17 of NFPA 72.
 - b. Activation of the initiating device occurs within 90 seconds of waterflow at the alarm-initiating device when flow occurs that is equal to or greater than that from a single sprinkler of the smallest orifice size installed in the system.
 - c. Movement of water due to waste, surges, or variable pressure must not initiate an alarm signal.
 - d. Adjustable time delay.
 - e. Pressure Range: **20 to 175 psig (1.38 to 12.07 bar)**.
 - f. Operating Type: **[Paddle][Pressure][Mechanically]** operated.
 - g. **[Coded][Non-coded]** signaling contacts.

2.17 AUDIBLE NOTIFICATION APPLIANCES

- A. Description: A fire-alarm system component such as a horn or loudspeaker that provides audible output to alert occupants by the sense of hearing.
- B. UL ULSZ - Horns :
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Ansul; brand of Johnson Controls International plc, Building Solutions North America]**
 - b. **[Cerberus; Siemens Industry, Inc.]**
 - c. **[Cooper Wheelock; brand of Eaton]**

- d. **[Edwards; Carrier Global Corporation]**
 - e. **[Kidde Commercial Fire & Life Safety Systems]**
 - f. **[Siemens Industry, Inc.; Fire Safety Division]**
 - g. **[Simplex; brand of Johnson Controls International plc, Building Solutions North America]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[Ansul; brand of Johnson Controls International plc, Building Solutions North America]**
 - b. **[Cerberus; Siemens Industry, Inc.]**
 - c. **[Cooper Wheelock; brand of Eaton]**
 - d. **[Edwards; Carrier Global Corporation]**
 - e. **[Kidde Commercial Fire & Life Safety Systems]**
 - f. **[Siemens Industry, Inc.; Fire Safety Division]**
 - g. **[Simplex; brand of Johnson Controls International plc, Building Solutions North America]**
 - h. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
- a. Electrically Operated Signal-Sounding Appliances: UL CCN ULSZ, including UL 464 and NFPA 72.
5. Standard Features:
- a. Product Reference Standards: Ch. 18 of NFPA 72.
 - b. Operating Temperature Range: **32 deg F to 120 deg F (0 deg C to 50 deg C)**.
 - c. Field-selectable volume settings.
 - d. Compatible with wires up to 12 AWG.
 - e. Capable of projecting through high ambient sound levels.
 - f. Designed to provide accurate reproduction of audible emergency and protective signals.
 - g. Flexibility of mounting on vertical or horizontal positions.
- C. UL UUMW - Loudspeakers :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
- a. **[Atlas Sound LP]**
 - b. **[Edwards; Carrier Global Corporation]**
 - c. **[Federal Signal Corporation]**
 - d. **[Johnson Controls, Inc.]**
 - e. **[Kidde Commercial Fire & Life Safety Systems]**
 - f. **[Potter Electric Signal Company, LLC]**
 - g. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Atlas Sound LP]**
 - b. **[Edwards; Carrier Global Corporation]**
 - c. **[Federal Signal Corporation]**
 - d. **[Johnson Controls, Inc.]**
 - e. **[Kidde Commercial Fire & Life Safety Systems]**
 - f. **[Potter Electric Signal Company, LLC]**
 - g. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. **Speakers and Amplifiers Used in Fire-Alarm and/or Emergency Communication Systems: UL CCN UUMW, including UL 1480 and NFPA 72.**
 5. Standard Features:
 - a. **Product Reference Standards: Ch. 18 of NFPA 72.**
 - b. **Flush and ceiling-tile mounting with use of ceiling tile brackets.**
 - c. **Field-selectable voltage and power tap settings.**
 - d. **Operating Temperature Range: 32 deg F to 120 deg F (0 deg C to 50 deg C).**
 - e. **Compatible with wires up to 12 AWG.**
- D. Accessories:
1. Audible appliance protective guard.

2.18 VISUAL NOTIFICATION APPLIANCES

- A. Description: A fire-alarm system component that provides a visible output to alert occupants by the sense of sight, including visual strobes. **[Textual visual notification appliances are specified in Section 284700 "Mass Notification."]**
- B. UL UVAV - Strobe :
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Avenger Systems LLC]**
 - b. **[Cooper Wheelock; brand of Eaton]**
 - c. **[Edwards; Carrier Global Corporation]**
 - d. **[Gentex Corporation]**
 - e. **[Kidde Commercial Fire & Life Safety Systems]**
 - f. **[Potter Electric Signal Company, LLC]**
 - g. **[Simplex; brand of Johnson Controls International plc, Building Solutions North America]**
 - h. **[Triga Life Safety Systems LLC]**
 - i. **[VES Fire Detection Systems; Hochiki America Corporation]**

- j. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Avenger Systems LLC]
 - b. [Cooper Wheelock; brand of Eaton]
 - c. [Edwards; Carrier Global Corporation]
 - d. [Gentex Corporation]
 - e. [Kidde Commercial Fire & Life Safety Systems]
 - f. [Potter Electric Signal Company, LLC]
 - g. [Simplex; brand of Johnson Controls International plc, Building Solutions North America]
 - h. [Triga Life Safety Systems LLC]
 - i. [VES Fire Detection Systems; Hochiki America Corporation]
 - j. <Insert manufacturer's name>
- 3. Source Limitations: Obtain products from single manufacturer.
- 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Visual-Signal Appliances for Fire-Protective Signaling Applications: UL CCN UVAV, including UL 1638 and NFPA 72.
- 5. Standard Features:
 - a. Product Reference Standards: Ch. 18 of NFPA 72.
 - b. Operating Temperature Range: **32 deg F to 120 deg F (0 deg C to 50 deg C).**
 - c. Compatible with wires up to 12 AWG.
 - d. Rated Light Output:[**6,**][**13,**] 15, 30, 75,[**or**] 110[, **or 177**] candela.
 - e. Field-selectable candela settings.
 - f. Clear or nominal white polycarbonate lens mounted on faceplate.
- 6. Other Available Features Required by Project:
 - a. For units with guards to prevent physical damage, light output ratings must be determined with guards in place.
 - b. Weather resistant to provide protection against water, humidity, and corrosion.
- C. Accessories:
 - 1. Visual appliance protective guard.

2.19 COMBINATION AUDIBLE/VISUAL NOTIFICATION APPLIANCES

- A. Description: A fire-alarm system component such as a horn/strobe or loudspeaker/strobe that provides both an audible and a visible output to alert occupants by the sense of hearing and sight.
- B. UL ULSZ and UVAV - Combination Horn/Strobe Appliances :
 - 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering

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

- a. [Cooper Wheelock; brand of Eaton]
 - b. [Gentex Corporation]
 - c. [Hochiki America Corporation]
 - d. [Potter Electric Signal Company, LLC]
 - e. [VES Fire Detection Systems; Hochiki America Corporation]
 - f. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Cooper Wheelock; brand of Eaton]
 - b. [Gentex Corporation]
 - c. [Hochiki America Corporation]
 - d. [Potter Electric Signal Company, LLC]
 - e. [VES Fire Detection Systems; Hochiki America Corporation]
 - f. <Insert manufacturer's name>
 3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Electrically Operated Signal-Sounding Appliances or Visual-Signal Appliances for Fire-Protective Signaling Applications: UL CCN ULSZ and UVAV, including UL 464, UL 1638, and NFPA 72.
 5. Standard Features:
 - a. Product Reference Standards: Ch. 18 of NFPA 72.
 - b. Operating Temperature Range: **32 deg F to 120 deg F (0 deg C to 50 deg C)**.
 - c. Compatible with wires up to 12 AWG.
 - d. Rated Light Output:[**6**,][**13**,] 15, 30, 75,[**or**] 110[, **or 177**] candela.
 - e. Clear or nominal white polycarbonate lens mounted on faceplate.
 - f. Strobe flash rate of 1 Hz over its entire operating range.
 - g. Operates on a coded or non-coded power supply.
 - h. Field-selectable candela settings.
 - i. Field-selectable volume settings.
 - j. Universal mounting plate for ceiling units.
 6. Other Available Features Required by Project:
 - a. For units with guards to prevent physical damage, light output ratings must be determined with guards in place.
 - b. Weather resistant to provide protection against water, humidity, and corrosion.
- C. UL UUMW and UVAV - Combination Loudspeaker/Strobe Appliances :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**



- a. [Cooper Wheelock; brand of Eaton]
 - b. [Gentex Corporation]
 - c. [Hochiki America Corporation]
 - d. [Potter Electric Signal Company, LLC]
 - e. [VES Fire Detection Systems; Hochiki America Corporation]
 - f. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Cooper Wheelock; brand of Eaton]
 - b. [Gentex Corporation]
 - c. [Hochiki America Corporation]
 - d. [Potter Electric Signal Company, LLC]
 - e. [VES Fire Detection Systems; Hochiki America Corporation]
 - f. <Insert manufacturer's name>
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Electrically Operated Signal-Sounding Appliances or Visual-Signal Appliances for Fire-Protective Signaling Applications: UL CCN UUMW and UVAV, including UL 1480, UL 1638, and NFPA 72.
5. Standard Features:
 - a. Product Reference Standards: Ch. 18 of NFPA 72.
 - b. Operating Temperature Range: 32 deg F to 120 deg F (0 deg C to 50 deg C).
 - c. Compatible with wires up to 12 AWG.
 - d. Rated Light Output: [6,][13,] 15, 30, 75,[or] 110[, or 177] candela.
 - e. Clear or nominal white polycarbonate lens mounted on faceplate.
 - f. Strobe flash rate of 1 Hz over its entire operating range.
 - g. Field-selectable candela settings.
 - h. Field-selectable voltage and power settings.
 - i. Universal mounting plate for ceiling units.
6. Other Available Features Required by Project:
 - a. For units with guards to prevent physical damage, light output ratings must be determined with guards in place.
7. Accessories:
 - a. Combination audible/visual appliance protective guard.
 - b. Weather resistant to provide protection against water, humidity, and corrosion.

2.20 FIREFIGHTERS' TWO-WAY, IN-BUILDING WIRED TELEPHONE COMMUNICATIONS SYSTEM

- A. Description: A two-way in-building telephone communications system used by firefighters and emergency response personnel when responding to, investigating, and conducting rescue activities in a fire incident.

B. Firefighters' Two-Way, In-Building Wired Telephone Communications System :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Fike Corporation]**
 - b. **[Fire-Lite Alarms; Honeywell International, Inc.]**
 - c. **[Firecom, Inc.]**
 - d. **[Gamewell-FCI; Honeywell International, Inc.]**
 - e. **[Keltron Corporation]**
 - f. **[Kidde; Carrier Global Corporation]**
 - g. **[Kingfisher Company, Inc.]**
 - h. **[Notifier; Honeywell International, Inc.]**
 - i. **[Potter Electric Signal Company, LLC]**
 - j. **[Siemens Industry, Inc.; Fire Safety Division]**
 - k. **[Silent Knight; Honeywell International, Inc.]**
 - l. **[Simplex; brand of Johnson Controls International plc, Building Solutions North America]**
 - m. **[Tyco Security Products and Solutions; brand of Johnson Controls]**
 - n. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Fike Corporation]**
 - b. **[Fire-Lite Alarms; Honeywell International, Inc.]**
 - c. **[Firecom, Inc.]**
 - d. **[Gamewell-FCI; Honeywell International, Inc.]**
 - e. **[Keltron Corporation]**
 - f. **[Kidde; Carrier Global Corporation]**
 - g. **[Kingfisher Company, Inc.]**
 - h. **[Notifier; Honeywell International, Inc.]**
 - i. **[Potter Electric Signal Company, LLC]**
 - j. **[Siemens Industry, Inc.; Fire Safety Division]**
 - k. **[Silent Knight; Honeywell International, Inc.]**
 - l. **[Simplex; brand of Johnson Controls International plc, Building Solutions North America]**
 - m. **[Tyco Security Products and Solutions; brand of Johnson Controls]**
 - n. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for one or more of the following UL product categories:
 - a. Control Unit Accessories for Fire-Protective Signaling Systems: UL CCN UOXX, including UL 864 and NFPA 72.
 - b. Control Units, System: UL CCN UOJZ, including UL 864 and NFPA 72.
 - c. Control Units, Releasing Device: UL CCN SYZV, including UL 864 and NFPA 72, in addition to standards related to suppressant or energy storage system being released.
 - d. Control and Communications Equipment: UL CCN PGWM, including UL 2572 and NFPA 72.
 - e. Smoke Control System Equipment: UL CCN UUKL, including UL 864, NFPA 72, and NFPA

92.

5. Standard Features:

- a. Product Reference Standards: Ch. 24 of NFPA 72.
- b. **<Insert existing system features that must be maintained>.**

2.21 FIRE-ALARM SUPERVISED CONTROL MODULE INTERFACES FOR FIRE SAFETY FUNCTIONS

A. Description: An addressable fire-alarm control module that interfaces to another building system for the purpose of initiating an action for that system based upon activation of a supervisory or alarm condition on the fire-alarm system. The interface between the control module and the other building system or equipment is supervised.

B. UL UOXX - Fire-Alarm Supervised Control Module :

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Fire-Lite Alarms; Honeywell International, Inc.]**
 - b. **[Firecom, Inc.]**
 - c. **[Gamewell-FCI; Honeywell International, Inc.]**
 - d. **[Johnson Controls, Inc.]**
 - e. **[Notifier; Honeywell International, Inc.]**
 - f. **[Siemens Industry, Inc.; Fire Safety Division]**
 - g. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Fire-Lite Alarms; Honeywell International, Inc.]**
 - b. **[Firecom, Inc.]**
 - c. **[Gamewell-FCI; Honeywell International, Inc.]**
 - d. **[Johnson Controls, Inc.]**
 - e. **[Notifier; Honeywell International, Inc.]**
 - f. **[Siemens Industry, Inc.; Fire Safety Division]**
 - g. **<Insert manufacturer's name>**
- 3. Source Limitations: Obtain products from single manufacturer.
- 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Control Unit Accessories - Addressable Control Modules: UL CCN UOXX, including UL 864 and NFPA 72.
- 5. Standard Features:
 - a. Product Reference Standards: Ch. 17 of NFPA 72.
 - b. Field programmable.
 - c. Resettable from the control unit.

- d. Supervises **[Class A][and][Class B]** initiating device circuits.
- e. Capable of interfacing with the following systems:
 - 1) Elevator controller.
 - 2) Elevator power shunt-trip.
 - 3) Elevator shunt-trip power monitoring.
 - 4) HVAC line voltage.
 - 5) Building management system.
 - 6) Magnetic door hold-open circuits.
 - 7) High-volume low-speed fans.
 - 8) **[Door][Shutter]** release.
 - 9) Electrically locked doors.
 - 10) **<Insert interface type>**.

2.22 FIRE-ALARM SUPERVISORY SIGNAL-INITIATING DEVICES

- A. Description: An initiating device such as a valve supervisory switch, water-level indicator, low-air-pressure switch, or low-temperature switch in which the change of state signals to the **[fire-alarm][releasing device]** control unit an off-normal condition and its restoration to normal of a fire-protection or life-safety system; or a need for action in connection with guard tours, fire-suppression systems or equipment, or maintenance features of related systems.
- B. UL USQT - Control Valve Supervisory Signal-Initiating Devices :
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Kopler, LLC]**
 - b. **[Lansdale Valve and Manufacturing]**
 - c. **[Potter Electric Signal Company, LLC]**
 - d. **[Southern Valve & Fitting USA]**
 - e. **[Tyco Fire and Building Products; brand of Johnson Controls International plc, Building Solutions North America]**
 - f. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Kopler, LLC]**
 - b. **[Lansdale Valve and Manufacturing]**
 - c. **[Potter Electric Signal Company, LLC]**
 - d. **[Southern Valve & Fitting USA]**
 - e. **[Tyco Fire and Building Products; brand of Johnson Controls International plc, Building Solutions North America]**
 - f. **<Insert manufacturer's name>**
 - 3. Source Limitations: Obtain products from single manufacturer.
 - 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Extinguishing System Attachments: UL CCN USQT, including UL 346 and NFPA 72.

5. Standard Features:

- a. Product Reference Standards: Ch. 17 of NFPA 72.
- b. Initiation of two separate and distinct signals; one indicating movement of the valve from its normal position, and the other indicating restoration of the valve to its normal position.
- c. Off-normal signal must be initiated during the first two revolutions of the handwheel, or during one-fifth of the travel distance of the valve from its normal position.
- d. Off-normal signal must not be restored at any valve position except normal.

C. UL USQT - Pressure-Monitoring/Supervisory Signal-Initiating Devices :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Potter Electric Signal Company, LLC]**
 - b. **[Viking Group Inc.]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Potter Electric Signal Company, LLC]**
 - b. **[Viking Group Inc.]**
 - c. **<Insert manufacturer's name>**
3. Source Limitations: Obtain products from single manufacturer.
4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Extinguishing System Attachments: UL CCN USQT, including UL 346, and NFPA 72.
5. Standard Features:
 - a. Product Reference Standards: Ch. 17 of NFPA 72.
 - b. Initiation of two separate and distinct signals; one indicating that the required pressure has increased or decreased (off-normal), and the other indicating restoration of the pressure to its normal value.

D. UL USQT - Water Level Supervisory Signal-Initiating Devices :

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

- a. **[Potter Electric Signal Company, LLC]**
 - b. **<Insert manufacturer's name>**
 - 3. Source Limitations: Obtain products from single manufacturer.
 - 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Extinguishing System Attachments: UL CCN USQT, including UL 346 and NFPA 72.
 - 5. Standard Features:
 - a. Product Reference Standards: Ch. 17 of NFPA 72.
 - b. Initiation of two separate and distinct signals; one indicating that the required water level has been lowered or raised (off-normal), and the other indicating restoration of the water level to normal.
 - c. Initiates a low-water-level signal when the water level falls **12 inch (300 mm)** in other than pressure tanks.
 - d. Pressure Tank: Off-normal signal initiated when the water level falls **3 inch (76 mm)** or rises **3 inch (76 mm)**.
- E. UL USQT - Water Temperature Supervisory Signal-Initiating Devices :
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **<Insert, in separate subparagraphs, manufacturer's name>**.
 - 2. Source Limitations: Obtain products from single manufacturer.
 - 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Extinguishing System Attachments: UL CCN USQT, including UL 346 and NFPA 72.
 - 4. Standard Features:
 - a. Product Reference Standards: Ch. 17 of NFPA 72.
 - b. Initiates two separate and distinct signals; one indicating a decrease in water temperature to **40 deg F (4.5 deg C)**, and the other indicating its restoration to above **40 deg F (4.5 deg C)**.
- F. UL USQT - Room Temperature Supervisory Signal-Initiating Devices :
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **<Insert, in separate subparagraphs, manufacturer's name>**.
 - 2. Source Limitations: Obtain products from single manufacturer.
 - 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product



categories:

- a. Extinguishing System Attachments: UL CCN USQT, including UL 346 and NFPA 72.

4. Standard Features:

- a. Product Reference Standards: Ch. 17 of NFPA 72.
- b. Initiates two separate and distinct signals; one indicating a decrease in room temperature to **40 deg F (4.5 deg C)**, and the other indicating its restoration to above **40 deg F (4.5 deg C)**.

G. UL USQT - Fire Extinguisher Supervisory Signal-Initiating Devices :

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

- a. **<Insert, in separate subparagraphs, manufacturer's name>.**

- 2. Source Limitations: Obtain products from single manufacturer.
- 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

- a. Extinguishing System Attachments: UL CCN USQT, including UL 346 and NFPA 72.

4. Standard Features:

- a. Product Reference Standards: Ch. 17 of NFPA 72.
- b. Indicates conditions for a specific fire extinguisher to a fire-alarm control unit.

H. UL USQT - Fire Pump Supervisory Signal-Initiating Devices :

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

- a. **<Insert, in separate subparagraphs, manufacturer's name>.**

- 2. Source Limitations: Obtain products from single manufacturer.
- 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

- a. Extinguishing System Attachments: UL CCN USQT, including UL 346 and NFPA 72.

4. Standard Features:

- a. Product Reference Standards: Ch. 17 of NFPA 72.
- b. Initiates a supervisory signal for any off-normal conditions of a fire pump, including the following:

- 1) Fire pump running.
- 2) Fire pump loss of power.
- 3) Fire pump phase reversal.
- 4) Fire pump transfer to secondary power.

I. UL UOXX - Generator Supervisory Signal-Initiating Devices :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **<Insert, in separate subparagraphs, manufacturer's name>.**
2. Source Limitations: Obtain products from single manufacturer.
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. System Control Unit Accessories: UL CCN UOXX, including UL 864 and NFPA 72.
4. Standard Features:
 - a. Product Reference Standards: Ch. 17 of NFPA 72.
 - b. Initiates a supervisory signal upon indication of generator running condition.

2.23 FIRE-ALARM DIGITAL ALARM COMMUNICATOR TRANSMITTERS

- A. Description: A fire-alarm system component at the protected premises to which the fire-alarm control unit connects and transmit signals indicating a status change of initiating devices or groups of devices. The DACT seizes the connected **[telephone line][cellular signal][ethernet network]**, dials a preselected number to connect to a DACR, and transmits signals indicating a status change of the initiating devices.
- B. UL UOXX - Fire-Alarm Digital Alarm Communicator Transmitter :
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Ademco; Honeywell]**
 - b. **[Digital Monitoring Products]**
 - c. **[Fike Corporation]**
 - d. **[Fire-Lite Alarms; Honeywell International, Inc.]**
 - e. **[Firecom, Inc.]**
 - f. **[Gamewell-FCI; Honeywell International, Inc.]**
 - g. **[Keltron Corporation]**
 - h. **[Kidde; Carrier Global Corporation]**
 - i. **[Kingfisher Company, Inc.]**
 - j. **[Notifier; Honeywell International, Inc.]**
 - k. **[Potter Electric Signal Company, LLC]**
 - l. **[Siemens Industry, Inc.; Fire Safety Division]**
 - m. **[Silent Knight; Honeywell International, Inc.]**
 - n. **[Simplex; brand of Johnson Controls International plc, Building Solutions North**



- o. **America]**
 - o. **[Tyco Security Products and Solutions; brand of Johnson Controls]**
 - p. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Ademco; Honeywell]**
 - b. **[Digital Monitoring Products]**
 - c. **[Fike Corporation]**
 - d. **[Fire-Lite Alarms; Honeywell International, Inc.]**
 - e. **[Firecom, Inc.]**
 - f. **[Gamewell-FCI; Honeywell International, Inc.]**
 - g. **[Keltron Corporation]**
 - h. **[Kidde; Carrier Global Corporation]**
 - i. **[Kingfisher Company, Inc.]**
 - j. **[Notifier; Honeywell International, Inc.]**
 - k. **[Potter Electric Signal Company, LLC]**
 - l. **[Siemens Industry, Inc.; Fire Safety Division]**
 - m. **[Silent Knight; Honeywell International, Inc.]**
 - n. **[Simplex; brand of Johnson Controls International plc, Building Solutions North America]**
 - o. **[Tyco Security Products and Solutions; brand of Johnson Controls]**
 - p. **<Insert manufacturer's name>**
- 3. Source Limitations: Obtain products from single manufacturer.
- 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Control Unit Accessories for Fire-Protective Signaling Systems: UL CCN UOXX, including UL 864 and NFPA 72.
- 5. Standard Features:
 - a. Product Reference Standards: Ch. 26 of NFPA 72.
 - b. Compatible with **[remote alarm receiving station][central station]** receiver.
 - c. Receive alarm, supervisory, or trouble signals from FACU and automatically transmit to **[remote alarm receiving station][central station]** via **[telephone line(s)][cellular network][internet]<Insert method>**.
 - d. Indicate trouble signal at FACU upon loss of communication with the **[remote alarm receiving station][central station]**.
 - e. Indicate local trouble signal upon loss of communication with the FACU.
 - f. Secondary Power: Integral rechargeable battery and automatic charger.
 - g. Digital data transmission of the following signals:
 - 1) Address of alarm-initiating device.
 - 2) Address of supervisory signal.
 - 3) Address of trouble-initiating device.
 - 4) Loss of AC supply.
 - 5) Loss of power.
 - 6) Low battery.
 - 7) Abnormal test signal.
 - 8) Communication bus failure.

9) <Insert signal to be transmitted>.

- h. Self-test automatically performed every 24 hours with report transmitted to [remote alarm receiving station][central station].

2.24 FIRE-ALARM RADIO ALARM TRANSMITTERS

- A. Description: A fire-alarm system component at the protected premises to which the fire-alarm control unit connects and transmit signals indicating a status change of initiating devices or groups of devices. The RAT transmits signals through a dedicated, licensed radio channel to the radio alarm receiver.
- B. UL UOXX - Fire-Alarm Radio Alarm Transmitter :
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [AES Corporation (The)]
 - b. [Keltron Corporation]
 - c. [Kingfisher Company, Inc.]
 - d. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [AES Corporation (The)]
 - b. [Keltron Corporation]
 - c. [Kingfisher Company, Inc.]
 - d. <Insert manufacturer's name>
 3. Source Limitations: Obtain products from single manufacturer.
 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Control Unit Accessories for Fire-Protective Signaling Systems: UL CCN UOXX, including UL 864 and NFPA 72.
 5. Standard Features:
 - a. Product Reference Standards: Ch. 26 of NFPA 72.
 - b. Modular UL 50E, Type 1 metal enclosure with tamper-resistant flush tumbler lock.
 - c. Compatible and coordinated with operating characteristics of remote-alarm receiving-station receiver.
 - d. Receive alarm, supervisory, or trouble signals from FACU and automatically transmit to remote alarm receiving station via [VHF][UHF]<Insert frequency> radio frequency using 2 W power output.
 - e. Indicate trouble signal at FACU upon loss of communication with the remote alarm receiving station.
 - f. Indicate local trouble signal upon loss of communication with the FACU.
 - g. Normal Power Input: 120 V(ac).
 - h. Secondary Power: Integral sealed, rechargeable, 12 V battery and charger.
 - i. Omnidirectional, coaxial half-wave, dipole-type antenna with driving point impedance

- matched to transmitter and antenna cable output impedance.
- j. Dry-contact inputs[**and serial communications interface**] to receive connections from fire-alarm system circuit boards, modules, and other auxiliary devices
- k. Digital data transmission of the following signals:
 - 1) [Address][Zone] of alarm-initiating device.
 - 2) [Address][Zone] of supervisory signal.
 - 3) [Address][Zone] of trouble-initiating device.
 - 4) Loss of AC supply.
 - 5) Loss of power.
 - 6) Low battery.
 - 7) Abnormal test signal.
 - 8) Communication bus failure.
 - 9) <Insert signal to be transmitted>.
- l. Self-test automatically performed every 24 hours with report transmitted to [remote alarm receiving station][central station].

2.25 FIRE-ALARM RECORD DOCUMENTATION CABINETS

- A. Description: A cabinet clearly labeled and intended for the storage of fire-alarm record documents, including as-built drawings; programming documentation; and inspection, testing, and maintenance documentation.
- B. UL UOXX - Fire-Alarm-System Record-Documents Storage Cabinet :
 - 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Space Age Electronics, Inc.]
 - b. <Insert manufacturer's name>
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Space Age Electronics, Inc.]
 - b. <Insert manufacturer's name>
 - 3. Source Limitations: Obtain products from single manufacturer.
 - 4. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. System Control Unit Accessories: UL CCN UOXX, including UL 864 and NFPA 72.
 - 5. Standard Features:
 - a. Labeled "SYSTEM RECORD DOCUMENTS."
 - b. Sized accordingly to contain all necessary documentation.
 - c. Accessible by authorized personnel only.

2.26 PASSIVE GRAPHIC MAPS

- A. Description: A printed graphic map showing building floor plans indicating initiating device locations and control equipment locations for use by emergency responders and maintenance personnel.
- B. Fire-Alarm Passive Graphic Map :
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **<Insert, in separate subparagraphs, manufacturer's name>**.
 - 2. Source Limitations: Obtain products from single manufacturer.
 - 3. Standard Features:
 - a. Product Reference Standards: Ch. 7 of NFPA 72.
 - b. Indicates initiating device type, locations, and corresponding addresses.
 - c. Indicates control equipment locations.
 - d. Mounted in a plexiglass frame adjacent to the FACU.
 - e. Legible and sized accordingly.

2.27 FIRE-ALARM CABLES

- A. UL HNHT - Non-Power-Limited Fire-Alarm Circuit Cable (NPLF) :
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Comtran Corporation]**
 - b. **[Genesis; Resideo Technologies, Inc.]**
 - c. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - d. **[Radix Wire]**
 - e. **[Remee Wire & Cable; Remee Products Corporation]**
 - f. **[Southwire Company, LLC]**
 - g. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - h. **[West Penn Wire; brand of Belden, Inc.]**
 - i. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Comtran Corporation]**
 - b. **[Genesis; Resideo Technologies, Inc.]**
 - c. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - d. **[Radix Wire]**
 - e. **[Remee Wire & Cable; Remee Products Corporation]**
 - f. **[Southwire Company, LLC]**
 - g. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - h. **[West Penn Wire; brand of Belden, Inc.]**
 - i. **<Insert manufacturer's name>**

3. Listing Criteria:
 - a. Non-Power-Limited Fire-Alarm Cable: UL CCN HNHT; including UL 1425 and Article 760 of NFPA 70.
 - b. Vertical-Tray Flame Test: UL 1685.
 - c. Limited Smoke "ST1" Marking: UL 1685 or UL 2556.

4. Standard Features:
 - a. **[Solid][Stranded]** copper conductors with 600 V rated, 75 deg C, color-coded insulation.
 - b. Minimum Conductor Size: **[18 AWG][16 AWG][14 AWG][12 AWG]**.

B. UL HNHT - Non-Power-Limited Fire-Alarm Circuit Plenum Cable (NPLFP) :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - b. **[Southwire Company, LLC]**
 - c. **[West Penn Wire; brand of Belden, Inc.]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - b. **[Southwire Company, LLC]**
 - c. **[West Penn Wire; brand of Belden, Inc.]**
 - d. **<Insert manufacturer's name>**
3. Listing Criteria:
 - a. Non-Power-Limited Fire-Alarm Cable: UL CCN HNHT; including UL 1425 and Article 760 of NFPA 70.
 - b. Vertical-Tray Flame Test: UL 1685.
 - c. Limited Smoke "ST1" Marking: UL 1685 or UL 2556.
 - d. Plenum Rating: NFPA 262 **[and New York City Electrical Code]**.
4. Standard Features:
 - a. **[Solid][Stranded]** copper conductors with 600 V rated, 75 deg C, color-coded insulation.
 - b. Minimum Conductor Size: **[18 AWG][16 AWG][14 AWG][12 AWG]**.

C. UL HNHT - Non-Power-Limited Fire-Alarm Circuit Riser Cable (NPLFR) :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Comtran Corporation]**
 - b. **[Prysmian Cables and Systems; Prysmian Group North America]**

- c. **[Radix Wire]**
 - d. **[Southwire Company, LLC]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[Comtran Corporation]**
 - b. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - c. **[Radix Wire]**
 - d. **[Southwire Company, LLC]**
 - e. **<Insert manufacturer's name>**
3. Listing Criteria:
- a. Non-Power-Limited Fire-Alarm Cable: UL CCN HNHT; including UL 1425 and Article 760 of NFPA 70.
 - b. Vertical-Tray Flame Test: UL 1685.
 - c. Limited Smoke "ST1" Marking: UL 1685 or UL 2556.
 - d. Riser Rating: UL 1666.
4. Standard Features:
- a. **[Solid][Stranded]** copper conductors with 600 V rated, 75 deg C, color-coded insulation.
 - b. Minimum Conductor Size: **[18 AWG][16 AWG][14 AWG][12 AWG]**.
- D. UL HNIR - Power-Limited Fire-Alarm Cable (FPL) :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
- a. **[Comtran Corporation]**
 - b. **[Genesis; Resideo Technologies, Inc.]**
 - c. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - d. **[Radix Wire]**
 - e. **[Remee Wire & Cable; Remee Products Corporation]**
 - f. **[Southwire Company, LLC]**
 - g. **[West Penn Wire; brand of Belden, Inc.]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[Comtran Corporation]**
 - b. **[Genesis; Resideo Technologies, Inc.]**
 - c. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - d. **[Radix Wire]**
 - e. **[Remee Wire & Cable; Remee Products Corporation]**
 - f. **[Southwire Company, LLC]**
 - g. **[West Penn Wire; brand of Belden, Inc.]**
 - h. **<Insert manufacturer's name>**



3. Listing Criteria:

- a. Power-Limited Fire-Alarm Cable: UL CCN HNIR; including UL 1424 and Article 760 of NFPA 70.
- b. Vertical-Tray Flame Test: UL 1685.
- c. Limited Smoke "ST1" Marking: UL 1685 or UL 2556.

4. Standard Features:

- a. **[Solid][Stranded]** copper conductors with 300 V rated, 75 deg C, color-coded insulation.
- b. Minimum Conductor Size: **[18 AWG][16 AWG][14 AWG][12 AWG]**.

E. UL HNIR - Power-Limited Fire-Alarm Plenum Cable (FPLP) :

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

- a. **[Comtran Corporation]**
- b. **[Genesis; Resideo Technologies, Inc.]**
- c. **[Prysmian Cables and Systems; Prysmian Group North America]**
- d. **[Radix Wire]**
- e. **[Southwire Company, LLC]**
- f. **[Superior Essex Inc.; subsidiary of LS Corp.]**
- g. **[West Penn Wire; brand of Belden, Inc.]**
- h. **<Insert manufacturer's name>**

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

- a. **[Comtran Corporation]**
- b. **[Genesis; Resideo Technologies, Inc.]**
- c. **[Prysmian Cables and Systems; Prysmian Group North America]**
- d. **[Radix Wire]**
- e. **[Southwire Company, LLC]**
- f. **[Superior Essex Inc.; subsidiary of LS Corp.]**
- g. **[West Penn Wire; brand of Belden, Inc.]**
- h. **<Insert manufacturer's name>**

3. Listing Criteria:

- a. Power-Limited Fire-Alarm Cable: UL CCN HNIR; including UL 1424 and Article 760 of NFPA 70.
- b. Vertical-Tray Flame Test: UL 1685.
- c. Limited Smoke "ST1" Marking: UL 1685 or UL 2556.
- d. Plenum Rating: NFPA 262 **[and New York City Electrical Code]**.

4. Standard Features:

- a. **[Solid][Stranded]** copper conductors with 300 V rated, 75 deg C, color-coded insulation.
- b. Minimum Conductor Size: **[18 AWG][16 AWG][14 AWG][12 AWG]**.

F. UL HNIR - Power-Limited Fire-Alarm Riser Cable (FPLR) :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Comtran Corporation]**
 - b. **[Genesis; Resideo Technologies, Inc.]**
 - c. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - d. **[Radix Wire]**
 - e. **[Southwire Company, LLC]**
 - f. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - g. **[West Penn Wire; brand of Belden, Inc.]**
 - h. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Comtran Corporation]**
 - b. **[Genesis; Resideo Technologies, Inc.]**
 - c. **[Prysmian Cables and Systems; Prysmian Group North America]**
 - d. **[Radix Wire]**
 - e. **[Southwire Company, LLC]**
 - f. **[Superior Essex Inc.; subsidiary of LS Corp.]**
 - g. **[West Penn Wire; brand of Belden, Inc.]**
 - h. **<Insert manufacturer's name>**
 3. Listing Criteria:
 - a. Power-Limited Fire-Alarm Cable: UL CCN HNIR; including UL 1424 and Article 760 of NFPA 70.
 - b. Vertical-Tray Flame Test: UL 1685.
 - c. Limited Smoke "ST1" Marking: UL 1685 or UL 2556.
 - d. Riser Rating: UL 1666.
 4. Standard Features:
 - a. **[Solid][Stranded]** copper conductors with 300 V rated, 75 deg C, color-coded insulation.
 - b. Minimum Conductor Size: **[18 AWG][16 AWG][14 AWG][12 AWG]**.
- G. UL HNIR and FHJR - Fire-Resistive Circuit Integrity Power-Limited Fire-Alarm Plenum Cable (FPLP-CI) :
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Belden Inc.]**
 - b. **[Radix Wire]**
 - c. **[VITALink; Omni Cable]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:



- a. **[Belden Inc.]**
- b. **[Radix Wire]**
- c. **[VITALink; Omni Cable]**
- d. **<Insert manufacturer's name>**

3. Listing Criteria:

- a. Power-Limited Fire-Alarm Cable: UL CCN HNIR; including UL 1424 and Article 760 of NFPA 70.
- b. Vertical-Tray Flame Test: UL 1685.
- c. Fire-Resistive Circuit Integrity "CI" Marking: UL CCN FHJR; including UL 2196.
- d. Plenum Rating: NFPA 262[**and New York City Electrical Code**].

4. Standard Features:

- a. Twisted, shielded pair.
- b. **[Solid][Stranded]** copper conductors with 300 V rated, 75 deg C, color-coded insulation.
- c. Conductor Size: **[Not smaller than][16 AWG]<Insert wire size>[Size recommended by manufacturer's published instructions]**.

5. Other Available Features Required by Project:

- a. Limited Smoke "ST1" Marking: UL 1685 or UL 2556.

H. UL HNIR and FHJR - Fire-Resistive Circuit Integrity Power-Limited Fire-Alarm Riser Cable (FPLR-CI) :

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

- a. **[Belden Inc.]**
- b. **[Comtran Corporation]**
- c. **[Radix Wire]**
- d. **[VITALink; Omni Cable]**
- e. **<Insert manufacturer's name>**

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

- a. **[Belden Inc.]**
- b. **[Comtran Corporation]**
- c. **[Radix Wire]**
- d. **[VITALink; Omni Cable]**
- e. **<Insert manufacturer's name>**

3. Listing Criteria:

- a. Power-Limited Fire-Alarm Cable: UL CCN HNIR; including UL 1424 and Article 760 of NFPA 70.
- b. Vertical-Tray Flame Test: UL 1685.
- c. Fire-Resistive Circuit Integrity "CI" Marking: UL CCN FHJR; including UL 2196.
- d. Riser Rating: UL 1666.

4. Standard Features:
 - a. Twisted, shielded pair.
 - b. **[Solid][Stranded]** copper conductors with 300 V rated, 75 deg C, color-coded insulation.
 - c. Conductor Size: **[Not smaller than][16 AWG]<Insert wire size>[Size recommended by manufacturer's published instructions]**.
5. Other Available Features Required by Project:
 - a. Limited Smoke "ST1" Marking: UL 1685 or UL 2556.

I. UL QAYK - Optical-Fiber Cable for Fire-Alarm Systems :

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Belden Inc.]**
 - b. **[Corning Optical Communications; Corning Incorporated]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Belden Inc.]**
 - b. **[Corning Optical Communications; Corning Incorporated]**
 - c. **<Insert manufacturer's name>**
3. Listing Criteria:
 - a. Optical-Fiber Cable: UL CCN QAYK; including UL 1651, TIA-568.3, and Article 770 of NFPA 70.
 - b. Vertical-Tray Flame Test: UL 1685.
 - c. Riser Rating: UL 1666.
4. Standard Features:
 - a. Single-mode OS2.
 - b. Nonconductive.
 - c. Glass core with glass cladding.
5. Other Available Features Required by Project:
 - a. Limited Smoke "ST1" Marking: UL 1685.
 - b. Halogen-Free "HF" Marking: UL Subject 2885.

2.28 MAINTENANCE MATERIAL ITEMS

- A. Spare Parts: Furnish to Owner spare parts, for repairing fire detection and alarm system components, that are packaged with protective covering for storage on-site and identified with labels describing contents. **[Include the following:]**

1. Smoke Detectors: <Insert quantity>.
2. Heat Detectors: <Insert quantity>.
3. Duct Smoke Detectors: <Insert quantity>.
4. Manual Fire-Alarm Boxes: <Insert quantity>.
5. Addressable Input Modules: <Insert quantity>.
6. Addressable Output Modules: <Insert quantity>.
7. Audible Notification Appliances: <Insert quantity>.
8. Visual Notification Appliances: <Insert quantity>.
9. Combination Audible/Visual Notification Appliances: <Insert quantity>.

- B. Special Tools: Furnish to Owner proprietary equipment, keys, and software required to operate, maintain, repair, adjust, or implement future changes to fire detection and alarm system, that are packaged with protective covering for storage on-site and identified with labels describing contents.[
Include the following:]

1. Keys for control equipment cabinets.
2. Keys for remote test switches.
3. Wrench for manual fire-alarm boxes.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine field conditions with Installer present for compliance with requirements for fire detection and alarm systems and other conditions affecting performance of the Work.
- B. Examine all materials, products, and equipment received for defects or damage.
- C. Reject all materials, products, and equipment that show signs of defects or damage.
- D. Examine roughing-in for fire detection and alarm system piping to verify actual locations of piping connections before equipment installation.
- E. Examine walls, floors, ceilings, and roofs for suitable conditions where fire detection and alarm system components will be installed.
- F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 SELECTION OF CABLING FOR FIRE ALARM

- A. Field Circuits:
1. SLC: 12 to 18 AWG [unshielded][twisted pair][FPL][FPLR][FPLP][FPLR-CI][FPLP-CI].
 2. NAC: 12 to 18 AWG [unshielded][shielded][twisted pair][FPL][FPLR][FPLP][FPLR-CI][FPLP-CI].
 3. Audio Circuits: 12 to 18 AWG [unshielded][shielded][twisted pair][FPL][FPLR][FPLP][FPLR-CI][FPLP-CI].
 4. Auxiliary Power Circuits: 12 to 18 AWG [unshielded][twisted pair][FPL][FPLR][FPLP].
 5. Network Communication Circuits: [12 to 18 AWG][unshielded][shielded][twisted pair][FPLR][FPLP][FPLR-CI][FPLP-CI][single-mode fiber-optic cable].

3.3 SELECTION OF RACEWAYS FOR FIRE ALARM

- A. Identification: At a minimum, all junction box covers for fire-alarm raceways must be identified using the color red.
- B. Outdoor Pathways:
 - 1. Exposed and Subject to Severe Physical Damage: [ERMC][IMC].
 - 2. Exposed and Subject to Physical Damage: [ERMC][IMC][Corrosion-resistant EMT]. Locations include the following:
 - a. Locations less than 2.5 m (8 ft) above finished grade.
 - b. <Insert designations of applicable spaces or locations>.
 - 3. Exposed and Not Subject to Physical Damage: [ERMC][IMC][Corrosion-resistant EMT][RTRC-AG][LFMC][LFNC].
 - 4. Marine Locations: [PVC-80][Corrosion-resistant EMT].
 - 5. Concealed Aboveground: [ERMC][IMC][EMT][LFMC].
 - 6. Direct Buried: [PVC-80][HDPE-80][LFMC].
 - 7. Concrete Encased Not in Trench: [PVC-80].
 - 8. Concrete Encased in Trench: [PVC-80][HDPE-80].
 - 9. Innerducts inside Other Raceway: [ENT][RTRC-AG][RTRC-BG][OFR][CR].
- C. Indoor Pathways:
 - 1. Hazardous Classified Locations: [ERMC][IMC].
 - 2. Exposed and Subject to Severe Physical Damage: [ERMC][IMC]. Locations include the following:
 - a. Loading docks.
 - b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
 - c. Mechanical rooms.
 - d. Gymnasiums.
 - e. <Insert designations of applicable spaces or locations>.
 - 3. Exposed and Subject to Physical Damage: [ERMC][IMC][EMT]. Locations include the following:
 - a. Locations less than 2.5 m (8 ft) above finished floor.
 - b. Stub-ups to above suspended ceilings.
 - c. <Insert designations of applicable spaces or locations>.
 - 4. Exposed and Not Subject to Physical Damage: [MC-FPL][MC-FPLR][MC-FPLP][ERMC][IMC][EMT][LFMC].
 - 5. Concealed above Suspended Ceilings: [MC-FPL][MC-FPLR][MC-FPLP][ERMC][IMC][EMT][LFMC][ERMC][IMC][EMT][LFMC][Hooks].
 - 6. Concealed in Ceilings and Interior Walls and Partitions: [MC-FPL][MC-FPLR][MC-FPLP][ERMC][IMC][EMT][LFMC][ERMC][IMC][EMT][LFMC][LFNC].
 - 7. Damp or Wet Locations: [ERMC][IMC][Corrosion-resistant EMT][LFMC][LFNC].
 - 8. Innerducts inside Metal Raceway: [ENT][RTRC-AG][OFR][CR].
 - 9. Exposed to Environmental Air: [ERMC][IMC][EMT][PVC-80].
 - 10. In Vertical Runs: [ERMC][IMC][EMT].

3.4 INSTALLATION OF FIRE DETECTION AND ALARM SYSTEMS

- A. Comply with manufacturer's published instructions.



- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:
1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
 2. Commissioning of Electrical Systems: NECA NEIS 90.
 3. Commissioning of Active and Passive Fire Protection Features: NFPA 3 and NFPA 4.
 4. Fire-Alarm and Premises Security Work: NFPA 72, NFPA 731, NFPA 1225, and NECA NEIS 305.
 5. Work in ITE Rooms: NFPA 75.
 6. Work in Health Care Facilities: NFPA 99 and Article 517 of NFPA 70.
 7. Life-Safety and Means-of-Egress Work: NFPA 101.
 8. Emergency and Standby Power Work: NFPA 110, NFPA 111, and NECA NEIS 416.
 9. Work in Confined Spaces: NFPA 350.
 10. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
 11. Work in Museums, Libraries, Places of Worship, and Historic Structures: NFPA 909 and NFPA 914.
 12. Fire-Alarm Circuits and Pathways: Ch. 12 of NFPA 72 and Article 760 of NFPA 70.
 13. Fire-Alarm Initiating Devices: Ch. 17 of NFPA 72.
 14. Fire-Alarm Notification Appliances: Ch. 18 of NFPA 72.
 15. Fire-Alarm Control Equipment: Ch. 23 of NFPA 72.
 16. Fire-Alarm Transmitting Equipment: Ch. 23 and Ch. 26 of NFPA 72.
 17. Consult Architect for resolution of conflicting requirements.
- C. Special Installation Techniques:
1. **<Insert more stringent installation requirements that supplement or supersede listed standards and manufacturer's published instructions>.**
- D. Interfaces with Other Work:
1. Identification: Provide labels for all initiating devices, control equipment cabinets, and associated electrical equipment.
 - a. Identify field-installed conductors, interconnecting wiring, and components.
 - b. Label initiating devices with unique identification.
 - c. Identify source of AC power inside each control equipment cabinet.
 - d. Identify circuit disconnecting means at AC power source with red engraved label. Provide approved locking device for circuit disconnecting means.
 - e. Label enclosures with engraved metal or laminated-plastic nameplate.
 - f. Identify junction box covers using the color red.
 - g. Identify **<Insert raceway component>** using the color red.
 2. Coordinate installation of new products for **<Insert system or product group/category>** with existing conditions.
 - a. **<Insert requirements for transition between new and existing>.**
 3. Coordinate with **<Insert Section number and title>** for **<Insert description of interfacing related Work>.**
 - a. **<Insert requirements for transition between this Section and related Work>.**
- E. Systems Integration:
1. **<Insert requirements for integration with other systems>.**

3.5 FIELD QUALITY CONTROL OF FIRE DETECTION AND ALARM SYSTEMS

- A. Administrant for Fire-Alarm Tests and Inspections:
1. **[Owner][Tenant]** will engage qualified fire-alarm testing and inspecting agency to administer and perform tests and inspections.
 2. Engage qualified fire-alarm testing and inspecting agency to administer and perform tests and inspections.
 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
 4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].
- B. Acceptance Testing Preparation:
1. **<Insert requirements>**.
- C. Field tests and inspections must be witnessed by **[Architect][Tenant][authorities having jurisdiction]<Insert names or titles of witnesses>**.
- D. Tests and Inspections:
1. Perform manufacturer's recommended tests and inspections.
 2. Perform system acceptance testing in accordance with Ch. 14[**and Appendix D**] of NFPA 72.
 3. Contractor is responsible for completing pre-acceptance testing to verify proper operation of the fire detection and alarm systems. Correct system deficiencies prior to scheduling a final acceptance test.
- E. Nonconforming Work:
1. Initiating devices, notification appliances, control equipment, and system accessories will be considered defective if they do not pass tests and inspections.
 2. Remove and replace defective units and retest.
- F. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.
- G. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** field tests and inspections.
1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at Project site.

3.6 SYSTEM STARTUP

- A. Perform startup service.
1. Complete installation and startup checks in accordance with manufacturer's published instructions.
 2. Provide power to the FACU and configure internal settings.
 3. Test all field wiring prior to connecting field devices and prior to connecting to the FACU. Ensure field wiring is free from ground faults and short circuits.
 4. Connect field devices to field wiring.
 5. Connect field wiring inside FACU cabinet.
 6. Ensure system is normal and free from ground faults, open circuits, or short circuits.



7. Allow system burn-in for **[30][60]** days.
8. Correct any issues that occur during the system burn-in period.
9. **<Insert startup steps if any>**.

B. Manufacturer Services: Engage factory-authorized service representative to **[support][supervise]** system startup.

1. Manufacturer's Field Reports for System Startup Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at Project site.

3.7 PROTECTION

A. After installation, protect fire detection and alarm system equipment from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

3.8 MAINTENANCE

A. Maintenance Service Agreement: Beginning at Substantial Completion, verify that maintenance service agreement includes **[three-month][six-month][nine-month][one-year]<Insert duration>** period for full maintenance by **[skilled employees of fire detection and alarm system installer][manufacturer's authorized service representative]**. Include **[monthly][quarterly][semiannual][annual]** preventive maintenance, repair, or replacement of worn or defective components; cleaning; and adjusting as required for proper fire detection and alarm system operation. Verify that parts and supplies are manufacturer's authorized replacement parts and supplies.

B. Software and Firmware Service Agreement:

1. Technical Support: Beginning at Substantial Completion, verify that software and firmware service agreement includes software and firmware support for **[two years]<Insert duration>**.
2. Upgrade Service: At Substantial Completion, update software and firmware to latest version. Install and program software and firmware upgrades that become available within **[two years]<Insert duration>** from date of Substantial Completion. **[Verify that upgrading software includes operating system and new or revised licenses for using software.][Conduct reacceptance testing of system components directly affected by software and firmware upgrades.]**
 - a. Upgrade Notice: Not less than **[30 days]<Insert duration>**; to allow Owner to schedule and access the system **[and to upgrade computer equipment if necessary]**.
3. Field Reports for Software and Firmware Upgrades: Prepare and submit report after each update, documenting upgrades installed.

END OF SECTION 28 46 00 00



28 - Electronic Safety and Security

Task	Specification	Specification Description
28 46 00 00	28 40 00 00	Emergency Responder Communications Enhancement System ERCES
28 46 13 00	28 46 00 00	Fire Detection and Alarm
28 46 13 00	28 40 00 00	Emergency Responder Communications Enhancement System ERCES
28 46 13 31	28 46 00 00	Fire Detection and Alarm
28 46 13 31	28 40 00 00	Emergency Responder Communications Enhancement System ERCES
28 46 31 00	28 46 00 00	Fire Detection and Alarm
28 46 31 00	28 40 00 00	Emergency Responder Communications Enhancement System ERCES
28 46 31 11	28 46 00 00	Fire Detection and Alarm
28 46 31 11	28 40 00 00	Emergency Responder Communications Enhancement System ERCES
28 46 41 00	28 46 00 00	Fire Detection and Alarm
28 46 41 00	28 40 00 00	Emergency Responder Communications Enhancement System ERCES
28 46 41 11	28 46 00 00	Fire Detection and Alarm
28 46 41 11	28 40 00 00	Emergency Responder Communications Enhancement System ERCES
28 46 41 31	28 46 00 00	Fire Detection and Alarm
28 46 41 31	28 40 00 00	Emergency Responder Communications Enhancement System ERCES



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SECTION 28 47 00 00 - MASS NOTIFICATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Mass notification systems.

B. Products Installed, but Not Furnished, under This Section:

1. **<Insert products identified in "Existing Products to be Modified" Article or "Existing Products to be Removed and Re-Installed" Article>.**

C. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. Section 260526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding referenced by this Section.
5. Section 260536 "Cable Trays for Electrical Systems" specifies cable trays referenced by this Section.
6. Section 260548 "Vibration and Seismic Controls for Electrical Systems" specifies seismic-restraint devices referenced by this Section.
7. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs referenced by this Section.
8. Section 270528 "Pathways for Communications Systems" specifies additional requirements for raceway materials, routing, locations, and identification of communications equipment and cabling.
9. Section 284600 "Fire Detection and Alarm" for fire-alarm cabling and interfaces with MNS equipment in this Section to create an EVACS.

1.2 DEFINITIONS

A. ATP: Acceptance Test Procedure.

B. Broadcast Media: Loudspeakers, radios, cellular phones, and other media that will carry the selected message to the selected audience.

C. Control Unit: A system component that monitors inputs and controls outputs through various types of circuits.

1. Autonomous Control Unit (ACU): The primary control unit for an in-building mass notification system (MNS).



2. Emergency Communications Control Unit (ECCU): A system capable of sending mass notification messages to individual buildings, zones of buildings, individual outdoor loudspeaker arrays, or zones of outdoor loudspeaker arrays; or a building, multiple buildings, outside areas, or a combination of these.
 3. Fire-alarm control unit (FACU).
 4. Wireless Control Unit: A component that transmits/receives and processes wireless signals.
- D. Emergency Communications System (ECS): A system for the protection of life by indicating the existence of an emergency situation and communicating information necessary to facilitate an appropriate response and action.
1. Distributed Recipient Mass Notification System (DRMNS): A system meant to communicate directly to targeted individuals and groups that might not be in a contiguous area.
 2. Emergency Voice/Alarm Communications System (EVACS): Dedicated manual or automatic facilities for originating and distributing voice instructions, as well as evacuation signals pertaining to an emergency, to the occupants of a building.
 3. Mass Notification System (MNS): A system used to provide information and instructions to people in buildings or other spaces using intelligible voice communications and including visual signals, text, graphics, tactile, or other communication methods (in-building MNS); and could have the capability to provide real-time information to outdoor areas and to communicate with other notification systems provided for a campus, region, or global geographic setting (wide-area MNS).
- E. High Power Loudspeaker Array (HPLA): A product providing capability for voice and tone communication to large outdoor areas.
- F. Local Operator Console (LOC): Equipment used by authorized personnel and emergency responders to activate and operate a mass notification system (MNS).
- G. NICET: National Institute for Certification in Engineering Technologies, a division of the National Society of Professional Engineers.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 3. Power calculations.
 4. Battery capacity calculations with the following supporting information:
 - a. Supervisory power requirements for all equipment.
 - b. Alarm power requirements for all equipment.
 - c. Power supply rating.
 - d. Voltage drop calculations for wiring runs demonstrating worst-case condition.
 - e. Notification appliance circuit design.
 5. Include manufacturer's sample extended warranty language.
- B. Shop Drawings: Prepare and submit the following in accordance with NFPA 72:
1. Floor Plans:

- a. Scaled floor plans indicating location and unique identification of each component and point-to-point wiring.
 - b. Indicating all acoustically distinguishable spaces (ADS) where intelligibility is required, and where intelligibility is not required or is not able to be achieved,
 - c. Elevations indicating equipment dimensions and mounting heights.
2. Wiring Diagrams:
 - a. System riser diagram, including power, signal, and control wiring.
 - b. Mass notification system component schematic wiring diagrams.
3. Details:
 - a. Component installation details.
 - b. Details of equipment assemblies, including dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
4. Calculations:
 - a. Battery calculations.
 - b. Voltage-drop calculations.
 - c. Spare capacity circuit calculations.
5. Sequence of Operations: Prepare a narrative description or input/output matrix of operation to describe the mass notification system sequence of operation.
6. Applicable Codes and Standards:
 - a. Indicate on Shop Drawings the applicable referenced codes and standards and their respective edition adopted in the jurisdiction where the project is located.

C. Field quality control reports.

1.4 INFORMATIONAL SUBMITTALS

A. Test and Evaluation Reports:

1. Product Test Reports: For each amplifier and loudspeaker, for tests performed by **[manufacturer and witnessed by a qualified testing agency] [a qualified testing agency]**.

1.5 CLOSEOUT SUBMITTALS

- A. Computer-generated instruction card mounted behind a Lexan plastic or glass cover in a stainless steel or aluminum frame. Card must indicate those steps to be taken by an operator when a signal is received as well as functional operation of system under all conditions: normal, alarm, supervisory, and trouble.
- B. Record Documentation: System documentation to Owner including, but not limited to, the following:
 1. System record Drawings and wiring details, including one set of full-size printed Drawings, and CD-ROM with copies of record Drawings in PDF format and DXF format.
 2. Documentation of all component and wiring identification, including a copy of each equipment nameplate.
 3. System matrix showing interaction of all input signals with output commands.



4. Documentation of system voltage, current, and resistance readings taken during installation, testing, and ATP phases of system installation.

C. System program showing control devices and operations, and system functions of equipment and devices.

D. Field Reports:

1. Manufacturer's field reports for field quality-control support.
2. Field reports for software and firmware upgrades.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Spare parts.

B. Special tools.

C. Schedule of maintenance material items.

1.7 QUALIFICATIONS

A. Fire-Alarm Systems (FAS) Technician Trainee: Having at least six months of experience and possessing active NICET FAS Level I certification. Able to perform limited tasks under direct supervision.

B. Fire-Alarm Systems (FAS) Associate Engineering Technician: Having at least two years of experience and possessing active NICET FAS Level II certification. Able to review drawings, specifications, codes, and standards; to conduct basic installation activities; and to perform basic troubleshooting.

C. Fire-Alarm Systems (FAS) Engineering Technician: Having at least five years of experience and possessing active NICET FAS Level III certification. Able to perform system layout activities, to supervise Level I and Level II technicians, to provide submittal packages, and to interact with authorities having jurisdiction.

D. Fire-Alarm Systems (FAS) Senior Engineering Technician: Having at least 10 years of experience and possessing active NICET FAS Level IV certification. Able to manage multiple projects at once, to interpret codes and standards, to conduct training, and to serve as liaison between authorities having jurisdiction, owners, engineers, and contractors.

E. Inspection and Testing of Fire-Alarm Systems (I&TFAS) Technician I: Possessing active NICET I&TFAS Level I certification. Able to perform periodic inspections and tests of basic fire-alarm systems and to prepare related records and reports.

F. Inspection and Testing of Fire-Alarm Systems (I&TFAS) Technician II: Possessing active NICET I&TFAS Level II certification. Able to plan, perform, and coordinate periodic inspections and tests of complex fire-alarm systems (including one or more of suppression interfaces, networked control units, smoke control interfaces, air sampling systems, multi-zone voice evacuation systems, or high-rise applications) and to prepare related records and reports.

G. Communications Design Professional: Design professional possessing active qualifications specified in Section 014000 "Quality Requirements" and the following:

1. Expertise in design of communications infrastructure and distribution equipment.
 2. BICSI Registered Communications Distribution Designer (RCDD)[or **Outside Plant Designer (OSP)**] certification.
- H. Communications Cable Installer: Entity possessing active qualifications specified in Section 014000 "Quality Requirements" and the following:
1. Training and manufacturer certification to install, splice, and terminate communications cabling.
 2. Installation Supervisor: BICSI Technician (TECH) certification.
 3. Copper Installers: **[30 percent]** <Insert quantity> of employees possess BICSI Copper Installer 2 (INSTC) certification. Remaining employees possess BICSI Installer 1 (INST1) certification.
 4. Fiber Installers: **[30 percent]** <Insert quantity> of employees possess BICSI Optical Fiber Installer 2 (INSTF) certification. Remaining employees possess BICSI Installer 1 (INST1) certification.
- I. Communications Testing and Inspecting Agency: Entity possessing active credentials from qualified electrical testing laboratory recognized by authorities having jurisdiction.
1. On-site communications testing supervisor must have **[BICSI Technician (TECH)]** <Insert certification program> certification and documented training, and be experienced with testing communications equipment in accordance with **[BICSI]** <Insert code enforced by authorities having jurisdiction> testing standards.
- J. Life-Safety Professional Engineer: Professional engineer possessing active qualifications specified in Section 014000 "Quality Requirements," with expertise in life-safety systems.
- K. Fire-Alarm Cable Installer: Entity possessing active qualifications specified in Section 014000 "Quality Requirements" with training and manufacturer certification to install, splice, and terminate fire-alarm cabling.
1. On-site fire-alarm cable installation supervisor must possess active NICET FAS **[Senior]** Engineering Technician certification.
- L. Fire-Alarm Testing Agency: Entity possessing active credentials from qualified electrical testing laboratory recognized by authorities having jurisdiction.
1. On-site fire-alarm testing supervisor must possess active NICET I&TFAS Technician **[I]** **[II]** certification.
- 1.8 WARRANTY
- A. Special Installer Extended Warranty: Installer warrants that installed MNS performs in accordance with specified requirements and agrees to repair or replace components or products that fail to perform as specified within extended-warranty period. Warranty must convey to Owner upon acceptance of the Work.
1. Extended-Warranty Period: **[Two]** **[Three]** **[Four]** <Insert number> years from date of Substantial Completion; full coverage for labor, materials, and equipment.
- B. Special Manufacturer Extended Warranty: Manufacturer warrants that MNS performs in accordance with specified requirements and agrees to provide repair or replacement of components or products that fail to perform as specified within extended-warranty period. Warranty must convey to Owner upon acceptance of the Work.



1. Initial Extended-Warranty Period: **[Three] [Four] [Five] <Insert number>** years from date of Substantial Completion; **[full] [prorated]** coverage for labor, materials, and equipment.
2. Follow-On Extended-Warranty Period: **[Eight] <Insert number>** years from date of Substantial Completion; **[full] [prorated]** coverage for materials only, free on board **[origin] [destination]**, freight prepaid.

PART 2 - PRODUCTS

2.1 EXISTING PRODUCTS TO BE MODIFIED

- A. Basis for Pricing: **<Insert name of manufacturer; model number or series for existing product>**.
- B. Description: **<Insert description of existing product, including special features, options, and finishes that may impact the Work>**.
- C. Accessories: **<Insert accessories included with existing product>**.

2.2 EXISTING PRODUCTS TO BE REMOVED AND RE-INSTALLED

- A. Basis for Pricing: **<Insert name of manufacturer; model number or series for existing product>**.
- B. Description: **<Insert description of existing product, including special features, options, and finishes that may impact the Work>**.
- C. Accessories: **<Insert accessories included with existing product>**.

2.3 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Products or components listed and labeled in accordance with Article 760 of NFPA 70 and Ch. 24 of NFPA 72, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- B. General Characteristics:
 1. ECS Classification: **[One-way, in-building EVACS] [One-way, in-building MNS] [One-way, wide-area MNS] [One-way DRMNS]**.
 2. Provide the following specified products with the MNS:
 - a. ACU.
 - b. Prerecorded message device.
 - c. Audio amplifiers.
 - d. Audible signaling devices.
 - e. Indoor speakers for voice notification.
 - f. Outdoor HPLAs.
 - g. Text displays.
 - h. Visual signaling devices for hearing impaired.
 - i. Web interfaces.
 - j. Overvoltage and surge protection.
 - k. LOCs.
 - l. Software.

3. Software-operated, network-based communications system with wired and wireless access points for control interface. Designated operators must be able to log in via a web browser and have complete access to their own portion of MNS.
4. ACU must monitor and control the notification appliance network and provide consoles for local operation. Authorized personnel must be able to use a console to initiate delivery of prerecorded voice messages, provide live voice messages and instructions, and initiate visual strobe and optional textual message notification appliances. ACU must override audible fire-alarm notification signals and voice messages based on the approved sequence of operation described in the risk analysis.
5. MNS messaging system must be capable of the following:
 - a. Communicating through use of wired networks, or wireless networks via wireless control units, for one- or two-way communications and control between a building or area and emergency personnel.
 - b. Automatically distribute no fewer than 100 simultaneous and unique messages to appropriate notification appliances.
 - c. Allow multiple operators to send messages simultaneously.
 - d. Grant access for control to another control station if location in control becomes inoperable and/or authorized operator at that control station can no longer operate the control station.
 - e. Send voice messages and text messages with an indication of the source of message that can only be sent from message source.
 - f. Send alert messages to end users (recipients) via multiple delivery methods including, but not limited to, the following:
 - 1) Audio-visual network alerts to computers via desktop pop-up.
 - 2) Text alerts to cellular phones and pagers.
 - 3) Text alerts to email clients.
 - 4) Text alerts to textual visible appliances.
 - 5) Alerts to visible appliances.
 - 6) Audio alerts to phones.
 - 7) Audio alerts to loudspeakers.
 - 8) Audio alerts to existing wide-area or in-building ECS.
 - 9) Network alerts to other IP-connected devices via standard XML and CAP protocols.
 - g. Suppress contact information for other end users with messages or in message headers.
6. Live announcements or prerecorded messages. Live messages must take precedence over prerecorded messages.
7. Notification appliance network must consist of loudspeakers and visual notification devices located to provide intelligible instructions at all ADS designated by designer to receive messages. **[Areas as indicated on Drawings] <Insert locations>.**
8. Interface with FACU to use voice modules, visual alarms, and loudspeakers of fire-alarm system.
9. Give priority to MNS announcements over other audible announcements of the system including fire-alarm system in a normal or alarm state based on the approved risk analysis. When an emergency announcement other than fire is activated during a fire alarm, fire-alarm system functions must continue in an alarm state, except for output signals of fire-alarm audible and visual notification appliances.
10. Comply with speech intelligibility requirements of NFPA 72.
11. Capable of overriding local control of loudspeaker volume levels for emergency communications. Local controls must be permitted to adjust volume levels of non-emergency signals only, such as, but not limited to, background music and convenience paging.
12. Capable of providing separate messages to one individual building or to multiple buildings at given time if MNS serves more than one building.
13. Capable of monitoring emergency notifications from multiple data sources (National Weather Service, Emergency Managers Weather Information Network, Naval Meteorology and



- Oceanography, and others as determined locally) and automatically send out notifications to designated facilities and personnel based on predefined rules.
14. Capable of centrally tracking, in real-time, all alerting activities for each individual recipient, including sending, receiving, and responding to alerts, and of generating reports based on tracked information.
 15. Capable of operating remote printer via USB output. Provide matching printer listed and labeled as part of MNS.
 16. Primary Power: Must be sized to supply not less than 125 percent of the total connected load in a worst-case condition.
 - a. Devices Powered by 24 V(dc):
 - 1) Control units.
 - 2) Notification appliances.
 - 3) Text displays.
 - 4) Trouble signals.
 - 5) Supervisory signals.
 - 6) Supervisory and digital alarm communicator transmitters.
 - 7) Digital alarm radio transmitters.
 17. Secondary Power: Must be sized to supply not less than 125 percent of the total connected load in a worst-case condition.
 - a. Batteries: **[Sealed lead calcium] [Sealed, valve-regulated, recombinant lead acid] [Sealed lead-calcium, valve-regulated, recombinant lead acid]**.

2.4 MASS NOTIFICATION SYSTEMS

A. UL PGWM - Autonomous Control Units (ACUs) <Insert drawing designation>:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Source Limitations: Obtain products from single manufacturer.
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Control and Communication Equipment: UL CCN PGWM, including UL 2572.
4. Standard Features:
 - a. Fully enclosed in a lockable steel cabinet with access for testing, and maintenance from the front of enclosure.
 - b. Solid-state, modular components, internally mounted and arranged for easy access for power, supervision, control, and logic for system.
 - c. 120 V ac, 60 Hz power supply.
 - d. An indicator for each message source must indicate which sources are available and which are selected.
 - e. Indicators for broadcast media used to convey the selected message to selected audience must indicate which sources are available and which are selected.
 - f. Capable of confirming receipt of a message. If message was not confirmed received, system must be capable of using other means of contact until receipt of confirmation or until a preset time has elapsed.
 - g. Capable of automatically sending another message after receipt of a new information or messages.

h. Operator Access Functions:

- 1) Select prerecorded message for transmission.
- 2) Select microphone for live broadcast.
- 3) Initiate message broadcast.
- 4) Terminate message broadcast.

i. Supervisory Access Functions:

- 1) Reset time and date.
- 2) Enable or disable printouts, initiators, and event-initiated programs.
- 3) Enable or disable individual message sources and broadcast media.
- 4) Supervisory level functions must not require computer programming skills. MNS must record changes to program functions, to be maintained in ACU for a minimum of **[one year]** **<Insert time>**. ACU must maintain the ID of supervisor making the change.

j. System Operator Level Access Functions:

- 1) Clear supervisory trouble alarms.
- 2) Revise programming.
- 3) Revise prerecorded messages.
- 4) Assign access rights to all levels.
- 5) MNS must record changes at system operator level in ACU, to be maintained for a minimum of **[one year]** **<Insert time>**. ACU must maintain the ID of system operator making the change.

k. Capable of no fewer than **[1000]** **[5000]** **<Insert number>** users, with each user having its own log-in and password credentials and no fewer than four contact methods.

l. Capable of storing users in one or multiple groups and able to create a minimum of **[10]** **[20]** **<Insert number>** groups.

m. Each panel must have supervisory functions for power failure, internal component failure, and operation.

n. MNS must have complete set of self-diagnostics for controller and appliance network, and local diagnostic information display, local diagnostic information, and system event log.

o. Printed records of changes, supervisory functions, message transmission, and operator actions must be maintained for a minimum of **[one year]** **<Insert time>**.

B. UL PGWM - Prerecorded Message Devices **<Insert drawing designation>**:

1. **<Double click here to find, evaluate, and insert list of manufacturers and products.>**
2. Source Limitations: Obtain products from single manufacturer.
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

a. Control and Communication Equipment: UL CCN PGWM, including UL 2572.

4. Standard Features:

- a. Description: Hardware that stores and outputs audible signals or messages.
- b. One-way, multichannel voice notification system incorporating no fewer than eight distinct sounds selectable by user for tone signaling and incorporating a voice module for delivery of prerecorded or live messages.
- c. Redundant microphones, preamplifiers, amplifiers, and tone generators provided in separate main and remote cabinets.



- d. Voice notification system must support facility-wide public address paging.
- e. Audible appliances must produce an initial message stating "May I have your attention please?" followed by a voice message with instructions as defined by the risk analysis that is repeated until ACU is reset or silenced. If the intent is for building or floor evacuation, the standard temporal pattern complying with ASA S3.41 will follow the message.
- f. Automatic messages must be broadcast through loudspeakers throughout the building or facility, but not in stairs or elevators.
- g. When using microphones, live messages must be broadcast throughout a selected floor or floors or all call, including stairs and elevators.
- h. Loudspeakers must not be installed in near a microphone that will be used for live messaging.
- i. Live voice message must override automatic or recorded audible output through use of a microphone input at ACU or the remote cabinet.
- j. Number of alarm channels must be indicated for automatic, simultaneous transmission of different announcements to different zones or for manual transmission of announcements by use of the central-control microphone.
 - 1) Allow sending an evacuation signal to selected zones and, concurrently, allow voice paging to other zones selectively or in combination.
 - 2) Programmable tone and message sequence selection.
 - 3) Standard digitally recorded messages for "Evacuation" and "All Clear."

C. UL UUMW - Audio Amplifiers **<Insert drawing designation>**:

- 1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
- 2. Source Limitations: Obtain products from single manufacturer.
- 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Amplifiers for Fire-Protective Signaling Systems: UL CCN UUMW, including UL 1711 and ISO 7240.
- 4. Standard Features:
 - a. Audio output must be selectable for line level. Minimum amplifier output must be **[100]** **<Insert number>** W rms.
 - b. Capable of operating all loudspeakers at the same time[**with fiber connection**].
 - c. Loss of operating power, supervisory power, or other malfunction that could render the voice module inoperative must automatically cause the standard temporal tone pattern complying with ASA S3.41 to take over all functions assigned to failed unit in the event an alarm is activated.

D. UL ULSZ - Audible Signaling Devices **<Insert drawing designation>**:

- 1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
- 2. Source Limitations: Obtain products from single manufacturer.
- 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Sounding Devices: UL CCN ULSZ, including UL 464.
- 4. Standard Features:

- a. Handheld push-to-talk microphone must be supervised and a key must be required to enable remote microphone use.
 - b. Microprocessor must actively integrate circuitry, field wiring, and digital coding necessary for immediate and accurate rebroadcasting of stored voice data into appropriate amplifier input.
- E. UL UUMW - Indoor Loudspeakers for Voice Notification **<Insert drawing designation>**:
 - 1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
 - 2. Source Limitations: Obtain products from single manufacturer.
 - 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Loudspeakers for Fire-Protective Signaling Systems: UL CCN UUMW, including UL 1480.
 - 4. Standard Features:
 - a. Construction: High-efficiency, sealed back; for maximum output at minimum power across a frequency range of 150 to 10 000 Hz.
 - b. High-Range Units: Rated 2 to 15 W.
 - c. Low-Range Units: Rated 1 to 2 W.
 - d. Mounting: **[Flush] [or] [semi-recessed] [or] [surface mounted and bidirectional]**.
 - e. Matching Transformers: Tap range matched to acoustical environment of loudspeaker location.
- F. UL UUMW - High Power Loudspeaker Arrays (HPLAs) **<Insert drawing designation>**:
 - 1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
 - 2. Source Limitations: Obtain products from single manufacturer.
 - 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Loudspeakers for Fire-Protective Signaling Systems: UL CCN UUMW, including UL 1480.
 - 4. Standard Features:
 - a. HPLAs, **[1600] [3200]** W, with acoustic performance and intelligibility features.
 - b. Sound Dispersion: **[Omnidirectional] [Horizontal 70 degrees, vertical 80 degrees]**.
 - c. Control unit providing signal processing, amplification, gain control, battery backup, and antenna surge protection.
 - d. Pole designed for HPLA with wind load of **[100 mph (160 km/h)] [110 mph (177 km/h)] <Insert value>**.
 - 5. Seismic and Wind Performance for Outdoor HPLAs: Installed assembly must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:
 - a. Supporting structure must be sized to accommodate the static and dynamic loads produced by the sound systems and all attachments.
 - b. Minimum design wind speed of **[100 mph (161 km/h)] <Insert other wind speed requirement>**.
 - c. Seismic design in accordance with site-specific requirements.
 - d. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events **[and unit must be fully operational after seismic events]."**

- e. Component Importance Factor (I_p): **[1.0] [1.5]**.
- f. Component Amplification Factor (a_p): **[1.0] [2.5] <Insert value>**.
- g. Component Response Modification Factor (R_p): **[1.5] [2.0] [2.5] [6.0] <Insert value>**.
- h. Component Overstrength Factor (Ω_o): **[1.5] [2.5] <Insert value>**.

G. UL UVAV - Text Displays <Insert drawing designation>:

- 1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
- 2. Source Limitations: Obtain products from single manufacturer.
- 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Visual-Signal Appliances for Fire-Protective Signaling Systems: UL CCN UVAV, including UL 1638.
- 4. Standard Features:
 - a. Indicate location of digital displays on Drawings.
 - b. Programmable, digital text displays having a minimum of 4 inch (100 mm) high letters for hearing-impaired occupants displaying content of voice message being played.
 - c. Capable of sending static, flashing, or scrolling messages to textual visible appliances.
 - d. ACU must interface with and control the programmable display controller to activate the proper message.
 - e. Textual visible notification must be primary notification when it is the only method used to convey emergency MNS information to general public or to specific individuals.

H. UL UUKC - Visual Signaling Devices for Hearing Impaired <Insert drawing designation>:

- 1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
- 2. Source Limitations: Obtain products from single manufacturer.
- 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Signaling Appliances and Equipment for Hearing Impaired: UL CCN UUKC, UL 1971.
- 4. Standard Features:
 - a. Strobes used solely for MNS must be **[amber] [clear]**, comply with UL 1971, and have the word "ALERT" factory printed on the trim.
 - b. Strobes used in combination systems, where the same strobe is used for both MNS and fire-alarm notification, must be clear and comply with UL 1971.
 - c. Strobes used for MNS must be synchronized in accordance with requirements of NFPA 72.

I. UL PGWM - Web Interfaces <Insert drawing designation>:

- 1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
- 2. Source Limitations: Obtain products from single manufacturer.
- 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Control and Communication Equipment: UL CCN PGWM, including UL 2572.

4. Standard Features:
 - a. Description: Systems hardware capable of using dedicated or existing IP networks to send alert messages.
 - b. System must be able to communicate with multiple modalities to include, but not be limited to, pop-up alerts on PCs, text messages to cellular phones, email messaging to IP-capable computers or devices, and recorded voice messages to VoIP telephones and PCs.
 - c. Capable of activating, through single interface, non-IP alerting systems such as wide-area alerting systems, fire-alarm systems, public address systems, handheld radio systems, radio broadcast systems, personal pager systems, nurse call systems, and traditional dial-up telephone alerting systems.
5. Other Available Features Required by the Project:
 - a. Capable of accessing user screens via multiple web browsers such as Microsoft Explorer, Mozilla Firefox, or Apple Safari.
 - b. Capable of sending live video stream from IP-based camera or security camera system to PC or video display.

J. UL QVGQ - Signaling Line Circuit Surge Protection **<Insert drawing designation>**:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Source Limitations: Obtain products from single manufacturer.
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Isolated Loop Circuit Protectors: UL CCN QVGQ, including UL 497B.
4. Standard Features:
 - a. Protected against surges induced on signaling line circuit located outdoors.
 - b. Protect cables and conductors that serve as communications links with surge protection devices installed at each end that comply with the following waveforms:
 - 1) 10 by 1000-microsecond waveform with a peak of 1500 V and a peak current of 60 A.
 - 2) 8 by 20-microsecond waveform with a peak of 1000 V and a peak current of 500 A. Protection must be provided at the equipment. Additional surge protectors, rated for application, must be installed on each circuit within 36 inch (900 mm) of the cable entrance to building.
 - c. Fuses must not be used for surge protection.

K. UL QVRP2 - Sensor Wiring Surge Protection **<Insert drawing designation>**:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Source Limitations: Obtain products from single manufacturer.
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Secondary Protectors for Communications Circuits Used with Specified Voltage Suppression - Component: UL CCN QVRP2, including UL 497A and UL Subject 497D.
4. Standard Features:

- a. Digital and analog inputs and outputs must be protected against surges induced by sensor wiring. Inputs and outputs must be tested with the following waveforms:
 - 1) 10 by 1000-microsecond waveform with a peak of 1500 V and a peak current of 60 A.
 - 2) 8 by 20-microsecond waveform with a peak of 1000 V and a peak current of 500 A.
- b. Fuses must not be used for surge protection.

L. UL PGWM - Local Operator Consoles (LOCs) <Insert drawing designation>:

- 1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
- 2. Source Limitations: Obtain products from single manufacturer.
- 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Control and Communication Equipment: UL CCN PGWM, including UL 2572.
- 4. Standard Features:
 - a. Description: Remote message initiation console.
 - b. Capable of initiating recorded messages and displays, and for delivering live voice messages.
 - c. Capacity for no fewer than [eight] <Insert number> prerecorded messages and ability to automatically repeat prerecorded messages.
 - d. Having a microphone for delivering live messages.
 - e. FACU Interface: Adequate discrete outputs to temporarily deactivate the fire-alarm audible notification appliances while delivering voice messages.
 - f. LOC must be capable of being locked out or overridden from ACU.
- 5. Other Available Features Required by the Project:
 - a. Provide redundant control of ACU.
 - b. When an installation has more than one LOC, LOCs must be programmed to allow only one LOC at a time to be available for messaging. Once one LOC becomes active, all other LOCs will have an indication that the system is busy (Amber Busy Light) and cannot be used at that time.

M. UL PGWM - Software <Insert drawing designation>:

- 1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
- 2. Source Limitations: Obtain products from single manufacturer.
- 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Control and Communication Equipment: UL CCN PGWM, including UL 2572.
- 4. Standard Features:
 - a. Description: PC-based equipment that is field programmable for control, notification, and supervisory functions; menu-driven program configuration; password protected.
 - b. Loading and editing instructions and operating sequences as necessary.
 - c. Storing and downloading while the system is in operation.

- d. Second set of operating software must reside in control units as backup if primary operating software is corrupted.
- e. Allows **[10 to 50]** **<Insert range>** remote users.
- f. Operating system used must be compatible with manufacturer software operating system.
- g. Memory: Software operations must be stored in nonvolatile programmable memory within MNS control unit. Loss of primary and secondary power must not erase nonvolatile programmable memory.

2.5 MAINTENANCE MATERIAL ITEMS

- A. Spare Parts: Furnish to Owner spare parts, for repairing MNS, that are packaged with protective covering for storage on-site and identified with labels describing contents. **[Include the following:]**
 - 1. Loudspeakers: Quantity equal to **[five]** **<Insert number>** percent of quantity installed **[for each type indicated]**, but no fewer than **[one]** **<Insert number>** unit(s).
 - 2. Fuses: **[Two]** **<Insert number>** of each type installed in the system. Provide in a box or cabinet with compartments marked with fuse types and sizes.
- B. Special Tools: Furnish to Owner proprietary equipment, keys, and software required to operate, maintain, repair, adjust, or implement future changes to MNS, that are packaged with protective covering for storage on-site and identified with labels describing contents. **[Include the following:]**
 - 1. Software, connecting cables, and proprietary equipment necessary for maintenance, testing, reprogramming, and implementing future changes to MNS. Tools listed by part number in operation and maintenance manuals are considered special tools.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:
 - 1. Electrical Construction: ICC IBC, ICC IFB, NFPA 1, NFPA 70, and NECA NEIS 1.
 - 2. Commissioning of Electrical Systems: NECA NEIS 90.
 - 3. Commissioning of Active and Passive Fire Protection Features: NFPA 3 and NFPA 4.
 - 4. Fire-Alarm and Premises Security Work: NFPA 72, NFPA 731, NFPA 1225, and NECA NEIS 305.
 - 5. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
 - 6. Communications Work: BICSI N1.
 - 7. Work in ITE Rooms: NFPA 75.
 - 8. Work in Health Care Facilities: NFPA 99 and Article 517 of NFPA 70.
 - 9. Life Safety and Means of Egress Work: NFPA 101.



10. Emergency and Standby Power Work: NFPA 110, NFPA 111, and NECA NEIS 416.
11. Work in Confined Spaces: NFPA 350.
12. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
13. Work in Museums, Libraries, Places of Worship, and Historic Structures: NFPA 909 and NFPA 914.
14. Consult Architect for resolution of conflicting requirements.

C. Special Installation Techniques:

1. Install remote amplification and control units in terminal cabinets. Power each remote amplification and control unit from a wiring riser specifically for that use or from a local emergency power panel located on the same floor as remote unit.
2. Equipment Installation: Install MNS cabinets with seismic-restraint devices, seismic-rated anchors, and mounting apparatus.
3. Provide rated fire-alarm cables and conductors for MNS.
4. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters[**and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used**]. Conceal raceway and cables except in unfinished spaces.
 - a. Install plenum cable in environmental airspaces, including plenum ceilings and in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring is used.
 - b. Install cables in cable trays where indicated on the Drawings.
 - c. Provide raceways and boxes for cables.
 - d. Conceal conductors and cables in accessible ceilings, walls, and floors where possible. Suspend cable not in a wireway or pathway a minimum of 8 inch (200 mm) above ceiling by cable supports not more than **[60 inch (1500 mm)]** <Insert dimension> apart.
 - e. Do not install cable through structural members or in contact with pipes, ducts, or other potentially damaging items.
 - f. Secure and support cables at intervals not exceeding 30 inch (750 mm) and not more than 6 inch (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
 - g. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's written limitations on bending radii. Maintain separation of conductor types as recommended by manufacturer. Install lacing bars and distribution spools.
 - h. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation, and replace it with new cable.
 - i. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamp use is prohibited.
 - j. Separation of Wires: Separate loudspeaker-microphone, line-level, loudspeaker-level, and power wiring runs. Install MNS wiring in separate raceways or, where exposed or in same enclosure, separate conductors at least 12 inch (300 mm) apart for loudspeaker-microphone wiring and adjacent parallel power and telephone wiring. Separate other intercommunication equipment conductors as recommended by equipment manufacturer.
 - k. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's written limitations on bending radii. Install lacing bars and distribution spools. Route conductors to allow accessibility to equipment for adjustment and maintenance.
 - l. Connections:
 - 1) Make all terminations on numbered terminal strips in terminal cabinets or equipment enclosures. No splices or butt joints will be accepted.
 - 2) Terminate all conductors; no cable must contain unterminated elements.

- 3) Crimp-on spade lugs must be used for terminations of stranded conductors to binder screw or stud terminals. Spade lugs must have upset legs and insulation sleeves sized for conductors.
5. Mount all devices and appliances to or in an approved electrical box.
6. Install operating instruction placard on the interior of ACU.
7. Install operating instruction placard on the frame in location acceptable to Architect and observable from ACU.
8. Weatherproof Equipment: For units that are mounted outdoors, in damp locations, or where exposed to weather, install consistent with requirements of weatherproof rating.
9. Cybersecurity:
 - a. Software:
 - 1) Coordinate security requirements with [IT department] [CIO] <Insert entity responsible for IT security>.
 - 2) Ensure that latest stable software release is installed and properly operating.
 - 3) Disable or change default passwords to password using a combination of uppercase and lower letters, numbers, and symbols no fewer than eight characters in length. Record passwords and turn over to party responsible for system operation and administration.
 - b. Hardware:
 - 1) Coordinate location and access requirements with [IT department] [CIO] <Insert entity responsible for IT security>.
 - 2) Enable highest level of wireless encryption that is compatible with Owner's ICT network.
 - 3) Disable dual network connections.

D. Interfaces with Other Work:

1. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
2. Signal Ground Terminal: Locate at main equipment cabinet. Connect to instrument ground system and isolate from power system and equipment grounding.
3. Identification: Provide labels for mass notification appliances and associated electrical equipment.
 - a. Identify field-installed conductors, interconnecting wiring, and components.
 - b. Label each enclosure with engraved metal or laminated-plastic nameplate.
 - c. Provide warning signs and arc-flash hazard warning labels for electrical equipment.
 - d. Color-code conductors and apply wire and cable marking tape to designate wires and cables so they identify media in coordination with system wiring diagrams.
 - e. Permanently label or mark each conductor at both ends with permanent alphanumeric wire markers.
 - f. Install framed instructions in a location visible from mass notification control unit.

3.3 FIELD QUALITY CONTROL

A. Administrant for Communications Tests and Inspections:

1. [Owner] [Tenant] will engage qualified communications testing and inspecting agency to administer and perform tests and inspections.
2. Engage qualified communications testing and inspecting agency to administer and perform tests and inspections.



3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
 4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].
- B. Administrant for Fire-Alarm Tests and Inspections:
1. **[Owner] [Tenant]** will engage qualified fire-alarm testing and inspecting agency to administer and perform tests and inspections.
 2. Engage qualified fire-alarm testing and inspecting agency to administer and perform tests and inspections.
 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
 4. Administer and perform tests and inspections[**with assistance of factory-authorized service representative**].
- C. Acceptance Testing Preparation:
1. Prepare a written ATP for testing MNS components and installation in accordance with NFPA 72 and this Section. Demonstrate specified function of system and verify the correct operation of all system components, circuits, and programming.
 2. Prepare a complete listing of device labels for alphanumeric annunciator displays prior to ATP.
 3. Schedule tests with no fewer than **[seven] <Insert number>** days' advance notice of test performance.
- D. Field tests must be witnessed by **[Architect] [authorities having jurisdiction] <Insert names or titles of witnesses>**.
- E. Tests and Inspections:
1. Take resistance, current, and voltage readings as work progresses.
 2. Signal Ground Test: Measure and report ground resistance at public address equipment signal ground. Perform additional tests specified in Section 260526 "Grounding and Bonding for Electrical Systems."
 3. Verify that wiring for each device is terminated at properly identified terminals.
 4. Test wiring runs for continuity, short circuits, and grounds before system is energized.
 5. All test equipment, instruments, tools, and labor required to conduct system tests must be made available by installing Contractor. The following equipment must be a minimum for conducting tests:
 - a. Ladders and scaffolds as required to access all installed equipment.
 - b. Multi-meter for reading voltage, current, and resistance.
 - c. Two-way radios and flashlights.
 - d. Decibel meter.
 - e. In addition to testing specified to be performed by installing Contractor, installation must be subject to test by **[Owner] [Architect] [Construction Manager]**.
 6. After installing MNS and after electrical circuitry has been energized, test for compliance with requirements.
 7. Perform tests in **[all] [50 percent of] [25 percent of] <Insert quantity>** zones and rooms[**as indicated on Drawings**].
 8. Perform indoor sound tests in a single test location in rooms less than 20 by 20 ft (6 by 6 m). Tests must be made on a 20 by 20 ft (6 by 6 m) grid for larger rooms.
 9. Sound level measurements must be taken at a worst-case location within each room or grid, not near loudspeakers.

10. Operational Test: Perform tests that include originating messages at microphone outlets, prerecorded messages, **[remote wired and non-wired inputs] [telephone] [cellular]** and other inputs. Verify proper routing and volume levels and that system is free of noise and distortion.
 11. Signal-to-Noise Ratio Test: Measure signal-to-noise ratio of complete system at normal gain settings as follows:
 - a. Disconnect microphone at connector or jack closest to it and replace it in the circuit with a signal generator using a 1000 Hz signal. Measure signal-to-noise ratio.
 - b. Repeat test for each separately controlled zone of loudspeakers.
 - c. Minimum acceptance ratio is 50 dB.
 12. Distortion Test: Measure distortion at normal gain settings and rated power. Feed signals at frequencies of 50, 200, 400, 1000, 3000, 8000, and 12 000 Hz into each preamplifier channel. For each frequency, measure distortion in the paging and all-call amplifier outputs. Maximum acceptable distortion at any frequency is 3 percent total harmonics.
 13. Intelligibility Test: Test for intelligibility in accordance with NFPA 72. See Annex D of NFPA 72 for additional guidance on speech intelligibility testing.
 14. Power Output Test: Measure electrical power output of each power amplifier at normal gain settings of 50, 1000, and 12 000 Hz. Maximum variation in power output at these frequencies must not exceed plus or minus 1 dB. Outdoor sound levels where personnel may be present must not exceed 120 dB(A-weighted) when measured on the A-scale of a standard sound level meter at slow response. Sound levels must not exceed 85 dB(A-weighted) at local microphone of MNS under the same conditions.
 15. System notification appliances must be demonstrated as follows:
 - a. All alarm notification appliances actuate as programmed.
 - b. Audibility and visibility at required levels.
 - c. Messages are intelligible in all areas.
 16. System indications must be demonstrated as follows:
 - a. Correct message display at MNS ACU for each alarm input.
 - b. Correct message display at remote panels and annunciators for each alarm input.
 - c. Correct history logging for all system activity.
 17. System off-site reporting functions must be demonstrated as follows:
 - a. Correct zone transmitted for each alarm input.
 - b. Trouble signals received.
 18. **<Insert additional tests and inspections>.**
- F. Nonconforming Work:
1. MNS will be considered defective if it does not pass tests and inspections.
 2. Remove and replace defective units and retest.
- G. Field Quality Control Reports: Collect, assemble, and submit test and inspection reports.
- H. Manufacturer Services: Engage factory-authorized service representative to **[support] [supervise]** field tests and inspections.
1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.



3.4 CLOSEOUT ACTIVITIES

A. Demonstration:

1. **[Engage a factory-authorized service representative to train] [Train]** Owner's maintenance personnel to adjust, operate, and maintain units.
 - a. Train a minimum of **[four] <Insert number>** employees of Owner.
 - b. Conduct training on installed equipment after acceptance testing.
 - c. Train on system operation, including manual control of output functions from ACU.
 - d. Train on testing of system, including logging of system tests, field test of devices, and response to common troubles.
 - e. Total training requirement must be a minimum of **[four] <Insert number>** hours but must be sufficient to cover all items specified.

3.5 MAINTENANCE

A. Software and Firmware Service Agreement:

1. Technical Support: Beginning at Substantial Completion, verify that software and firmware service agreement includes software and firmware support for **[two years] <Insert duration>**.
2. Upgrade Service: At Substantial Completion, update software and firmware to latest version. Install and program software and firmware upgrades that become available within **[two years] <Insert duration>** from date of Substantial Completion. **[Verify that upgrading software includes operating system and new or revised licenses for using software.]**
 - a. Upgrade Notice: Not less than **[30 days] <Insert duration>**; to allow Owner to schedule and access the system **[and to upgrade computer equipment if necessary.]**
3. Field Reports for Software and Firmware Upgrades: Prepare and submit report after each update, documenting upgrades installed.

END OF SECTION 28 47 00 00



Task	Specification	Specification Description
28 47 00 00	28 40 00 00	Emergency Responder Communications Enhancement System ERCES
28 47 15 00	28 47 00 00	Mass Notification
28 47 15 00	28 40 00 00	Emergency Responder Communications Enhancement System ERCES
28 47 17 00	28 47 00 00	Mass Notification
28 47 17 00	28 40 00 00	Emergency Responder Communications Enhancement System ERCES
28 47 17 17	28 47 00 00	Mass Notification
28 47 17 17	28 40 00 00	Emergency Responder Communications Enhancement System ERCES
28 47 21 00	28 47 00 00	Mass Notification
28 47 21 00	28 40 00 00	Emergency Responder Communications Enhancement System ERCES
28 47 21 21	28 47 00 00	Mass Notification
28 47 21 21	28 40 00 00	Emergency Responder Communications Enhancement System ERCES
28 49 00 00	28 40 00 00	Emergency Responder Communications Enhancement System ERCES
28 49 11 00	28 31 00 00	Intrusion Detection
28 49 11 00	28 16 11 00	Area and Perimeter Intrusion Detection
28 49 11 00	28 40 00 00	Emergency Responder Communications Enhancement System ERCES
28 49 17 00	28 40 00 00	Emergency Responder Communications Enhancement System ERCES



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Task	Specification	Specification Description
31 05 13 00	31 20 00 00	Earth Moving
31 05 13 00	33 46 00 00	Subdrainage
31 05 16 00	31 20 00 00	Earth Moving
31 05 16 00	33 46 00 00	Subdrainage



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SECTION 31 10 00 00 - SITE CLEARING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Protecting existing vegetation to remain.
2. Removing existing vegetation.
3. Clearing and grubbing.
4. Stripping and stockpiling topsoil.
5. Stripping and stockpiling rock.
6. Removing above- and below-grade site improvements.
7. Disconnecting, capping or sealing, and **[removing site utilities][abandoning site utilities in place]**.
8. Temporary erosion and sedimentation control.

B. Related Requirements:

1. Section 015000 "Temporary Facilities and Controls" for temporary erosion- and sedimentation-control measures.

1.2 DEFINITIONS

- A. Subsoil: Soil beneath the level of subgrade; soil beneath the topsoil layers of a naturally occurring soil profile, typified by less than 1 percent organic matter and few soil organisms.
- B. Surface Soil: Soil that is present at the top layer of the existing soil profile. In undisturbed areas, surface soil is typically called "topsoil," but in disturbed areas such as urban environments, the surface soil can be subsoil.
- C. Topsoil: Top layer of the soil profile consisting of existing native surface topsoil or existing in-place surface soil; the zone where plant roots grow.
- D. Topsoil: Top layer of the soil profile consisting of existing native surface topsoil or existing in-place surface soil; the zone where plant roots grow. Its appearance is generally friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects larger than **2 inches (50 mm)** in diameter; and free of weeds, roots, toxic materials, or other nonsoil materials.
- E. Plant-Protection Zone: Area surrounding individual trees, groups of trees, shrubs, or other vegetation to be protected during construction and indicated on Drawings.
- F. Tree-Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction and **[indicated on Drawings][indicated according to requirements in Section 015639 "Temporary Tree and Plant Protection."]<Insert requirement>**.
- G. Vegetation: Trees, shrubs, groundcovers, grass, and other plants.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at **[Project site]**<Insert location>.

1.4 MATERIAL OWNERSHIP

- A. Except for materials indicated to be stockpiled or otherwise remain Owner's property, cleared materials shall become Contractor's property and shall be removed from Project site.

1.5 INFORMATIONAL SUBMITTALS

- A. Existing Conditions: Documentation of existing trees and plantings, adjoining construction, and site improvements that establishes preconstruction conditions that might be misconstrued as damage caused by site clearing.
 - 1. Use sufficiently detailed photographs or video recordings.
 - 2. Include plans and notations to indicate specific wounds and damage conditions of each tree or other plant designated to remain.
- B. Topsoil stripping and stockpiling program.
- C. Rock stockpiling program.
- D. Record Drawings: Identifying and accurately showing locations of capped utilities and other subsurface structural, electrical, and mechanical conditions.
- E. Burning: Documentation of compliance with burning requirements and permitting of authorities having jurisdiction. Identify location(s) and conditions under which burning will be performed.

1.6 QUALITY ASSURANCE

- A. Topsoil Stripping and Stockpiling Program: Prepare a written program to systematically demonstrate the ability of personnel to properly follow procedures and handle materials and equipment during the Work. Include dimensioned diagrams for placement and protection of stockpiles.
- B. Rock Stockpiling Program: Prepare a written program to systematically demonstrate the ability of personnel to properly follow procedures and handle materials and equipment during the Work. Include dimensioned diagrams for placement and protection of stockpiles.

1.7 FIELD CONDITIONS

- A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.
 - 1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
 - 2. Provide alternate routes around closed or obstructed trafficways if required by Owner or authorities having jurisdiction.
- B. Improvements on Adjoining Property: Authority for performing site clearing indicated on property

adjoining Owner's property will be obtained by Owner before award of Contract.

1. Do not proceed with work on adjoining property until directed by Architect.
- C. Salvageable Improvements: Carefully remove items indicated to be salvaged and store on Owner's premises[**where indicated**]<Insert location>.
- D. Utility Locator Service: Notify [**utility locator service**][**Miss Utility**][**Call Before You Dig**][**Dig Safe System**][**One Call**]<Insert name> for area where Project is located before site clearing.
- E. Do not commence site clearing operations until temporary erosion- and sedimentation-control[**and plant-protection**] measures are in place.
- F. Tree- and Plant-Protection Zones: Protect according to requirements in Section 015639 "Temporary Tree and Plant Protection."
- G. Soil Stripping, Handling, and Stockpiling: Perform only when the soil is dry or slightly moist.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Satisfactory Soil Material: Requirements for satisfactory soil material are specified in Section 312000 "Earth Moving."
 1. Obtain approved borrow soil material off-site when satisfactory soil material is not available on-site.
- B. Antirust Coating: Fast-curing, lead- and chromate-free, self-curing, universal modified-alkyd primer complying with [**MPI #23 (surface-tolerant, anticorrosive metal primer)**][or][**SSPC-Paint 20 or SSPC-Paint 29 zinc-rich coating**]<Insert requirement>.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protect and maintain benchmarks and survey control points from disturbance during construction.
- B. Verify that trees, shrubs, and other vegetation to remain or to be relocated have been flagged and that protection zones have been identified and enclosed according to requirements in Section 015639 "Temporary Tree and Plant Protection."
- C. Protect existing site improvements to remain from damage during construction.
 1. Restore damaged improvements to their original condition, as acceptable to Owner.

3.2 TEMPORARY EROSION AND SEDIMENTATION CONTROL

- A. Provide temporary erosion- and sedimentation-control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to erosion-

and sedimentation-control Drawings and requirements of authorities having jurisdiction.

- B. Verify that flows of water redirected from construction areas or generated by construction activity do not enter or cross protection zones.
- C. Inspect, maintain, and repair erosion- and sedimentation-control measures during construction until permanent vegetation has been established.
- D. Remove erosion and sedimentation controls, and restore and stabilize areas disturbed during removal.

3.3 TREE AND PLANT PROTECTION

- A. Protect trees and plants remaining on-site according to requirements in Section 015639 "Temporary Tree and Plant Protection."
- B. Repair or replace trees, shrubs, and other vegetation indicated to remain or be relocated that are damaged by construction operations according to requirements in Section 015639 "Temporary Tree and Plant Protection."

3.4 EXISTING UTILITIES

- A. Owner will arrange for disconnecting and sealing indicated utilities that serve existing structures before site clearing, when requested by Contractor.
 - 1. Verify that utilities have been disconnected and capped before proceeding with site clearing.
- B. Locate, identify, disconnect, and seal or cap utilities indicated to be removed[**or abandoned in place**].
 - 1. Arrange with utility companies to shut off indicated utilities.
 - 2. Owner will arrange to shut off indicated utilities when requested by Contractor.
- C. Locate, identify, and disconnect utilities indicated to be abandoned in place.
- D. Interrupting Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others, unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
 - 1. Notify Architect not less than [**two**]**<Insert number>** days in advance of proposed utility interruptions.
 - 2. Do not proceed with utility interruptions without Architect's written permission.
- E. Excavate for and remove underground utilities indicated to be removed.
- F. Removal of underground utilities is included in earthwork sections; in applicable fire suppression, plumbing, HVAC, electrical, communications, electronic safety and security, and utilities sections; and in Section 024116 "Structure Demolition" and Section 024119 "Selective Demolition."

3.5 CLEARING AND GRUBBING

- A. Remove obstructions, trees, shrubs, and other vegetation to permit installation of new construction.

1. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.
 2. Grind down stumps and remove roots larger than [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> in diameter, obstructions, and debris to a depth of [18 inches (450 mm)]<Insert dimension> below exposed subgrade.
 3. Use only hand methods or air spade for grubbing within protection zones.
 4. Chip removed tree branches and [stockpile in areas approved by Architect][dispose of off-site]<Insert requirement>.
- B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.
1. Place fill material in horizontal layers not exceeding a loose depth of 8 inches (200 mm), and compact each layer to a density equal to adjacent original ground.

3.6 TOPSOIL STRIPPING

- A. Remove sod and grass before stripping topsoil.
- B. Strip topsoil to depth [indicated on Drawings][of 6 inches (150 mm)]<Insert requirement> in a manner to prevent intermingling with underlying subsoil or other waste materials.
1. Remove subsoil and nonsoil materials from topsoil, including clay lumps, gravel, and other objects larger than 2 inches (50 mm) in diameter; trash, debris, weeds, roots, and other waste materials.
- C. Stockpile topsoil away from edge of excavations without intermixing with subsoil or other materials. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust and erosion by water.
1. Limit height of topsoil stockpiles to [72 inches (1800 mm)]<Insert dimension>.
 2. Do not stockpile topsoil within protection zones.
 3. Dispose of surplus topsoil. Surplus topsoil is that which exceeds quantity indicated to be stockpiled or reused.
 4. Stockpile surplus topsoil to allow for respreading deeper topsoil.

3.7 STOCKPILING ROCK

- A. Remove from [area indicated on Drawings][construction area]<Insert requirement> naturally formed rocks that measure more than [1 foot (300 mm)]<Insert dimension> across in least dimension. Do not include excavated or crushed rock.
1. Separate or wash off non-rock materials from rocks, including soil, clay lumps, gravel, and other objects larger than 2 inches (50 mm) in diameter; trash, debris, weeds, roots, and other waste materials.
- B. Stockpile rock [where indicated on Drawings][away from edge of excavations]<Insert requirement> without intermixing with other materials. Cover to prevent windblown debris from accumulating among rocks.
1. Limit height of rock stockpiles to [36 inches (900 mm)]<Insert dimension>.
 2. Do not stockpile rock within protection zones.
 3. Dispose of surplus rock. Surplus rock is that which exceeds quantity indicated to be stockpiled or reused.
 4. Stockpile surplus rock to allow later use by the Owner.

3.8 SITE IMPROVEMENTS

- A. Remove existing above- and below-grade improvements as indicated and necessary to facilitate new construction.
- B. Remove slabs, paving, curbs, gutters, and aggregate base as indicated.
 - 1. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut along line of existing pavement to remain before removing adjacent existing pavement. Saw-cut faces vertically.
 - 2. Paint cut ends of steel reinforcement in concrete to remain with two coats of antirust coating, following coating manufacturer's written instructions. Keep paint off surfaces that will remain exposed.

3.9 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off Owner's property.
- B. Burning tree, shrub, and other vegetation waste is permitted according to burning requirements and permitting of authorities having jurisdiction. Control such burning to produce the least smoke or air pollutants and minimum annoyance to surrounding properties. Burning of other waste and debris is prohibited.
- C. Separate recyclable materials produced during site clearing from other nonrecyclable materials. Store or stockpile without intermixing with other materials, and transport them to recycling facilities. Do not interfere with other Project work.

END OF SECTION 31 10 00 00



Task	Specification	Specification Description
31 11 00 00	31 10 00 00	Site Clearing
31 13 00 00	31 10 00 00	Site Clearing
31 13 13 00	31 10 00 00	Site Clearing
31 13 16 00	31 10 00 00	Site Clearing



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SECTION 31 20 00 00 - EARTH MOVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Soil materials.
2. Geotextiles.
3. Controlled low-strength material.
4. Geofoam.
5. Accessories.

B. Related Requirements:

1. **[Section 013200 "Construction Progress Documentation"]****[Section 013233 "Photographic Documentation"]** for recording preexcavation and earth-moving progress.
2. Section 311000 "Site Clearing" for site stripping, grubbing, stripping [**and stockpiling**] topsoil, and removal of above- and below-grade improvements and utilities.
3. Section 315000 "Excavation Support and Protection" for shoring, bracing, and sheet piling of excavations.
4. Section 316329 "Drilled Concrete Piers and Shafts" for excavation of shafts and disposal of surplus excavated material.
5. Section 329200 "Turf and Grasses" for finish grading in turf and grass areas, including preparing and placing planting soil for turf areas.
6. Section 329300 "Plants" for finish grading in planting areas and tree and shrub pit excavation and planting.

1.2 UNIT PRICES

- A. Work of this Section is affected by unit prices for earth moving specified in Section 012200 "Unit Prices."
- B. Quantity allowances for earth moving are included in Section 012100 "Allowances."
- C. Rock Measurement: Volume of rock actually removed, measured in original position, but not to exceed the following. Unit prices for rock excavation include replacement with approved materials.
1. **[24 inches (600 mm)]<Insert dimension>** outside of concrete forms other than at footings.
 2. **[12 inches (300 mm)]<Insert dimension>** outside of concrete forms at footings.
 3. **[6 inches (150 mm)]<Insert dimension>** outside of minimum required dimensions of concrete cast against grade.
 4. Outside dimensions of concrete walls indicated to be cast against rock without forms or exterior waterproofing treatments.
 5. **[6 inches (150 mm)]<Insert dimension>** beneath bottom of concrete slabs-on-grade.
 6. **[6 inches (150 mm)]<Insert dimension>** beneath pipe in trenches, and the greater of **[24 inches (600 mm)]<Insert dimension>** wider than pipe or **[42 inches (1065 mm)]<Insert dimension>** wide.

1.3 DEFINITIONS

- A. Backfill: Soil material or controlled low-strength material used to fill an excavation.
 - 1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
 - 2. Final Backfill: Backfill placed over initial backfill to fill a trench.
- B. Base Course: Aggregate layer placed between the subbase course and hot-mix asphalt paving.
- C. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe.
- D. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.
- E. Drainage Course: Aggregate layer supporting the slab-on-grade that also minimizes upward capillary flow of pore water.
- F. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.
 - 1. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by Architect. Authorized additional excavation and replacement material will be paid for in accordance with Contract provisions for **[unit prices][changes in the Work]**.
 - 2. Bulk Excavation: Excavation more than **[10 ft. (3 m)]<Insert dimension>** in width and more than **[30 ft. (9 m)]<Insert dimension>** in length.
 - 3. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by Architect. Unauthorized excavation, as well as remedial work directed by Architect, will be without additional compensation.
- G. Fill: Soil materials used to raise existing grades.
- H. Rock:
 - 1. Rock material in beds, ledges, unstratified masses, conglomerate deposits, and boulders of rock material that exceed **[1 cu. yd. (0.76 cu. m)]<Insert volume>** for bulk excavation or **[3/4 cu. yd. (0.57 cu. m)]<Insert volume>** for footing, trench, and pit excavation that cannot be removed by rock-excavating equipment equivalent to the following in size and performance ratings, without systematic drilling, ram hammering, ripping, or blasting, when permitted:
 - a. Equipment for Footing, Trench, and Pit Excavation: Late-model, track-mounted hydraulic excavator; equipped with a **42-inch- (1065-mm-)** maximum-width, short-tip-radius rock bucket; rated at not less than **138-hp (103-kW)** flywheel power with bucket-curling force of not less than **28,700 lbf (128 kN)** and stick-crowd force of not less than **18,400 lbf (82 kN)** with extra-long reach boom.
 - b. Equipment for Bulk Excavation: Late-model, track-mounted loader; rated at not less than **230-hp (172-kW)** flywheel power and developing a minimum of **47,992-lbf (213.3-kN)** breakout force with a general-purpose bare bucket.
 - 2. Rock material in beds, ledges, unstratified masses, conglomerate deposits, and boulders of rock material **[3/4 cu. yd. (0.57 cu. m)]<Insert volume>** or more in volume that exceed a standard penetration resistance of **[100 blows/2 inches (97 blows/50 mm)]<Insert value>** when tested by a geotechnical testing agency, in accordance with ASTM D1586/D1586M.
- I. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and

electrical appurtenances, or other fabricated stationary features constructed above or below the ground surface.

- J. Subbase Course: Aggregate layer placed between the subgrade and base course for hot-mix asphalt pavement, or aggregate layer placed between the subgrade and a cement concrete pavement or a cement concrete or hot-mix asphalt walk.
- K. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials.
- L. Utilities: On-site underground pipes, conduits, ducts, and cables as well as underground services within buildings.

1.4 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct preexcavation conference **[at Project site][by web conference]<Insert location>** .

- 1. Review methods and procedures related to earthmoving, including, but not limited to, the following:
 - a. Personnel and equipment needed to make progress and avoid delays.
 - b. Coordination of Work with utility locator service.
 - c. Coordination of Work and equipment movement with the locations of tree- and plant-protection zones.
 - d. Extent of trenching by hand or with air spade.
 - e. Field quality control.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of specified product.
- B. Samples for Verification: For the following products, in sizes indicated below:
 - 1. Geotextile: **12 by 12 inches (300 by 300 mm)**.
 - 2. Warning Tape: **12 inches (300 mm)** long; of each color.

1.6 INFORMATIONAL SUBMITTALS

- A. Material Test Reports: For each **[on-site][and][borrow]** soil material proposed for fill and backfill as follows:
 - 1. Classification in accordance with ASTM D2487.
 - 2. Laboratory compaction curve in accordance with **[ASTM D698][ASTM D1557]** .
- B. Blasting plan **[approved by authorities having jurisdiction]** .
- C. Seismic survey report from seismic survey agency.
- D. Preexcavation Photographs or Videotape: Show existing conditions of adjoining construction and site improvements, including finish surfaces that might be misconstrued as damage caused by earth-moving operations. Submit before earth moving begins.

- E. Qualification Statements: For qualified testing agency.

1.7 QUALITY ASSURANCE

- A. Blasting: Comply with applicable requirements in NFPA 495, "Explosive Materials Code," and prepare a blasting plan reporting the following:
1. Types of explosive and sizes of charge to be used in each area of rock removal, types of blasting mats, sequence of blasting operations, and procedures that will prevent damage to site improvements and structures on Project site and adjacent properties.
 2. Seismographic monitoring during blasting operations.
- B. Seismic Survey Agency: An independent testing agency, acceptable to authorities having jurisdiction, experienced in seismic surveys and blasting procedures to perform the following services:
1. Report types of explosive and sizes of charge to be used in each area of rock removal, types of blasting mats, sequence of blasting operations, and procedures that will prevent damage to site improvements and structures on Project site and adjacent properties.
 2. Seismographic monitoring during blasting operations.
- C. Geotechnical Testing Agency Qualifications: Qualified in accordance with ASTM E329 and ASTM D3740 for testing indicated.

1.8 FIELD CONDITIONS

- A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during earth-moving operations.
1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
 2. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.
- B. Improvements on Adjoining Property: Authority for performing earth moving indicated on property adjoining Owner's property will be obtained by Owner before award of Contract.
1. Do not proceed with work on adjoining property until directed by Architect.
- C. Utility Locator Service: Notify [utility locator service] ["Miss Utility"] ["Call Before You Dig"] ["Dig Safe System"] ["One Call"] <Insert name> for area where Project is located before beginning earth-moving operations.
- D. Do not commence earth-moving operations until temporary site fencing and erosion- and sedimentation-control measures specified in [Section 015000 "Temporary Facilities and Controls"] [and] [Section 311000 "Site Clearing"] are in place.
- E. Do not commence earth-moving operations until plant-protection measures specified in Section 015639 "Temporary Tree and Plant Protection" are in place.
- F. The following practices are prohibited within protection zones:
1. Storage of construction materials, debris, or excavated material.

2. Parking vehicles or equipment.
 3. Foot traffic.
 4. Erection of sheds or structures.
 5. Impoundment of water.
 6. Excavation or other digging unless otherwise indicated.
 7. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.
- G. Do not direct vehicle or equipment exhaust towards protection zones.
- H. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

- A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.
- B. Satisfactory Soils: Soil Classification [**Groups GW, GP, GM, SW, SP, and SM in accordance with ASTM D2487**][**Groups A-1, A-2-4, A-2-5, and A-3 in accordance with AASHTO M 145**] , or a combination of these groups; free of rock or gravel larger than [**3 inches (75 mm)**]**<Insert dimension>** in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.
1. Liquid Limit: **<Insert value>** .
 2. Plasticity Index: **<Insert value>** .
- C. Unsatisfactory Soils: Soil Classification [**Groups GC, SC, CL, ML, OL, CH, MH, OH, and PT in accordance with ASTM D2487**][**Groups A-2-6, A-2-7, A-4, A-5, A-6, and A-7 in accordance with AASHTO M 145**] , or a combination of these groups.
1. Unsatisfactory soils also include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction.
- D. Subbase Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940/D2940M; with at least 90 percent passing a **1-1/2-inch (37.5-mm)** sieve and not more than 12 percent passing a **No. 200 (0.075-mm)** sieve.
- E. Base Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940/D2940M; with at least 95 percent passing a **1-1/2-inch (37.5-mm)** sieve and not more than 8 percent passing a **No. 200 (0.075-mm)** sieve.
- F. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940/D2940M; with at least 90 percent passing a **1-1/2-inch (37.5-mm)** sieve and not more than 12 percent passing a **No. 200 (0.075-mm)** sieve.
- G. Bedding Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940/D2940M; except with 100 percent passing a **1-inch (25-mm)** sieve and not more than 8 percent passing a **No. 200 (0.075-mm)** sieve.
- H. Drainage Course: Narrowly graded mixture of [**washed**] crushed stone, or crushed or uncrushed gravel; ASTM D448; coarse-aggregate grading Size 57; with 100 percent passing a **1-1/2-inch (37.5-mm)** sieve and zero to 5 percent passing a **No. 8 (2.36-mm)** sieve.

- I. Filter Material: Narrowly graded mixture of natural or crushed gravel, or crushed stone and natural sand; ASTM D448; coarse-aggregate grading Size 67; with 100 percent passing a 1-inch (25-mm) sieve and zero to 5 percent passing a No. 4 (4.75-mm) sieve.
- J. Sand: ASTM C33/C33M; fine aggregate.
- K. Impervious Fill: Clayey gravel and sand mixture capable of compacting to a dense state.

2.2 GEOTEXTILES

- A. Subsurface Drainage Geotextile: Nonwoven needle-punched geotextile, manufactured for subsurface drainage applications, made from polyolefins or polyesters; with elongation greater than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:
 - 1. Survivability:
 - a. Class 2; AASHTO M 288.
 - b. As follows:
 - 1) Grab Tensile Strength: **157 lbf (700 N)**; ASTM D4632/D4632M.
 - 2) Sewn Seam Strength: **142 lbf (630 N)**; ASTM D4632/D4632M.
 - 3) Tear Strength: **56 lbf (250 N)**; ASTM D4533.
 - 4) Puncture Strength: **56 lbf (250 N)**; ASTM D4833/D4833M.
 - c. Apparent Opening Size: **[No. 40 (0.425-mm)][No. 60 (0.250-mm)][No. 70 (0.212-mm)]** sieve, maximum; ASTM D4751.
 - d. Permittivity: **[0.5][0.2][0.1]** per second, minimum; ASTM D4491/D4491M.
 - e. UV Stability: 50 percent after 500 hours' exposure; ASTM D4355.
- B. Separation Geotextile: Woven geotextile fabric, manufactured for separation applications, made from polyolefins or polyesters; with elongation less than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:
 - 1. Survivability:
 - a. Class 2; AASHTO M 288.
 - b. As follows:
 - 1) Grab Tensile Strength: **247 lbf (1100 N)**; ASTM D4632/D4632M.
 - 2) Sewn Seam Strength: **222 lbf (990 N)**; ASTM D4632/D4632M.
 - 3) Tear Strength: **90 lbf (400 N)**; ASTM D4533/D4533M.
 - 4) Puncture Strength: **90 lbf (400 N)**; ASTM D4833/D4833M.
 - c. Apparent Opening Size: **No. 60 (0.250-mm)** sieve, maximum; ASTM D4751.
 - d. Permittivity: 0.02 per second, minimum; ASTM D4491/D4491M.
 - e. UV Stability: 50 percent after 500 hours' exposure; ASTM D4355.

2.3 CONTROLLED LOW-STRENGTH MATERIAL

- A. Controlled Low-Strength Material: Self-compacting [, **cellular, low-density**] , flowable concrete material produced from the following:

1. Portland Cement: ASTM C150/C150M, [Type I][Type II][or][Type III] .
2. Fly Ash: ASTM C618, Class C or F.
3. Normal-Weight Aggregate: ASTM C33/C33M, [3/4-inch (19-mm)][3/8-inch (10-mm)]<Insert dimension> nominal maximum aggregate size.
4. Foaming Agent: ASTM C869/C869M.
5. Water: ASTM C94/C94M.
6. Air-Entraining Admixture: ASTM C260/C260M.

B. Produce cellular, low-density, controlled low-strength material with the following physical properties:

1. As-Cast Unit Weight: [30 to 36 lb/cu. ft. (480 to 576 kg/cu. m)][36 to 42 lb/cu. ft. (576 to 675 kg/cu. m)]<Insert unit weight range> at point of placement, when tested in accordance with ASTM C138/C138M.
2. Compressive Strength: [80 psi (550 kPa)][140 psi (965 kPa)]<Insert value> , when tested in accordance with ASTM C495/C495M.

C. Produce conventional-weight, controlled low-strength material with [80-psi (550-kPa)][140-psi (965-kPa)]<Insert value> compressive strength when tested in accordance with ASTM C495/C495M.

2.4 GEOFOAM

- A. Extruded-Polystyrene Board Insulation: ASTM C578, [Type IV, 1.55-lb/cu. ft. (25-kg/cu. m) density, 25-psi (173-kPa) compressive strength][Type X, 1.30-lb/cu. ft. (21-kg/cu. m) density, 15-psi (104-kPa) compressive strength][Type VI, 1.80-lb/cu. ft. (29-kg/cu. m) density, 40-psi (276-kPa) compressive strength][Type VII, 2.20-lb/cu. ft. (35-kg/cu. m) density, 60-psi (414-kPa) compressive strength][Type V, 3.00-lb/cu. ft. (48-kg/cu. m) density, 100-psi (690-kPa) compressive strength] .
- B. Molded-Polystyrene Board Insulation: ASTM C578, [Type I, 0.90-lb/cu. ft. (15-kg/cu. m) density, 10-psi (69-kPa) compressive strength][Type VIII, 1.15-lb/cu. ft. (18-kg/cu. m) density, 13-psi (90-kPa) compressive strength][Type II, 1.35-lb/cu. ft. (22-kg/cu. m) density, 15-psi (104-kPa) compressive strength] .
 1. Manufacture molded polystyrene with an inorganic mineral registered with the EPA and suitable for application as a termite deterrent.
- C. Rigid Cellular Polystyrene Geofoam: ASTM D6817/D6817M, [Type EPS 19, 1.15-lb/cu. ft. (18.4-kg/cu. m) density, 5.8-psi (40-kPa) compressive strength at 1 percent deformation; 16-psi (110-kPa) compressive strength at 10 percent deformation][Type EPS 39, 2.40-lb/cu. ft. (38.4-kg/cu. m) density, 15-psi (103-kPa) compressive strength at 1 percent deformation; 40-psi (276-kPa) compressive strength at 10 percent deformation]<Insert requirement> .
- D. Connectors: [Geofoam manufacturer's multibarbed, galvanized-steel sheet connectors][Deformed steel reinforcing bars, 3/4 inch (19 mm) in diameter]<Insert requirement> .

2.5 ACCESSORIES

- A. Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, 6 inches (150 mm) wide and 4 mils (0.1 mm) thick, continuously inscribed with a description of the utility; colored as follows:
 1. Red: Electric.
 2. Yellow: Gas, oil, steam, and dangerous materials.
 3. Orange: Telephone and other communications.

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4. Blue: Water systems.
 5. Green: Sewer systems.
- B. Detectable Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, a minimum of **6 inches (150 mm)** wide and **4 mils (0.1 mm)** thick, continuously inscribed with a description of the utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to **30 inches (750 mm)** deep; colored as follows:
1. Red: Electric.
 2. Yellow: Gas, oil, steam, and dangerous materials.
 3. Orange: Telephone and other communications.
 4. Blue: Water systems.
 5. Green: Sewer systems.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earth-moving operations.
- B. Protect and maintain erosion and sedimentation controls during earth-moving operations.
- C. Protect subgrades and foundation soils from freezing temperatures and frost. Remove temporary protection before placing subsequent materials.

3.2 DEWATERING

- A. Provide dewatering system of sufficient scope, size, and capacity to control hydrostatic pressures and to lower, control, remove, and dispose of ground water and permit excavation and construction to proceed on dry, stable subgrades.
- B. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.
- C. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.
 1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.
- D. Dispose of water removed by dewatering in a manner that avoids endangering public health, property, and portions of work under construction or completed. Dispose of water and sediment in a manner that avoids inconvenience to others.

3.3 EXPLOSIVES

- A. Explosives:

1. Do not use explosives.
2. Obtain written permission from authorities having jurisdiction before bringing explosives to Project site or using explosives on Project site.
 - a. Perform blasting without damaging adjacent structures, property, or site improvements.
 - b. Perform blasting without weakening the bearing capacity of rock subgrade and with the least-practicable disturbance to rock to remain.

3.4 EXCAVATION, GENERAL

- A. Unclassified Excavation: Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil materials, and obstructions. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation or removal of obstructions.
1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.
 2. Remove rock to lines and grades indicated to permit installation of permanent construction without exceeding the following dimensions:
 - a. **[24 inches (600 mm)]<Insert dimension>** outside of concrete forms other than at footings.
 - b. **[12 inches (300 mm)]<Insert dimension>** outside of concrete forms at footings.
 - c. **[6 inches (150 mm)]<Insert dimension>** outside of minimum required dimensions of concrete cast against grade.
 - d. Outside dimensions of concrete walls indicated to be cast against rock without forms or exterior waterproofing treatments.
 - e. **[6 inches (150 mm)]<Insert dimension>** beneath bottom of concrete slabs-on-grade.
 - f. **[6 inches (150 mm)]<Insert dimension>** beneath pipe in trenches and the greater of **[24 inches (600 mm)]<Insert dimension>** wider than pipe or **[42 inches (1065 mm)]<Insert dimension>** wide.
- B. Classified Excavation: Excavate to subgrade elevations. Material to be excavated will be classified as earth and rock. Do not excavate rock until it has been classified and cross sectioned by Architect. The Contract Sum will be adjusted for rock excavation in accordance with unit prices included in the Contract Documents. Changes in the Contract Time may be authorized for rock excavation.
1. Earth excavation includes excavating pavements and obstructions visible on surface; underground structures, utilities, and other items indicated to be removed; and soil, boulders, and other materials not classified as rock or unauthorized excavation.
 - a. Intermittent drilling; blasting, if permitted; ram hammering; or ripping of material not classified as rock excavation is earth excavation.
 2. Rock excavation includes removal and disposal of rock. Remove rock to lines and subgrade elevations indicated to permit installation of permanent construction without exceeding the following dimensions:
 - a. **[24 inches (600 mm)]<Insert dimension>** outside of concrete forms other than at footings.
 - b. **[12 inches (300 mm)]<Insert dimension>** outside of concrete forms at footings.
 - c. **[6 inches (150 mm)]<Insert dimension>** outside of minimum required dimensions of concrete cast against grade.
 - d. Outside dimensions of concrete walls indicated to be cast against rock without forms or exterior waterproofing treatments.

- e. **[6 inches (150 mm)]<Insert dimension>** beneath bottom of concrete slabs-on-grade.
- f. **[6 inches (150 mm)]<Insert dimension>** beneath pipe in trenches and the greater of **[24 inches (600 mm)]<Insert dimension>** wider than pipe or **[42 inches (1065 mm)]<Insert dimension>** wide.

3.5 EXCAVATION FOR STRUCTURES

- A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus **1 inch (25 mm)**. If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.
 - 1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.
 - 2. Pile Foundations: Stop excavations **6 to 12 inches (150 to 300 mm)** above bottom of pile cap before piles are placed. After piles have been driven, remove loose and displaced material. Excavate to final grade, leaving solid base to receive concrete pile caps.
 - 3. Excavation for Underground Tanks, Basins, and Mechanical or Electrical Utility Structures: Excavate to elevations and dimensions indicated within a tolerance of plus or minus **1 inch (25 mm)**. Do not disturb bottom of excavations intended as bearing surfaces.
- B. Excavations at Edges of Tree- and Plant-Protection Zones:
 - 1. Excavate by hand or with an air spade to indicated lines, cross sections, elevations, and subgrades. If excavating by hand, use narrow-tine spading forks to comb soil and expose roots. Do not break, tear, or chop exposed roots. Do not use mechanical equipment that rips, tears, or pulls roots.
 - 2. Cut and protect roots in accordance with requirements in Section 015639 "Temporary Tree and Plant Protection."

3.6 EXCAVATION FOR WALKS AND PAVEMENTS

- A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

3.7 EXCAVATION FOR UTILITY TRENCHES

- A. Excavate trenches to indicated gradients, lines, depths, and elevations.
 - 1. Beyond building perimeter, excavate trenches to allow installation of top of pipe below frost line.
- B. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to **12 inches (300 mm)** higher than top of pipe or conduit unless otherwise indicated.
 - 1. Clearance: **[12 inches (300 mm) each side of pipe or conduit][As indicated]** .
- C. Trench Bottoms:
 - 1. Excavate and shape trench bottoms to provide uniform bearing and support of pipes and conduit. Shape subgrade to provide continuous support for bells, joints, and barrels of pipes and for joints,

fittings, and bodies of conduits. Remove projecting stones and sharp objects along trench subgrade.

- a. For pipes and conduit less than **6 inches (150 mm)** in nominal diameter, hand-excavate trench bottoms and support pipe and conduit on an undisturbed subgrade.
 - b. For pipes and conduit **6 inches (150 mm)** or larger in nominal diameter, shape bottom of trench to support bottom 90 degrees of pipe or conduit circumference. Fill depressions with tamped sand backfill.
 - c. For flat-bottomed, multiple-duct conduit units, hand-excavate trench bottoms and support conduit on an undisturbed subgrade.
 - d. Excavate trenches **6 inches (150 mm)** deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.
2. Excavate trenches **4 inches (100 mm)** deeper than bottom of pipe and conduit elevations to allow for bedding course. Hand-excavate deeper for bells of pipe.
 - a. Excavate trenches **6 inches (150 mm)** deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.

D. Trenches in Tree- and Plant-Protection Zones:

1. Hand-excavate to indicated lines, cross sections, elevations, and subgrades. Use narrow-tine spading forks to comb soil and expose roots. Do not break, tear, or chop exposed roots. Do not use mechanical equipment that rips, tears, or pulls roots.
2. Do not cut main lateral roots or taproots; cut only smaller roots that interfere with installation of utilities.
3. Cut and protect roots in accordance with requirements in Section 015639 "Temporary Tree and Plant Protection."

3.8 EXCAVATION FOR ELEVATOR CYLINDER

- A. Drill well hole plumb in elevator pit to accommodate installation of elevator-cylinder assembly. Coordinate with applicable requirements for diameter and tolerances in [**Section 142400 "Hydraulic Elevators."**][**Section 142413 "Hydraulic Freight Elevators."**]
- B. Provide well casing as necessary to retain walls of well hole.

3.9 SUBGRADE INSPECTION

- A. Notify Architect when excavations have reached required subgrade.
- B. If Architect determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.
- C. Proof-roll subgrade [**below the building slabs and pavements**][**Insert locations**] with a pneumatic-tired [**and loaded 10-wheel, tandem-axle dump truck weighing not less than 15 tons (13.6 tonnes)**][**Insert requirement**] to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.
 1. Completely proof-roll subgrade in one direction [, **repeating proof-rolling in direction perpendicular to first direction**] . Limit vehicle speed to **3 mph (5 km/h)**.
 2. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Architect, and replace with compacted backfill or fill as directed.

- D. Authorized additional excavation and replacement material will be paid for in accordance with Contract provisions for **[unit prices][changes in the Work]** .
- E. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Architect, without additional compensation.

3.10 UNAUTHORIZED EXCAVATION

- A. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. Lean concrete fill, with 28-day compressive strength of **2500 psi (17.2 MPa)**, may be used when approved by Architect.
 - 1. Fill unauthorized excavations under other construction, pipe, or conduit as directed by Architect.

3.11 STORAGE OF SOIL MATERIALS

- A. Stockpile borrow soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.
 - 1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

3.12 BACKFILL

- A. Place and compact backfill in excavations promptly, but not before completing the following:
 - 1. Construction below finish grade including, where applicable, subdrainage, dampproofing, waterproofing, and perimeter insulation.
 - 2. Surveying locations of underground utilities for Record Documents.
 - 3. Testing and inspecting underground utilities.
 - 4. Removing concrete formwork.
 - 5. Removing trash and debris.
 - 6. Removing temporary shoring, bracing, and sheeting.
 - 7. Installing permanent or temporary horizontal bracing on horizontally supported walls.
- B. Place backfill on subgrades free of mud, frost, snow, or ice.

3.13 UTILITY TRENCH BACKFILL

- A. Place backfill on subgrades free of mud, frost, snow, or ice.
- B. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.
- C. Trenches under Footings: Backfill trenches excavated under footings and within **[18 inches (450 mm)]<Insert dimension>** of bottom of footings with satisfactory soil; fill with concrete to elevation of bottom of footings. Concrete is specified in Section 033000 "Cast-in-Place Concrete."
- D. Trenches under Roadways: Provide **[4-inch- (100-mm-)]<Insert dimension>** thick, concrete-base slab

support for piping or conduit less than **[30 inches (750 mm)]<Insert dimension>** below surface of roadways. After installing and testing, completely encase piping or conduit in a minimum of **[4 inches (100 mm)]<Insert dimension>** of concrete before backfilling or placing roadway subbase course. Concrete is specified in Section 033000 "Cast-in-Place Concrete."

- E. Backfill voids with satisfactory soil while removing shoring and bracing.
- F. Initial Backfill:
 - 1. Soil Backfill: Place and compact initial backfill of **[subbase material][satisfactory soil]** , free of particles larger than **[1 inch (25 mm)]<Insert dimension>** in any dimension, to a height of **12 inches (300 mm)** over the pipe or conduit.
 - a. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.
 - 2. Controlled Low-Strength Material: Place initial backfill of controlled low-strength material to a height of **12 inches (300 mm)** over the pipe or conduit. Coordinate backfilling with utilities testing.
- G. Final Backfill:
 - 1. Soil Backfill: Place and compact final backfill of satisfactory soil to final subgrade elevation.
 - 2. Controlled Low-Strength Material: Place final backfill of controlled low-strength material to final subgrade elevation.
- H. Warning Tape: Install warning tape directly above utilities, **12 inches (300 mm)** below finished grade, except **6 inches (150 mm)** below subgrade under pavements and slabs.

3.14 SOIL FILL

- A. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.
- B. Place and compact fill material in layers to required elevations as follows:
 - 1. Under grass and planted areas, use satisfactory soil material.
 - 2. Under walks and pavements, use satisfactory soil material.
 - 3. Under steps and ramps, use engineered fill.
 - 4. Under building slabs, use engineered fill.
 - 5. Under footings and foundations, use engineered fill.
- C. Place soil fill on subgrades free of mud, frost, snow, or ice.

3.15 GEOFOAM FILL

- A. Place a leveling course of sand, **[2 inches (50 mm)]<Insert dimension>** thick, over subgrade. Finish leveling course to a tolerance of **1/2 inch (13 mm)** when tested with a **10-foot (3-m)** straightedge.
 - 1. Place leveling course on subgrades free of mud, frost, snow, or ice.
- B. Install geofoam blocks in layers with abutting edges and ends and with the long dimension of each block at right angles to blocks in each subsequent layer. Offset joints of blocks in successive layers.

- C. Install geofoam connectors at each layer of geofoam to resist horizontal displacement in accordance with geofoam manufacturer's written instructions.
- D. Cover geofoam with [subdrainage][separation] geotextile before placing overlying soil materials.

3.16 SOIL MOISTURE CONTROL

- A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2 percent of optimum moisture content.
 - 1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.
 - 2. Remove and replace, or scarify and air dry, otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.

3.17 COMPACTION OF SOIL BACKFILLS AND FILLS

- A. Place backfill and fill soil materials in layers not more than [8 inches (200 mm)]<Insert dimension> in loose depth for material compacted by heavy compaction equipment and not more than 4 inches (100 mm) in loose depth for material compacted by hand-operated tampers.
- B. Place backfill and fill soil materials evenly on all sides of structures to required elevations and uniformly along the full length of each structure.
- C. Compact soil materials to not less than the following percentages of maximum dry unit weight in accordance with [ASTM D698][ASTM D1557] :
 - 1. Under structures, building slabs, steps, and pavements, scarify and recompact top 12 inches (300 mm) of existing subgrade and each layer of backfill or fill soil material at [95]<Insert number> percent.
 - 2. Under walkways, scarify and recompact top 6 inches (150 mm) below subgrade and compact each layer of backfill or fill soil material at [92]<Insert number> percent.
 - 3. Under turf or unpaved areas, scarify and recompact top 6 inches (150 mm) below subgrade and compact each layer of backfill or fill soil material at [85]<Insert number> percent.
 - 4. For utility trenches, compact each layer of initial and final backfill soil material at [85]<Insert number> percent.

3.18 GRADING

- A. Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.
 - 1. Provide a smooth transition between adjacent existing grades and new grades.
 - 2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.
- B. Site Rough Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to elevations required to achieve indicated finish elevations, within the following subgrade tolerances:
 - 1. Turf or Unpaved Areas: Plus or minus [1 inch (25 mm)]<Insert dimension> .
 - 2. Walks: Plus or minus [1 inch (25 mm)]<Insert dimension> .
 - 3. Pavements: Plus or minus [1/2 inch (13 mm)]<Insert dimension> .

- C. Grading inside Building Lines: Finish subgrade to a tolerance of [1/2 inch (13 mm)]<Insert dimension> when tested with a 10-foot (3-m) straightedge.

3.19 SUBSURFACE DRAINAGE

- A. Subsurface Drain: Place subsurface drainage geotextile around perimeter of subdrainage trench. Place a 6-inch (150-mm) course of filter material on subsurface drainage geotextile to support subdrainage pipe. Encase subdrainage pipe in a minimum of 12 inches (300 mm) of filter material, placed in compacted layers 6 inches (150 mm) thick, and wrap in subsurface drainage geotextile, overlapping sides and ends at least 6 inches (150 mm).
1. Compact each filter material layer [to 85 percent of maximum dry unit weight in accordance with ASTM D698][with a minimum of two passes of a plate-type vibratory compactor] .
- B. Drainage Backfill: Place and compact filter material over subsurface drain, in width indicated, to within 12 inches (300 mm) of final subgrade, in compacted layers 6 inches (150 mm) thick. Overlay drainage backfill with one layer of subsurface drainage geotextile, overlapping sides and ends at least 6 inches (150 mm).
1. Compact each filter material layer [to 85 percent of maximum dry unit weight in accordance with ASTM D698][with a minimum of two passes of a plate-type vibratory compactor] .
 2. Place and compact impervious fill over drainage backfill in 6-inch- (150-mm-) thick compacted layers to final subgrade.

3.20 SUBBASE AND BASE COURSES UNDER PAVEMENTS AND WALKS

- A. Place subbase course [and base course] on subgrades free of mud, frost, snow, or ice.
- B. On prepared subgrade, place subbase course [and base course] under pavements and walks as follows:
1. Install separation geotextile on prepared subgrade in accordance with manufacturer's written instructions, overlapping sides and ends.
 2. Place base course material over subbase course under hot-mix asphalt pavement.
 3. Shape subbase course [and base course] to required crown elevations and cross-slope grades.
 4. Place subbase course [and base course] 6 inches (150 mm) or less in compacted thickness in a single layer.
 5. Place subbase course [and base course] that exceeds 6 inches (150 mm) in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches (150 mm) thick or less than 3 inches (75 mm) thick.
 6. Compact subbase course [and base course] at optimum moisture content to required grades, lines, cross sections, and thickness to not less than [95]<Insert number> percent of maximum dry unit weight in accordance with [ASTM D698][ASTM D1557] .
- C. Pavement Shoulders: Place shoulders along edges of subbase course [and base course] to prevent lateral movement. Construct shoulders, at least 12 inches (300 mm) wide, of satisfactory soil materials and compact simultaneously with each subbase [and base] layer to not less than [95]<Insert number> percent of maximum dry unit weight in accordance with [ASTM D698][ASTM D1557] .

3.21 DRAINAGE COURSE UNDER CONCRETE SLABS-ON-GRADE

- A. Place drainage course on subgrades free of mud, frost, snow, or ice.

- B. On prepared subgrade, place and compact drainage course under cast-in-place concrete slabs-on-grade as follows:
1. Install subdrainage geotextile on prepared subgrade in accordance with manufacturer's written instructions, overlapping sides and ends.
 2. Place drainage course **6 inches (150 mm)** or less in compacted thickness in a single layer.
 3. Place drainage course that exceeds **6 inches (150 mm)** in compacted thickness in layers of equal thickness, with no compacted layer more than **6 inches (150 mm)** thick or less than **3 inches (75 mm)** thick.
 4. Compact each layer of drainage course to required cross sections and thicknesses to not less than **[95]<Insert number>** percent of maximum dry unit weight in accordance with ASTM D698.

3.22 FIELD QUALITY CONTROL

- A. Special Inspections: Owner will engage a qualified special inspector to perform the following special inspections:
1. Determine prior to placement of fill that site has been prepared in compliance with requirements.
 2. Determine that fill material classification and maximum lift thickness comply with requirements.
 3. Determine, during placement and compaction, that in-place density of compacted fill complies with requirements.
- B. Testing Agency: Owner will engage a qualified geotechnical engineering testing agency to perform tests and inspections.
- C. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earth moving only after test results for previously completed work comply with requirements.
- D. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by Architect.
- E. Compaction Testing: Testing agency will test compaction of soils in place in accordance with ASTM D1556/D1556M, ASTM D2937, and ASTM D6938, as applicable. Tests will be performed at the following locations and frequencies:
1. Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, at least one test for every **[2000 sq. ft. (186 sq. m)]<Insert area>** or less of paved area or building slab but in no case fewer than three tests.
 2. Foundation Wall Backfill: At each compacted backfill layer, at least one test for every **[100 ft. (30 m)]<Insert dimension>** or less of wall length but no fewer than two tests.
 3. Trench Backfill: At each compacted initial and final backfill layer, at least one test for every **[150 ft. (46 m)]<Insert dimension>** or less of trench length but no fewer than two tests.
- F. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.

3.23 PROTECTION

- A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.

- B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.
 - 1. Scarify or remove and replace soil material to depth as directed by Architect; reshape and recompact.
- C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.
 - 1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.24 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Remove surplus satisfactory soil and waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.
- B. Transport surplus satisfactory soil to designated storage areas on Owner's property. Stockpile or spread soil as directed by Architect.
 - 1. Remove waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.

END OF SECTION 31 20 00 00



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Task	Specification	Specification Description
31 22 00 00	31 20 00 00	Earth Moving
31 22 13 00	31 20 00 00	Earth Moving
31 22 16 00	31 20 00 00	Earth Moving
31 22 16 13	31 20 00 00	Earth Moving
31 22 19 00	31 20 00 00	Earth Moving
31 22 19 13	31 20 00 00	Earth Moving
31 23 00 00	31 20 00 00	Earth Moving
31 23 16 00	31 20 00 00	Earth Moving
31 23 16 13	31 20 00 00	Earth Moving
31 23 16 16	31 20 00 00	Earth Moving
31 23 16 16	32 31 13 00	Chain Link Fences And Gates
31 23 16 26	31 20 00 00	Earth Moving
31 23 16 33	31 20 00 00	Earth Moving
31 23 16 36	31 20 00 00	Earth Moving



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SECTION 31 23 19 00 - DEWATERING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Construction dewatering.

B. Related Requirements:

1. Section 013233 "Photographic Documentation" for recording preexisting conditions and dewatering system progress.
2. Section 015723 "Temporary Storm Water Pollution Control" for temporary storm water pollution controls mandated under the EPA's National Pollutant Discharge Elimination System.
3. Section 312000 "Earth Moving" for excavating, backfilling, site grading, and controlling surface-water runoff and ponding.

1.2 ALLOWANCES

A. See Section 012100 "Allowances" for description of allowances affecting items specified in this Section.

1. Dewatering observation wells are part of [dewatering]<Insert description> allowance.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at [Project site]<Insert location>.

1. Verify availability of Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
2. Review condition of site to be dewatered, including coordination with temporary erosion-control measures and temporary controls and protections.
3. Review geotechnical report.
4. Review proposed site clearing and excavations.
5. Review existing utilities and subsurface conditions.
6. Review observation and monitoring of dewatering system.

1.4 ACTION SUBMITTALS

A. Shop Drawings: For dewatering system, prepared by or under the supervision of a qualified professional engineer.

1. Include plans, elevations, sections, and details.
2. Show arrangement, locations, and details of wells and well points; locations of risers, headers, filters, pumps, power units, and discharge lines; and means of discharge, control of sediment, and disposal of water.
3. Include layouts of piezometers and flow-measuring devices for monitoring performance of dewatering system.

4. Include written plan for dewatering operations, including sequence of well and well-point placement coordinated with excavation shoring and bracings and control procedures to be adopted if dewatering problems arise.

- B. Delegated Design Submittals: For dewatering system, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.5 INFORMATIONAL SUBMITTALS

- A. Field Quality-Control Submittals:

1. Field quality-control reports.

- B. Qualification Statements: For **[Installer][and][land surveyor]<Insert entity or specialist>**.

- C. Delegated design engineer qualifications.

- D. Existing Conditions: Using **[photographs][or][video recordings]**, show existing conditions of adjacent construction and site improvements that might be misconstrued as damage caused by dewatering operations. Submit before Work begins.

- E. Record Drawings: Identify locations and depths of capped wells and well points and other abandoned-in-place dewatering equipment.

1.6 QUALITY ASSURANCE

- A. Qualifications:

1. Installer: An experienced installer that has specialized in **[design of dewatering systems and]**dewatering work.
2. Delegated Design Engineer: A professional engineer who is legally qualified to practice in **[state]<Insert jurisdiction>** where Project is located and who is experienced in providing engineering services of the type indicated.
3. Land Surveyor: A professional land surveyor who is legally qualified to practice in **[state]<Insert jurisdiction>** where Project is located.

1.7 FIELD CONDITIONS

- A. Project-Site Information: A geotechnical report has been prepared for this Project and is available for information only. The opinions expressed in this report are those of a geotechnical engineer and represent interpretations of subsoil conditions, tests, and results of analyses conducted by a geotechnical engineer. Owner is not responsible for interpretations or conclusions drawn from this data.

1. Make additional test borings and conduct other exploratory operations necessary for dewatering in accordance with the performance requirements.
2. The geotechnical report is **[included][referenced]** elsewhere in Project Manual.

- B. Survey Work: Engage a qualified land surveyor or professional engineer to survey adjacent existing buildings, structures, and site improvements; establish exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design dewatering system.
- B. Dewatering Performance: Design, furnish, install, test, operate, monitor, and maintain dewatering system of sufficient scope, size, and capacity to control hydrostatic pressures and to lower, control, remove, and dispose of groundwater and permit excavation and construction to proceed on dry, stable subgrades.
 - 1. Design dewatering system, including comprehensive engineering analysis by a qualified professional engineer.
 - 2. Continuously monitor and maintain dewatering operations to ensure erosion control, stability of excavations and constructed slopes, prevention of flooding in excavation, and prevention of damage to subgrades and permanent structures.
 - 3. Prevent surface water from entering excavations by grading, dikes, or other means.
 - 4. Accomplish dewatering without damaging existing buildings, structures, and site improvements adjacent to excavation.
 - 5. Remove dewatering system when no longer required for construction.
- C. Regulatory Requirements: Comply with governing EPA notification regulations before beginning dewatering. Comply with water- and debris-disposal regulations of authorities having jurisdiction.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by dewatering operations.
 - 1. Prevent surface water and subsurface or groundwater from entering excavations, from ponding on prepared subgrades, and from flooding site or surrounding area.
 - 2. Protect subgrades and foundation soils from softening and damage by rain or water accumulation.
- B. Install dewatering system to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.
 - 1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.
- C. Provide temporary grading to facilitate dewatering and control of surface water.
- D. Protect and maintain temporary erosion and sedimentation controls, which are specified in [Section 015000 "Temporary Facilities and Controls,"][Section 015723 "Temporary Storm Water Pollution Control"] [Section 311000 "Site Clearing,"] during dewatering operations.

3.2 INSTALLATION

- A. Install dewatering system utilizing wells, well points, or similar methods complete with pump equipment, standby power and pumps, filter material gradation, valves, appurtenances, water disposal, and surface-water controls.
 - 1. Space well points or wells at intervals required to provide sufficient dewatering.
 - 2. Use filters or other means to prevent pumping of fine sands or silts from the subsurface.
- B. Place dewatering system into operation to lower water to specified levels before excavating below groundwater level.
- C. Provide sumps, sedimentation tanks, and other flow-control devices as required by authorities having jurisdiction.
- D. Provide standby equipment on-site, installed and available for immediate operation, to maintain dewatering on continuous basis if any part of system becomes inadequate or fails.

3.3 OPERATION

- A. Operate system continuously until drains, sewers, and structures have been constructed and fill materials have been placed or until dewatering is no longer required.
- B. Operate system to lower and control groundwater to permit excavation, construction of structures, and placement of fill materials on dry subgrades. Drain water-bearing strata above and below bottom of foundations, drains, sewers, and other excavations.
 - 1. Do not permit open-sump pumping that leads to loss of fines, soil piping, subgrade softening, and slope instability.
 - 2. Reduce hydrostatic head in water-bearing strata below subgrade elevations of foundations, drains, sewers, and other excavations.
 - 3. Maintain piezometric water level a minimum of **[24 inches (600 mm)][60 inches (1500 mm)]<Insert dimension>** below bottom of excavation.
- C. Dispose of water removed by dewatering in a manner that avoids endangering public health, property, and portions of work under construction or completed. Dispose of water and sediment in a manner that avoids inconvenience to others.
- D. Remove dewatering system from Project site on completion of dewatering. Plug or fill well holes with sand or cut off and cap wells a minimum of **36 inches (900 mm)** below overlying construction.

3.4 FIELD QUALITY CONTROL

- A. Observation Wells: Provide observation wells or piezometers, take measurements, and maintain at least the minimum number indicated; additional observation wells may be required by authorities having jurisdiction.
 - 1. Observe and record daily elevation of groundwater and piezometric water levels in observation wells.
 - 2. Repair or replace, within 24 hours, observation wells that become inactive, damaged, or destroyed. In areas where observation wells are not functioning properly, suspend construction activities until reliable observations can be made. Add or remove water from observation-well

- risers to demonstrate that observation wells are functioning properly.
3. Fill observation wells, remove piezometers, and fill holes when dewatering is completed.
 - B. Survey-Work Benchmarks: Resurvey benchmarks **[regularly][monthly]<Insert time period>** during dewatering and maintain an accurate log of surveyed elevations for comparison with original elevations. Promptly notify Architect if changes in elevations occur or if cracks, sags, or other damage is evident in adjacent construction.
 - C. Provide continual observation to ensure that subsurface soils are not being removed by the dewatering operation.
 - D. Prepare reports of observations.

3.5 PROTECTION

- A. Protect and maintain dewatering system during dewatering operations.
- B. Promptly repair damages to adjacent facilities caused by dewatering.

END OF SECTION 31 23 19 00



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Task	Specification	Specification Description
31 23 19 00	31 20 00 00	Earth Moving
31 23 23 00	31 20 00 00	Earth Moving
31 23 23 23	31 20 00 00	Earth Moving
31 23 23 33	31 20 00 00	Earth Moving
31 24 00 00	31 20 00 00	Earth Moving



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SECTION 31 24 13 00 - LEVEE CLOSURE

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing of labor and materials for providing levee closures.

1.2 PRODUCTS - (Not Used)

1.3 EXECUTION

A. If there is deemed, by the Owner, to be considerable risk of flooding involved with removing drainage structures and gates in the existing Levee System, the Contractor shall perform the work of this contract as follows:

1. Only one drainage structure/flap gate will be allowed to be disrupted at one time. All proposed work at each drainage structure shall be completed before proceeding to the next structure.
2. The Contractor shall have all materials required for each structure installation secured on site, before beginning construction on that structure.
3. The Contractor shall have all necessary materials on site to temporarily plug existing and/or proposed piping through the levee.
4. Weather and river flow conditions shall be monitored at all times by the Contractor while each drainage structure is open to flow. The Contractor shall construct an adequate closure in a timely fashion to plug the drainage structure preventing flow through the levee.

END OF SECTION 31 24 13 00



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Task	Specification	Specification Description
31 24 13 00	31 20 00 00	Earth Moving
31 25 00 00	31 20 00 00	Earth Moving
31 25 14 00	31 20 00 00	Earth Moving
31 25 14 13	31 20 00 00	Earth Moving
31 25 14 16	31 20 00 00	Earth Moving
31 25 14 23	31 20 00 00	Earth Moving
31 25 14 23	32 14 00 00	Unit Paving
31 25 14 26	31 20 00 00	Earth Moving



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SECTION 31 31 16 00 - TERMITE CONTROL

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Soil treatment.
2. Wood treatment.
3. Bait-station system.
4. Metal mesh barrier system.

B. Related Requirements:

1. Section 061000 "Rough Carpentry" for wood preservative treatment by pressure process.
2. Section 076200 "Sheet Metal Flashing and Trim" for custom-fabricated, metal termite shields.

1.2 PREINSTALLATION MEETINGS

- A. Preinstallation Conference:** Conduct conference at **[Project site]<Insert location>**.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components, and profiles for termite control products.
2. Include the EPA-Registered Label for termiticide products.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Product Certificates: For each type of termite control product.

C. Soil Treatment Application Report: After application of termiticide is completed, submit report for Owner's records and include the following:

1. Date and time of application.
2. Moisture content of soil before application.
3. Termiticide brand name and manufacturer.
4. Quantity of undiluted termiticide used.
5. Dilutions, methods, volumes used, and rates of application.
6. Areas of application.
7. Water source for application.

D. Wood Treatment Application Report: After application of termiticide is completed, submit report for Owner's records and include the following:

1. Date and time of application.
2. Termiticide brand name and manufacturer.
3. Quantity of undiluted termiticide used.
4. Dilutions, methods, volumes used, and rates of application.
5. Areas of application.

E. Bait-Station System Installation Report: After installation of bait-station system is completed, submit report for Owner's records and include the following:

1. Location of areas and sites conducive to termite feeding and activity.
2. Plan drawing showing number and locations of bait stations.
3. Dated report for each monitoring and inspection occurrence, indicating level of termite activity, procedure, and treatment applied before time of Substantial Completion.
4. Termiticide brand name and manufacturer.
5. Quantities of **[termiticide][and][nontoxic termite bait]** used.
6. Schedule of inspections for one year from date of Substantial Completion.

F. Research/Evaluation Reports: For metal mesh barrier system, from **<Insert applicable model code organization>**.

G. Sample Warranties: For special warranties.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: A specialist who is licensed according to regulations of authorities having jurisdiction to apply termite control treatment and products in jurisdiction where Project is located **[and who employs workers trained and approved by manufacturer to install manufacturer's products][and who is accredited by manufacturer]**.

1.6 FIELD CONDITIONS

A. Soil Treatment:

1. Environmental Limitations: To ensure penetration, do not treat soil that is water saturated or frozen. Do not treat soil while precipitation is occurring. Comply with requirements of the EPA-Registered Label and requirements of authorities having jurisdiction.
2. Related Work: Coordinate soil treatment application with excavating, filling, grading, and concreting operations. Treat soil under footings, grade beams, and ground-supported slabs before construction.

1.7 WARRANTY

A. Soil Treatment Special Warranty: Manufacturer's standard form, signed by Applicator and Contractor, certifying that termite control work consisting of applied soil termiticide treatment will prevent infestation of subterranean termites **[, including Formosan termites (Coptotermes formosanus)]<Insert requirement>**. If subterranean termite activity or damage is discovered during warranty period, re-treat soil and repair or replace damage caused by termite infestation.

1. Warranty Period: **[Three][Five]<Insert number>** years from date of Substantial Completion.

B. Wood Treatment Special Warranty: Manufacturer's standard form, signed by Applicator and Contractor,

certifying that termite control work consisting of applied wood termiticide treatment will prevent infestation of subterranean termites[, **including Formosan termites (Coptotermes formosanus)**]<Insert requirement>. If subterranean termite damage is discovered during warranty period, repair or replace damage caused by termite infestation and treat replacement wood.

1. Warranty Period: [12]<Insert number> years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

- A. Obtain termite control products from single source[**from single manufacturer**].

2.2 SOIL TREATMENT

- A. Termiticide: EPA-Registered termiticide acceptable to authorities having jurisdiction, in an aqueous solution formulated to prevent termite infestation.
 1. Manufacturers: Subject to compliance with requirements, [**provide products by the following**][**provide products by one of the following**][**available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following**]:
 - a. **[Bayer Environmental Science]**
 - b. **[Ensystem, Inc]**
 - c. **[Syngenta Crop Protection, LLC]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Bayer Environmental Science]**
 - b. **[Ensystem, Inc]**
 - c. **[Syngenta Crop Protection, LLC]**
 - d. **<Insert manufacturer's name>**
 3. Service Life of Treatment: Soil treatment termiticide that is effective for not less than **[three][five]<Insert number>** years against infestation of subterranean termites.

2.3 WOOD TREATMENT

- A. Borate: EPA-Registered borate termiticide acceptable to authorities having jurisdiction, in an aqueous solution for spray application and a gel solution for pressure injection, formulated to prevent termite infestation in wood.
 1. Manufacturers: Subject to compliance with requirements, [**provide products by the following**][**provide products by one of the following**][**available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following**]:

- a. **[Ensystem, Inc]**
 - b. **[Nisus Corporation]**
 - c. **[NovaGuard Technologies, Inc]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Ensystem, Inc]**
 - b. **[Nisus Corporation]**
 - c. **[NovaGuard Technologies, Inc]**
 - d. **<Insert manufacturer's name>**

2.4 BAIT-STATION SYSTEM

- A. Bait-Station System: EPA-Registered system acceptable to authorities having jurisdiction. Provide bait stations based on the dimensions of building perimeter indicated on Drawings, according to product's EPA-Registered Label and manufacturer's written instructions.
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Ensystem, Inc]**
 - b. **[The Dow Chemical Company]**
 - c. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Ensystem, Inc]**
 - b. **[The Dow Chemical Company]**
 - c. **<Insert manufacturer's name>**

2.5 METAL MESH BARRIER SYSTEM

- A. Stainless-Steel Mesh Barrier System: **0.025-by-0.018-inch (0.64-by-0.45-mm)** mesh of **0.08-inch- (2.0-mm-)** diameter, stainless-steel wire, Type 316.
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Termimesh, LLC]**
 - b. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. [Termimesh, LLC]
- b. <Insert manufacturer's name>

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Applicator present, for compliance with requirements for[**moisture content of soil per termiticide label,**] interfaces with earthwork, slab and foundation work, landscaping, utility installation, and other conditions affecting performance of termite control.
- B. Proceed with application only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. General: Prepare work areas according to the requirements of authorities having jurisdiction and according to manufacturer's written instructions before beginning application and installation of termite control treatment(s). Remove extraneous sources of wood cellulose and other edible materials, such as wood debris, tree stumps and roots, stakes, formwork, and construction waste wood from soil within and around foundations.
- B. Soil Treatment Preparation: Remove foreign matter and impermeable soil materials that could decrease treatment effectiveness on areas to be treated. Loosen, rake, and level soil to be treated, except previously compacted areas under slabs and footings. Termiticides may be applied before placing compacted fill under slabs if recommended in writing by termiticide manufacturer.
 - 1. Fit filling hose connected to water source at the site with a backflow preventer, according to requirements of authorities having jurisdiction.

3.3 APPLYING SOIL TREATMENT

- A. Application: Mix soil treatment termiticide solution to a uniform consistency. Distribute treatment uniformly. Apply treatment at the product's EPA-Registered Label volume and rate for maximum specified concentration of termiticide to the following so that a continuous horizontal and vertical termiticidal barrier or treated zone is established around and under building construction.
 - 1. Slabs-on-Grade and Basement Slabs: Under ground-supported slab construction, including footings, building slabs, and attached slabs as an overall treatment. Treat soil materials before concrete footings and slabs are placed.
 - 2. Foundations: Soil adjacent to and along the entire inside perimeter of foundation walls; along both sides of interior partition walls; around plumbing pipes and electric conduit penetrating the slab; around interior column footers, piers, and chimney bases; and along the entire outside perimeter, from grade to bottom of footing.
 - 3. Crawlspace: Soil under and adjacent to foundations. Treat adjacent areas, including around entrance platform, porches, and equipment bases. Apply overall treatment only where attached concrete platform and porches are on fill or ground.
 - 4. Masonry: Treat voids.
 - 5. Penetrations: At expansion joints, control joints, and areas where slabs and below-grade walls will be penetrated.
- B. Post warning signs in areas of application.

- C. Reapply soil treatment solution to areas disturbed by subsequent excavation, grading, landscaping, or other construction activities following application.

3.4 APPLYING WOOD TREATMENT

- A. Wood Treatment: Apply wood treatment after framing, sheathing, and exterior weather protection is completed but before electrical and mechanical systems are installed.
- B. Application: Mix borate wood treatment solution to a uniform consistency. Apply treatment at the product's EPA-Registered Label volume and rate for the maximum borate concentration allowed for each specific use so that wood framing, sheathing, siding, and structural members subject to infestation receive treatment. **[Apply treatment to the height of 8 feet (244 mm) above grade]<Insert requirement>.**
 - 1. Framing and Sheathing: Apply termiticide solution by spray to bare wood and with complete coverage.
 - 2. Heavy Wood Members: For wood greater than **4 inches (100 mm)** thick, inject termiticide gel solution under pressure into holes of size and spacing required by manufacturer for treatment.
 - 3. Exterior Uncoated Wood Trim and Siding: Apply termiticide solution to bare wood only when forecasted weather conditions indicate no precipitation or fog before application of seal coat. After 48 hours, verify that surface is sufficiently dry for seal coat and apply seal coat of **[paint]<Insert coating>** as specified in **[Section 099113 "Exterior Painting."]<Insert Section title>.**

3.5 INSTALLING BAIT-STATION SYSTEM

- A. Bait-Station System: Install **[during construction to determine areas of termite activity][and][after construction, including landscaping, is completed]**.
- B. Place bait stations according to product's EPA-Registered Label and manufacturer's written instructions, in the following locations:
 - 1. Conducive sites and locations indicated on Drawings.
 - 2. In and around infested trees and stumps.
 - 3. In mulch beds.
 - 4. Where wood directly contacts soil.
 - 5. Areas of high soil moisture.
 - 6. Near irrigation sprinkler heads.
 - 7. Each area where roof drainage system, including downspouts and scuppers, drains to soil.
 - 8. Along driplines of roof overhangs without gutters.
 - 9. Where condensate lines from mechanical equipment drip or drain to soil.
 - 10. At plumbing penetrations through ground-supported slabs.
 - 11. Other sites and locations as determined by licensed Installer.
- C. Spacing: Place bait stations according to manufacturer's written instructions and at a frequency no less than the following:
 - 1. One bait station per **[8 linear feet (2.4 linear meters)][20 linear feet (6.1 linear meters)]<Insert value>.**
 - 2. One cluster of bait stations per **20 linear feet (6.1 linear meters)**, with no fewer than three bait stations per cluster.

3.6 INSTALLING METAL MESH BARRIER SYSTEM

- A. Install metal mesh barrier system to provide a continuous barrier to entry of subterranean termites, according to manufacturer's written instructions.
 - 1. Fit mesh tightly around pipes and other penetrations and terminate at slab and foundation perimeters.
 - 2. Install mesh under the perimeter of concrete slab edges and joints after vapor retarder and reinforcing steel are in place.

3.7 PROTECTION

- A. Avoid disturbance of treated soil after application. Keep off treated areas until completely dry.
- B. Protect termiticide solution dispersed in treated soils and fills from being diluted by exposure to water spillage or weather until ground-supported slabs are installed. Use waterproof barrier according to EPA-Registered Label instructions.

3.8 MAINTENANCE SERVICE

- A. Maintenance Service: Beginning at Substantial Completion, maintenance service shall include [three][six][nine][12] months' full maintenance by [**skilled employees of termite-control-treatment Installer**][**manufacturer's authorized service representative**]. Include [monthly][quarterly][semiannual][annual] maintenance as required for proper performance according to the product's EPA-Registered Label and manufacturer's written instructions. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
- B. Continuing Maintenance Proposal: Provide from termite-control-treatment Installer to Owner, in the form of a standard yearly (or other period) maintenance agreement, starting on date initial maintenance service is concluded. State services, obligations, conditions, and terms for agreement period and for future renewal options.
 - 1. Include [annual]<Insert time period> inspection for termite activity and effectiveness of termite treatment according to manufacturer's written instructions.

END OF SECTION 31 31 16 00



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Task	Specification	Specification Description
31 31 16 13	31 31 16 00	Termite Control



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SECTION 31 32 19 16 - POND AND RESERVOIR LINERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes geomembrane liners[**and floating covers**] for ponds and reservoirs fabricated from the following:
 - 1. Linear low-density polyethylene (LLDPE).
 - 2. High-density polyethylene (HDPE).
 - 3. Polypropylene (PP).
 - 4. Ethylene-propylene-diene monomer (EPDM).
 - 5. Polyvinyl chloride (PVC).
 - 6. Ethylene interpolymers alloy (EIA).
 - 7. Chlorosulfonated polyethylene (CSPE).
- B. Related Requirements:
 - 1. Section 033000 "Cast-in-Place Concrete" for perimeter concrete.
 - 2. Section 221429 "Sump Pumps" for drainage of floating covers.
 - 3. Section 312000 "Earth Moving" for excavating, compacting, and grading the subgrade; for excavating and backfilling the anchor trench; for protecting the earthwork; for removing ground water from subgrade to the extent required by liner manufacturer; for adding requirements for the earth cover; and for the filter fabric and other geotextiles.

1.2 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at **[Project site]<Insert location>**.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, and accessories for geomembrane liners[**and floating covers**].
- B. Shop Drawings: Include panel layout, seams, penetrations, perimeter anchorage, and methods of attachment and sealing to other construction. Differentiate between factory and field seams and joints.
- C. Samples: For each exposed product and for each color specified. Include one **12-inch (300-mm)** seam length for factory-bonded sheets and one **12-inch (300-mm)** seam length for field-bonded sheets.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.
- B. Product Certificates: For each type of geomembrane liner[**and floating cover**].

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- C. Product Test Reports: For each geomembrane sheet, for tests performed by a qualified testing agency.
- D. Source quality-control reports.
- E. Field quality-control reports.
- F. Sample Warranty: For manufacturer's special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For geomembrane liner[**and floating cover**] to include in maintenance manuals.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: **[Fabricator of products][An entity that employs installers and supervisors who are trained and approved by manufacturer]**.

1.7 WARRANTY

- A. Manufacturer's Special Warranty: Manufacturer agrees to repair or replace geomembrane liner[**and floating cover**] that fail(s) in materials or workmanship within specified warranty period.

- 1. Failures include, but are not limited to, the following:
 - a. Leaks in geomembrane liner[**and floating cover**].
 - b. Defects in seams.
 - c. Cracks and holes in floating cover.
- 2. Warranty Period: **[One][Five][10]<Insert number>** year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

- A. Obtain geomembrane liner[**and floating cover**], accessories, and required seaming materials, solvents, and adhesives from single source.

2.2 PERFORMANCE REQUIREMENTS

- A. Provide geomembrane liners[**and floating covers**] that prevent the passage of water[**and gas**].

2.3 LLDPE SHEET MATERIALS

- A. LLDPE Sheet: Formulated from virgin PE, compounded for use in hydraulic structures, and formed into uniform sheets with material properties complying with **[GRI Test Method GM17, non-reinforced,][GRI Test Method GM25, reinforced,]** for thickness indicated.

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Agru America, Inc]**
 - b. **[In Line Plastics, LC]**
 - c. **[Integra Plastics, Inc]**
 - d. **[Layfield Environmental Containment; Layfield Group Limited]**
 - e. **[Poly-Flex, Inc]**
 - f. **[Solmax International Inc.]**
 - g. **[Viaflex]**
 - h. **[Watersaver Company, Inc]**
 - i. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Agru America, Inc]**
 - b. **[In Line Plastics, LC]**
 - c. **[Integra Plastics, Inc]**
 - d. **[Layfield Environmental Containment; Layfield Group Limited]**
 - e. **[Poly-Flex, Inc]**
 - f. **[Solmax International Inc.]**
 - g. **[Viaflex]**
 - h. **[Watersaver Company, Inc]**
 - i. **<Insert manufacturer's name>**
3. Minimum Average Sheet Thickness: **[20 mils (0.50 mm)][30 mils (0.75 mm)][40 mils (1.00 mm)][50 mils (1.25 mm)][60 mils (1.50 mm)][80 mils (2.00 mm)][100 mils (2.50 mm)][120 mils (3.00 mm)]<Insert dimension>** per ASTM D5199.
4. Nominal Sheet Thickness: **[24 mils (0.61 mm)][36 mils (0.91 mm)][45 mils (1.10 mm)]<Insert dimension>** per ASTM D5199.
5. Sheet Texture: One side smooth; other side **[smooth][textured]**.

2.4 HDPE SHEET MATERIALS

- A. HDPE Sheet: Formulated from virgin PE, compounded for use in hydraulic structures, and formed into uniform sheets with material properties complying with GRI Test Method GM13 for thickness indicated.
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Agru America, Inc]**
 - b. **[In Line Plastics, LC]**
 - c. **[Integra Plastics, Inc]**
 - d. **[Layfield Environmental Containment; Layfield Group Limited]**
 - e. **[Plastic Fusion Fabricators, Inc]**
 - f. **[Poly-Flex, Inc]**
 - g. **[Solmax International Inc.]**
 - h. **[Viaflex]**
 - i. **[Yunker Plastics, Inc.]**

- j. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Agru America, Inc]
 - b. [In Line Plastics, LC]
 - c. [Integra Plastics, Inc]
 - d. [Layfield Environmental Containment; Layfield Group Limited]
 - e. [Plastic Fusion Fabricators, Inc]
 - f. [Poly-Flex, Inc]
 - g. [Solmax International Inc.]
 - h. [Viaflex]
 - i. [Yunker Plastics, Inc.]
 - j. <Insert manufacturer's name>
- 3. Minimum Average Sheet Thickness: [30 mils (0.75 mm)][40 mils (1.00 mm)][50 mils (1.25 mm)][60 mils (1.50 mm)][80 mils (2.00 mm)][100 mils (2.50 mm)][120 mils (3.00 mm)]<Insert dimension> per ASTM D5199.
- 4. Sheet Texture: One side smooth; other side [smooth][textured].

2.5 PP SHEET MATERIALS

- A. PP Sheet: Formulated from virgin PP, compounded for use in hydraulic structures, and formed into uniform, flexible [non-reinforced][reinforced] sheets with material properties complying with GRI Test Method GM18 for thickness indicated.
 - 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Carlisle Syntec Systems]
 - b. [Cooley Group]
 - c. [Elevate; Holcim Building Envelope]
 - d. [Environmental Protection, Inc]
 - e. [EVOQUA Water Technologies]
 - f. [Integra Plastics, Inc]
 - g. [Layfield Environmental Containment; Layfield Group Limited]
 - h. [Viaflex]
 - i. [Watersaver Company, Inc]
 - j. <Insert manufacturer's name>
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Carlisle Syntec Systems]
 - b. [Cooley Group]
 - c. [Elevate; Holcim Building Envelope]
 - d. [Environmental Protection, Inc]
 - e. [EVOQUA Water Technologies]
 - f. [Integra Plastics, Inc]

- g. [Layfield Environmental Containment; Layfield Group Limited]
 - h. [Viaflex]
 - i. [Watersaver Company, Inc]
 - j. <Insert manufacturer's name>
- 3. Minimum Average Sheet Thickness: [30 mils (0.75 mm)][40 mils (1.00 mm)][60 mils (1.50 mm)][36 mils (0.91 mm)][45 mils (1.10 mm)]<Insert dimension> per ASTM D5199.
 - 4. Reinforcing Scrim: One-ply polyester fabric totally encapsulated between two sheets.
 - a. Construction: [9 x 9 - 1000 d][10 x 10 - 1000 d]<Insert value(s)>.
 - 5. Sheet Texture: One side smooth; other side [smooth][textured].

2.6 EPDM SHEET MATERIALS

- A. EPDM Sheet: Formulated from EPDM, compounded for use in hydraulic structures and formed into uniform, flexible [non-reinforced][reinforced] sheets with material properties complying with GRI Test Method GM21 for nominal thickness indicated.
 - 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Carlisle Syntec Systems]
 - b. [Elevate; Holcim Building Envelope]
 - c. [Layfield Environmental Containment; Layfield Group Limited]
 - d. [Watersaver Company, Inc]
 - e. [Yunker Plastics, Inc.]
 - f. <Insert manufacturer's name>
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Carlisle Syntec Systems]
 - b. [Elevate; Holcim Building Envelope]
 - c. [Layfield Environmental Containment; Layfield Group Limited]
 - d. [Watersaver Company, Inc]
 - e. [Yunker Plastics, Inc.]
 - f. <Insert manufacturer's name>
 - 3. Minimum Average Sheet Thickness: [45 mils (1.10 mm)][60 mils (1.50 mm)]<Insert dimension> per ASTM D5199.
 - 4. Reinforcing Scrim: One-ply polyester fabric totally encapsulated between two sheets.
 - a. Construction: [9 x 9 - 1000 d][10 x 10 - 1000 d]<Insert value(s)>.

2.7 PVC SHEET MATERIALS

- A. PVC Sheet: Formulated from virgin PVC with plasticizers and other modifiers, compounded for use in hydraulic structures, and formed into uniform, flexible non-reinforced sheets with material properties complying with [ASTM D7176][PGI 1104, "Specification for PVC Geomembranes,"] for nominal thickness indicated.

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Environmental Protection, Inc]**
 - b. **[Solmax International Inc.]**
 - c. **[Watersaver Company, Inc]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Environmental Protection, Inc]**
 - b. **[Solmax International Inc.]**
 - c. **[Watersaver Company, Inc]**
 - d. **<Insert manufacturer's name>**
3. Nominal Thickness: **[10 mils (0.25 mm)][20 mils (0.51 mm)][30 mils (0.76 mm)][40 mils (1.02 mm)][50 mils (1.3 mm)][60 mils (1.5 mm)]**.
4. Sheet Texture: One side smooth; other side **[smooth][matte][faill textured]**.

2.8 EIA SHEET MATERIALS

- A. EIA Sheet: Formulated from EIA for use in hydraulic structures and formed into uniform, flexible reinforced sheets.
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Burke Industries, Inc.]**
 - b. **[Cooley Group]**
 - c. **[EVOQUA Water Technologies]**
 - d. **[Integra Plastics, Inc]**
 - e. **[Seaman Corporation]**
 - f. **[Watersaver Company, Inc]**
 - g. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Burke Industries, Inc.]**
 - b. **[Cooley Group]**
 - c. **[EVOQUA Water Technologies]**
 - d. **[Integra Plastics, Inc]**
 - e. **[Seaman Corporation]**
 - f. **[Watersaver Company, Inc]**
 - g. **<Insert manufacturer's name>**
 3. Reinforcing Scrim: One-ply polyester fabric totally encapsulated between two sheets.

- a. Construction: [6 x 6 - 1000 d][8 x 8 - 500 d][10 x 10 - 1000 d][10 x 11 - 2520 d x 2000 d]<Insert value(s)>.
4. Nominal Thickness: [36-mil- (0.91-mm-)]<Insert dimension> thick sheet per ASTM D1593 or ASTM D751, Optical Method.
5. Tensile Strength: Not less than [400 lbf (1.8 kN)]<Insert value> minimum average per ASTM D751, Procedure A.
6. Tear Strength: Not less than [35 lbf (0.16 kN)]<Insert value> minimum average per ASTM D5884 or ASTM D751, Procedure B.
7. Puncture Resistance: Not less than [150 lbf (0.67 kN)]<Insert value> minimum average per ASTM D4833.
8. Hydrostatic Resistance: Not less than [100-psi (690-kPa)]<Insert value> minimum average resistance per ASTM D751, Procedure A.
9. Dimensional Stability, Reinforced Sheet: Not more than plus or minus 2 percent per ASTM D1204.
10. Low-Temperature Flexibility: Pass, 1/8-inch (3-mm) mandrel, four hours at minus 30 deg F (minus 34 deg C), and per ASTM D2136.
11. UV-Light Resistance: Pass, 4000 hours at 176 deg F (80 deg C), per ASTM G155.
12. Ply Adhesion: Not less than [7 lbf/in. (1.2 kN/m)][10 lbf/in. (1.75 kN/m)]<Insert value> of seam width, or film tearing bond, according to ASTM D413, Machine Method.

2.9 CSPE SHEET MATERIALS

- A. CSPE Sheet: Formulated from CSPE for use in hydraulic structures and formed into uniform, flexible reinforced sheets.
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Burke Industries, Inc.]
 - b. [EVOQUA Water Technologies]
 - c. [Layfield Environmental Containment; Layfield Group Limited]
 - d. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Burke Industries, Inc.]
 - b. [EVOQUA Water Technologies]
 - c. [Layfield Environmental Containment; Layfield Group Limited]
 - d. <Insert manufacturer's name>
 3. Reinforcing Scrim: One-ply polyester fabric totally encapsulated between two sheets.
 - a. Construction: [6 x 6 - 1000 d][8 x 8 - 250 d][10 x 10 - 1000 d]<Insert value(s)>.
 4. Water Absorption: Not more than 2 percent at 70 deg F (21 deg C) and not more than 30 percent at 158 deg F (70 deg C) for 30 days each per ASTM D471, 30-mil- (0.76-mm-) thick sheet.
 5. Nominal Thickness: [45-mil- (1.14-mm-)]<Insert dimension> thick sheet per ASTM D5199 or ASTM D751, Optical Method.
 6. Nominal Thickness over Scrim: [11-mil- (0.28-mm-)]<Insert dimension> thick sheet per ASTM D5199 or ASTM D751, Optical Method.

7. Breaking Strength: Not less than [200 lbf (0.89 kN)]<Insert value> minimum average per ASTM D751, Procedure A.
8. Tear Strength, Initial: Not less than [70 lbf (0.31 kN)]<Insert value> minimum average per ASTM D5884 or ASTM D751, Procedure B.
9. Tear Strength, after Aging: Not less than [35 lbf (0.16 kN)]<Insert value> minimum average per ASTM D5884 or ASTM D751, Procedure B.
10. Puncture Resistance: Not less than [200 lbf (0.89 kN)]<Insert value> minimum average per ASTM D4833.
11. Hydrostatic Resistance: Not less than [250-psi (1725-kPa)]<Insert value> minimum average resistance per ASTM D5514, Procedure A or ASTM D751, Method A, Procedure 1.
12. Dimensional Stability, Reinforced Sheet: Not more than plus or minus 2 percent per ASTM D1204.
13. Low-Temperature Flexibility: Pass, 1/8-inch (3-mm) mandrel, four hours at minus 40 deg F (minus 40 deg C), and per ASTM D2136.
14. UV-Light Resistance: Pass, 4000 hours at 176 deg F (80 deg C), per ASTM G155.
15. Ply Adhesion: Not less than [7 lbf/in. (1.2 kN/m)][10 lbf/in. (1.75 kN/m)]<Insert value> of seam width, or film tearing bond, according to ASTM D413, Machine Method.

2.10 FLOATING COVER ACCESSORIES

- A. Screened Scupper Hoses: Manufacturer's standard.
- B. Flotation Blocks: Closed-cell PE foam blocks approximately 4 by 12 inches (102 by 300 mm), 2.2 lb/cu. ft. (35.2 kg/cu. m).
- C. Access Hatch: Manufacturer's standard, in size indicated.

2.11 MISCELLANEOUS MATERIALS

- A. Adhesives: Provide types of adhesive primers, compounds, solvents, and tapes recommended in writing by geomembrane liner manufacturer for bonding to structures (if required), for sealing of seams in geomembrane liner, and for sealing penetrations through geomembrane liner.
- B. Penetration Assemblies: Provide manufacturer's standard factory-fabricated assemblies for sealing penetrations. Include joint sealant recommended in writing by geomembrane liner manufacturer and compatible with geomembrane liner, containment conditions, and materials.
- C. Battens: Long-length strips of material indicated, size as indicated on Drawings. Fabricate battens with sharp projections removed and edges eased and then predrilled or punched for anchors. Provide anchors, or other type of attachment, of type and spacing recommended in writing by geomembrane liner manufacturer for attaching geomembrane liner system to substrate and as indicated.
 1. Batten Material:
 - a. Liner manufacturer's standard system.
 - b. Aluminum; with stainless steel anchors, complete with gasket and sealant compatible with geomembrane liner, containment conditions, and materials.
 - c. Stainless steel; with stainless steel anchors, complete with gasket and sealant compatible with geomembrane liner, containment conditions, and materials.
 - d. Plastic compatible with geomembrane liner, cast in place or fastened with stainless-steel anchors, designed to continuously seal geomembrane liner to batten.
- D. Sand: ASTM C33/C33M; fine aggregate, natural or manufactured sand.

2.12 FABRICATION

- A. Fabricate geomembrane liner[**and floating cover**] panels from sheets in sizes as large as possible with factory-sealed seams, consistent with limitations of weight and installation procedures. Minimize field seaming.
- B. Fabricate flotation blocks, wrap in geomembrane sheet, and attach to underside of floating cover according to manufacturer's written instructions.
- C. Fabricate ballast tubes of sand-filled geomembrane sheet and attach to top surface of floating cover according to manufacturer's written instructions.
- D. Install built-in accessories, hatches, access panels, vents, and walkways on geomembrane floating cover.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, with Installer present, for compliance with requirements for soil compaction and grading; for subgrade free from angular rocks, rubble, roots, vegetation, debris, voids, protrusions, and ground water; and for other conditions affecting performance of geomembrane liner.
- B. Examine anchor [**trench excavation**][**concrete perimeter**], where geomembrane liner[**and floating cover**] will be secured, for substrate conditions indicated above and for correct location and configuration.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Provide temporary ballast, until edges are permanently secured, that does not damage geomembrane liner or substrate, to prevent uplift of geomembrane liner in areas with prevailing winds.
- B. Prepare surfaces of construction penetrating through geomembrane liner according to geomembrane liner manufacturer's written instructions.
- C. Remove curing compounds and coatings from concrete surfaces to be sealed to geomembrane liner.

3.3 INSTALLATION

- A. General: Place geomembrane liner over prepared surfaces to ensure minimum handling. Install according to Shop Drawings and in compliance with geomembrane liner manufacturer's written instructions. Begin placing geomembrane liner at Project's upwind direction and proceed downwind. Install geomembrane liner in a relaxed condition, free from stress and with minimum wrinkles, and in full contact with subgrade. Do not bridge over voids or low areas in the subgrade. Fit closely and seal around inlets, outlets, and other projections through geomembrane liner. Permanently secure edges.
- B. Field Seams: Comply with geomembrane liner[**and floating cover**] manufacturer's written instructions. Form seams by lapping edges of panels **2 to 4 inches (50 to 102 mm)**, unless instructions require a larger overlap. Wipe contact surfaces clean and free of dirt, dust, moisture, and other foreign materials.

Use solvent-cleaning methods and grind geomembrane seam surfaces if recommended by geomembrane liner manufacturer. Proceed with seaming at required temperatures for materials and ambient conditions. Continuously bond sheet to sheet to construct single or double seams of width recommended for method of seaming used. Seal or fuse free seam edges. Inspect seams and reseal voids.

1. Adhesive Bonding: Apply bonding cement to both contact surfaces in seam area and press together immediately, or use other seaming methods as instructed by geomembrane liner manufacturer. Roll to press surfaces together, to distribute adhesive to leading edges of panels, and to remove wrinkles and fishmouths. Remove excess adhesive.
2. Thermal Bonding: Use thermal-welding technique recommended by geomembrane liner manufacturer. Apply pressure to smoothly bond surfaces together. Examine for and patch wrinkles and fishmouths.

C. Installation in Anchor Trench: Install geomembrane liner[**and floating cover**] in trench according to manufacturer's written instructions. Backfill and compact to lock liner into trench.

D. Attachment to Concrete: Use manufacturer's standard system to suit Project conditions. Support adhesive and geomembrane on minimum **8-inch- (200-mm-)** wide concrete substrate unless otherwise indicated.

1. Install batten strips over geomembrane liner[**and floating cover**] as indicated on Drawings.
2. Install antichafing strips of geomembrane sheet between geomembrane liner and floating cover according to manufacturer's written instructions.
3. Install floating cover with perimeter fold.

E. Floating Cover Flotation Control: Connect drainage hoses in perimeter fold, sumps, or scuppers to pump or gravity drain system.

F. Liner Repairs: Repair tears, punctures, and other imperfections in geomembrane liner field and seams using patches of geomembrane liner material, liner-to-liner bonding materials, and bonding methods according to geomembrane liner manufacturer's written instructions. Apply bonding solvent or weld to contact surfaces of both patch and geomembrane liner, and press together immediately. Roll to remove wrinkles.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: [**Owner will engage**][**Engage**] a qualified testing agency to perform tests and inspections.

B. Nondestructive Testing: Visually inspect seams and patches. Comply with ASTM D4437 for Air Lance Test, Vacuum Box Testing, or Ultrasonic (High Frequency) Pulse Echo Testing or with GRI Test Method GM6, as applicable to geomembrane liner[**and floating cover**] and seam construction. Record locations of failed seams and patches. Individually number and date occurrences and details of leak and remedial action. Repair leaking seams and patches.

C. Destructive Testing: Comply with GRI Test Method GM19, as applicable to geomembrane liner[**and floating cover**] and seam construction. Record locations of sample locations and failed seams. Individually number and date occurrences and details of leak and remedial action. Repair leaking seams and patches, and test sample locations.

D. Prepare test and inspection reports.

3.5 DISINFECTION

- A. Disinfect the complete installation according to procedures in AWWA C652.

3.6 PROTECTION

- A. Protect installed geomembrane liner[**and floating cover**] according to manufacturer's written instructions. Repair or replace areas of geomembrane liner damaged by scuffing, punctures, traffic, rough subgrade, or other unacceptable conditions.
- B. Before initial filling of pond or placement of earth cover, inspect seams and patched areas to ensure tight, continuously bonded installation. Repair damaged geomembrane liner and seams and reinspect repaired work.

END OF SECTION 31 32 19 16



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SECTION 31 41 13 00 - DRILLED CONCRETE PIERS AND SHAFTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Dry-installed drilled piers.
2. Slurry displacement-installed drilled piers.
3. Dry-installed or slurry displacement-installed drilled piers at Contractor's choice.

1.2 UNIT PRICES

- A. Drilled Piers: Actual net volume of drilled piers in place and approved. Actual length, shaft diameter, and bell diameter if applicable, may vary, to coincide with elevations where satisfactory bearing strata are encountered. These dimensions may also vary with actual bearing value of bearing strata determined by an independent testing and inspecting agency. Adjustments are made on net variation of total quantities, based on design dimensions for shafts and bells.

1. Base bids on indicated number of drilled piers and, for each pier, the design length from top elevation to bottom of shaft, extended through the bell, if applicable, and the diameter of shaft and bell.
2. Unit prices include labor, materials, tools, equipment, and incidentals required for excavation, trimming, shoring, casings, dewatering, reinforcement, concrete fill, testing and inspecting, and other items for complete drilled-pier installation.

- B. Rock Measurement: Volume of rock actually removed, measured in original position, but not to exceed outside dimensions of drilled piers cast against rock. Unit prices for rock excavation include replacement with approved materials.

- C. Trial Drilled Pier: Same unit price as indicated for drilled pier, including backfilling.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at **[Project site]**<Insert location>.

1. Review methods and procedures related to drilled piers including, but not limited to, the following:
 - a. Review geotechnical report.
 - b. Discuss existing utilities and subsurface conditions.
 - c. Review coordination with temporary controls and protections.
 - d. Review measurement and payment of unit prices.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.

- B. Design Mixtures: For each concrete mixture. Submit alternative design mixtures when characteristics of

materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

1. Indicate amounts of mixing water to be withheld for later addition at Project site.

C. Shop Drawings: For concrete reinforcement, detailing fabricating, bending, supporting, and placing.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer [**land surveyor**][**professional engineer**][**and**][**testing agency**].

B. Welding certificates.

C. Material Certificates: From manufacturer, for the following:

1. Cementitious materials.
2. Admixtures.
3. Steel reinforcement and accessories.

D. Material Test Reports: For each material below, by a qualified testing agency:

1. Aggregates: [**Include service record data indicating absence of deleterious expansion of concrete due to alkali aggregate reactivity.**]

E. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Record drawings.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer that has specialized in drilled-pier work.

B. Testing Agency Qualifications: Qualified according to ASTM C1077, ASTM D3740, and ASTM E329 for testing indicated.

C. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. AWS D1.4/D1.4M, "Structural Welding Code - Reinforcing Steel."

1.8 TRIAL DRILLED PIER

A. Trial Drilled Pier: Construct trial drilled pier of diameter and depth and at location indicated or, if not indicated, of same diameter and depth as largest drilled piers, located at least three diameters clear of permanent drilled piers, to demonstrate Installer's construction methods, equipment, standards of workmanship, and tolerances.

1. Install reinforcement, fill with concrete, remove temporary casings, and terminate trial drilled pier **24 inches (600 mm)** below subgrade and leave in place.

2. Install permanent casings, excavate bell, excavate rock socket, and place slurry, as required for permanent drilled piers.
3. If Architect determines that trial drilled pier does not comply with requirements, excavate for and cast another until it is accepted.

1.9 FIELD CONDITIONS

- A. Existing Utilities: Locate existing underground utilities before excavating drilled piers. If utilities are to remain in place, provide protection from damage during drilled-pier operations.
 1. Should uncharted or incorrectly charted piping or other utilities be encountered during excavation, adapt drilling procedure if necessary to prevent damage to utilities. Cooperate with Owner and utility companies in keeping services and facilities in operation without interruption. Repair damaged utilities to satisfaction of utility owner.
- B. Interruption of Existing Utilities: Do not interrupt any utility to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility according to requirements indicated:
 1. Notify **[Architect][Owner]** no fewer than **[two]<Insert number>** days in advance of proposed interruption of utility.
 2. Do not proceed with interruption of utility without **[Architect's][Owner's]** written permission.
- C. Project-Site Information: A geotechnical report has been prepared for this Project and is available for information only. The opinions expressed in this report are those of geotechnical engineer and represent interpretations of subsoil conditions, tests, and results of analyses conducted by geotechnical engineer. Owner is not responsible for interpretations or conclusions drawn from this data.
 1. Make additional test borings and conduct other exploratory operations necessary for drilled piers.
 2. The geotechnical report is **[included][referenced]** elsewhere in the Project Manual.
- D. Survey Work: Engage a qualified land surveyor or professional engineer to perform surveys, layouts, and measurements for drilled piers. Before excavating, lay out each drilled pier to lines and levels required. Record actual measurements of each drilled pier's location, shaft diameter, bottom and top elevations, deviations from specified tolerances, and other specified data.
 1. Record and maintain information pertinent to each drilled pier and indicate on record Drawings. Cooperate with Owner's testing and inspecting agency to provide data for required reports.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Drilled-Pier Standard: Comply with ACI 336.1 except as modified in this Section.

2.2 STEEL REINFORCEMENT

- A. Reinforcing Bars: ASTM A615/A615M, **Grade 60 (Grade 420)**, deformed.
- B. Low-Alloy-Steel Reinforcing Bars: ASTM A706/A706M, deformed.



- C. Galvanized Reinforcing Bars: **[ASTM A615/A615M, Grade 60 (Grade 420)][ASTM A706/A706M]**, deformed bars, ASTM A767/A767M, **[Class I][Class II]** zinc coated after fabrication and bending.
- D. Epoxy-Coated Reinforcing Bars: **[ASTM A615/A615M, Grade 60 (Grade 420)][ASTM A706/A706M]**, deformed bars, **[ASTM A775/A775M][or][ASTM A934/A934M]**, epoxy coated, with less than 2 percent damaged coating in each **12-inch (300-mm)** bar length.
- E. Plain and Deformed Steel Wire: ASTM A1064/A1064M, **[as drawn][galvanized]**.
- F. Epoxy-Coated Wire: ASTM A884/A884M, Class A, Type 1 coated, **[as-drawn, plain][deformed]**-steel wire, with less than 2 percent damaged coating in each **12-inch (300-mm)** wire length.
- G. Joint Dowel Bars: ASTM A615/A615M, **Grade 60 (Grade 420)**, plain. Cut bars true to length with ends square and free of burrs.

2.3 CONCRETE MATERIALS

- A. Cementitious Material: Use the following cementitious materials, of same type, brand, and source, throughout Project:
 - 1. Portland Cement: ASTM C150/C150M, **[Type I][Type II][Type I/II][Type III][Type V].**
Supplement with the following:
 - a. Fly Ash: ASTM C618, **[Class C][Class F]**.
 - b. Ground Granulated Blast-Furnace Slag: ASTM C989, Grade 100 or 120.
 - 2. Blended Hydraulic Cement: ASTM C595/C595M, **[Type IS, portland blast-furnace slag][Type IP, portland-pozzolan][Type I (PM), pozzolan-modified portland][Type I (SM), slag-modified portland]** cement.
- B. Normal-Weight Aggregate: ASTM C33/C33M, graded, **[3/4-inch- (19-mm-)]<Insert dimension>** nominal maximum coarse-aggregate size. Provide aggregate from a single source **[with documented service record data of at least 10 years' satisfactory service in similar applications and service conditions using similar aggregates and cementitious materials]**.
 - 1. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.
- C. Water: ASTM C94/C94M **[and potable]**.
- D. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and that do not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.
 - 1. Water-Reducing Admixture: ASTM C494/C494M, Type A.
 - 2. Water-Reducing and Retarding Admixture: ASTM C494/C494M, Type D.
 - 3. High-Range, Water-Reducing and Retarding Admixture: ASTM C494/C494M, Type G.
 - 4. Plasticizing and Retarding Admixture: ASTM C1017/C1017M, Type II.
 - 5. **<Insert admixture>**.
- E. Sand-Cement Grout: Portland cement, ASTM C150/C150M, Type II; clean natural sand, ASTM C404; and water to result in grout with a minimum 28-day compressive strength of **1000 psi (6.9 MPa)**, of consistency required for application.

2.4 STEEL CASINGS

- A. Steel Pipe Casings: ASTM A283/A283M, Grade C, or ASTM A36/A36M, carbon-steel plate, with joints full-penetration welded according to AWS D1.1/D1.1M.
- B. Corrugated-Steel Pipe Casings: ASTM A929/A929M, steel sheet, zinc coated.
- C. Liners: Comply with ACI 336.1.

2.5 SLURRY

- A. Slurry: [**Pulverized bentonite**][**pulverized attapulgate**][or][**polymers**] mixed with water to form stable colloidal suspension; complying with ACI 336.1 for density, viscosity, sand content, and pH.

2.6 CONCRETE MIXTURES

- A. Prepare design mixtures for each type and strength of concrete, proportioned on the basis of laboratory trial mixture or field test data, or both, according to **ACI 301 (ACI 301M)**.
- B. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement according to **ACI 301 (ACI 301M)** limits as if concrete were exposed to deicing chemicals.
- C. Limit water-soluble, chloride-ion content in hardened concrete to **[0.15][0.30]** percent by weight of cement.
- D. Proportion normal-weight concrete mixture as follows:
 - 1. Compressive Strength (28 Days): **[6000 psi (41.4 MPa)][5000 psi (34.5 MPa)][4500 psi (31 MPa)][4000 psi (27.6 MPa)][3500 psi (24.1 MPa)][3000 psi (20.7 MPa)]<Insert value>**.
 - 2. Maximum Water-Cementitious Materials Ratio: **[0.50][0.45][0.40]<Insert ratio>**.
 - 3. Minimum Slump: Capable of maintaining the following slump until completion of placement:
 - a. **4 inches (100 mm)** for dry, uncased, or permanent-cased drilling method.
 - b. **6 inches (150 mm)** for temporary-casing drilling method.
 - c. **7 inches (175 mm)** for slurry displacement method.
 - 4. Air Content: Do not air entrain concrete.

2.7 REINFORCEMENT FABRICATION

- A. Fabricate steel reinforcement according to CRSI's "Manual of Standard Practice."

2.8 CONCRETE MIXING

- A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C94/C94M, and furnish batch ticket information.
 - 1. When air temperature is between **85 and 90 deg F (30 and 32 deg C)**, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above **90 deg F (32 deg C)**, reduce mixing and delivery time to 60 minutes.

PART 3 - EXECUTION**3.1 PREPARATION**

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, vibration, and other hazards created by drilled-pier operations.

3.2 EXCAVATION

- A. Unclassified Excavation: Excavate to bearing elevations regardless of character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil materials, and obstructions.
 - 1. Obstructions: Unclassified excavation may include removal of unanticipated boulders, concrete, masonry, or other subsurface obstructions. No changes in the Contract Sum or the Contract Time are authorized for removal of obstructions.
 - 2. Obstructions: Unclassified excavated materials may include removal of unanticipated boulders, concrete, masonry, or other subsurface obstructions. Payment for removing obstructions that cannot be removed by conventional augers fitted with soil or rock teeth, drilling buckets, or underreaming tools attached to drilling equipment of size, power, torque, and downthrust necessary for the Work is according to Contract provisions for changes in the Work.
- B. Classified Excavation: Excavation is classified as standard excavation, special excavation, and obstruction removal and includes excavation to bearing elevations as follows:
 - 1. Standard excavation includes excavation accomplished with conventional augers fitted with soil or rock teeth, drilling buckets, or underreaming tools attached to drilling equipment of size, power, torque, and downthrust necessary for the Work.
 - 2. Special excavation includes excavation that requires special equipment or procedures where drilled-pier excavation equipment used in standard excavation, operating at maximum power, torque, and downthrust, cannot advance the shaft.
 - a. Special excavation requires use of special rock augers, core barrels, air tools, blasting, or other methods of hand excavation.
 - b. Earth seams, rock fragments, and voids included in rock excavation area are considered rock for full volume of shaft from initial contact with rock.
 - 3. Obstructions: Payment for removing unanticipated boulders, concrete, masonry, or other subsurface obstructions that cannot be removed by conventional augers fitted with soil or rock teeth, drilling buckets, or underreaming tools attached to drilling equipment of size, power, torque, and downthrust necessary for the Work is according to Contract provisions for changes in the Work.
- C. Prevent surface water from entering excavated shafts. Conduct water to site drainage facilities.
- D. Excavate shafts for drilled piers to indicated elevations. Remove loose material from bottom of excavation.
 - 1. Excavate bottom of drilled piers to level plane within 1:12 tolerance.
 - 2. Remove water from excavated shafts before concreting.
 - 3. Excavate rock sockets of dimensions indicated.
 - 4. Cut series of grooves about perimeter of shaft to height from bottom of shaft, vertical spacing, and dimensions indicated.

- E. Notify and allow testing and inspecting agency to test and inspect bottom of excavation. If unsuitable bearing stratum is encountered, make adjustments to drilled piers as determined by Architect.
 - 1. Do not excavate shafts deeper than elevations indicated unless approved by Architect.
 - 2. Payment for additional authorized excavation is according to Contract provisions for changes in the Work.
- F. End-Bearing Drilled Piers: Probe with auger to a depth below bearing elevation, equal to diameter of the bearing area of drilled pier. Determine whether voids, clay seams, or solution channels exist.
 - 1. Test first three drilled piers and one of every six drilled piers thereafter.
 - 2. Fill auger-probe holes with grout.
- G. End-Bearing Drilled Piers: Probe with auger to a depth of **96 inches (2450 mm)** below bottom elevation of shaft, and visually inspect and classify soil. Verify continuity and thickness of strata.
 - 1. Test first three drilled piers and one of every six drilled piers thereafter.
- H. Excavate shafts for closely spaced drilled piers and for drilled piers occurring in fragile or sand strata only after adjacent drilled piers are filled with concrete and allowed to set.
- I. Slurry Displacement Method: Stabilize excavation with slurry maintained a minimum of **60 inches (1500 mm)** above ground-water level and above unstable soil strata to prevent caving or sloughing of shaft. Maintain slurry properties before concreting.
 - 1. Excavate and complete concreting of drilled pier on same day, or redrill, clean, and test slurry in excavation before concreting.
- J. Temporary Casings: Install watertight steel casings of sufficient length and thickness to prevent water seepage into shaft; to withstand compressive, displacement, and withdrawal stresses; and to maintain stability of shaft walls.
 - 1. Remove temporary casings, maintained in plumb position, during concrete placement and before initial set of concrete[, **or leave temporary casings in place**].
- K. Bells: Excavate bells for drilled piers to shape, base thickness, and slope angle indicated. Excavate bottom of bells to level plane and remove loose material before placing concrete.
 - 1. Shore bells in unstable soil conditions to prevent cave-in during excavation, inspection, and concreting.
- L. Tolerances: Construct drilled piers to remain within ACI 336.1 tolerances.
 - 1. If location or out-of-plumb tolerances are exceeded, provide corrective construction. Submit corrective construction proposals to Architect for review before proceeding.

3.3 PERMANENT STEEL CASING INSTALLATION

- A. Install permanent steel casings of minimum wall thickness indicated and of diameter not less than diameter of drilled pier.
 - 1. Install casings as excavation proceeds, to maintain sidewall stability.
 - 2. Fabricate bottom edge of lowest casing section with cutting shoe capable of penetrating rock and achieving water seal.

3. Connect casing sections by continuous penetration welds to form watertight, continuous casing.
4. Remove and replace or repair casings that have been damaged during installation and that could impair strength or efficiency of drilled pier.
5. Fill annular void between casing and shaft wall with grout.

B. Corrugated-Steel Casings: Provide corrugated-steel casings formed from zinc-coated steel sheet.

1. Corrugated casings may be delivered in sections or panels of convenient length and field connected according to manufacturer's written instructions.

3.4 STEEL REINFORCEMENT INSTALLATION

- A. Comply with recommendations in CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.
- B. Clean reinforcement of loose rust and mill scale, earth, and other materials that reduce or destroy bond with concrete.
- C. Fabricate and install reinforcing cages symmetrically about axis of shafts in a single unit.
- D. Accurately position, support, and secure reinforcement against displacement during concreting. Maintain minimum cover over reinforcement.
- E. Use templates to set anchor bolts, leveling plates, and other accessories furnished in work of other Sections. Provide blocking and holding devices to maintain required position during final concrete placement.
- F. Protect exposed ends of extended reinforcement, dowels, or anchor bolts from mechanical damage and exposure to weather.

3.5 CONCRETE PLACEMENT

- A. Place concrete in continuous operation and without segregation immediately after inspection and approval of shaft by a qualified **[Special Inspector][testing agency]**.
 1. Construct a construction joint if concrete placement is delayed more than one hour. Level top surface of concrete **[and insert joint dowel bars]**. Before placing remainder of concrete, clean surface laitance, roughen, and slush concrete with commercial bonding agent or with sand-cement grout mixed at ratio of 1:1.
- B. Dry Method: Place concrete to fall vertically down the center of drilled pier without striking sides of shaft or steel reinforcement.
 1. Where concrete cannot be directed down shaft without striking reinforcement, place concrete with chutes, tremies, or pumps.
 2. Vibrate top **60 inches (1500 mm)** of concrete.
- C. Slurry Displacement Method: Place concrete in slurry-filled shafts by tremie methods or pumping. Control placement operations to ensure that tremie or pump pipe is embedded no less than **60 inches (1500 mm)** into concrete and that flow of concrete is continuous from bottom to top of drilled pier.
- D. Coordinate withdrawal of temporary casings with concrete placement to maintain at least a **60-inch**

(1500-mm) head of concrete above bottom of casing.

1. Vibrate top **60 inches (1500 mm)** of concrete after withdrawal of temporary casing.
- E. Screed concrete at cutoff elevation level and apply scoured, rough finish. Where cutoff elevation is above the ground elevation, form top section above grade and extend shaft to required elevation.
- F. Protect concrete work, according to **ACI 301 (ACI 301M)**, from frost, freezing, or low temperatures that could cause physical damage or reduced strength.
 1. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.
 2. Do not use calcium chloride, salt, or other mineral-containing antifreeze agents or chemical accelerators.
- G. If hot-weather conditions exist that would seriously impair quality and strength of concrete, place concrete according to **ACI 301 (ACI 301M)** to maintain delivered temperature of concrete at no more than **90 deg F (32 deg C)**.
 1. Place concrete immediately on delivery. Keep exposed concrete surfaces and formed shaft extensions moist by fog sprays, wet burlap, or other effective means for a minimum of seven days.

3.6 FIELD QUALITY CONTROL

- A. Special Inspections: **[Owner will engage][Engage]** a qualified special inspector to perform the following special inspections:
 1. Drilled piers.
 2. Excavation.
 3. Concrete.
 4. Steel reinforcement welding.
 5. **<Insert special inspections>**.
- B. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- C. Drilled-Pier Tests and Inspections: For each drilled pier, before concrete placement.
 1. Soil Testing: Bottom elevations, bearing capacities, and lengths of drilled piers indicated have been estimated from available soil data. Actual elevations and drilled-pier lengths and bearing capacities are determined by testing and inspecting agency. Final evaluations and approval of data are determined by Architect.
 - a. Bearing Stratum Tests: Testing agency takes undisturbed **[hardpan][rock]** core samples from drilled-pier bottoms; tests each sample for compression, moisture content, and density; and reports results and evaluations.
- D. Concrete Tests and Inspections: ASTM C172/C172M except modified for slump to comply with ASTM C94/C94M.
 1. Slump: ASTM C143/C143M; one test at point of placement for each compressive-strength test but no fewer than one test for each concrete load.
 2. Concrete Temperature: ASTM C1064/C1064M; one test hourly when air temperature is **40 deg F (4.4 deg C)** and below and **80 deg F (27 deg C)** and above, and one test for each set of

- compressive-strength specimens.
 3. Compression Test Specimens: ASTM C31/C31M; one set of four standard cylinders for each compressive-strength test unless otherwise indicated. Mold and store cylinders for laboratory-cured test specimens unless field-cured test specimens are required.
 4. Compressive-Strength Tests: ASTM C39/C39M; one set for each drilled pier but not more than one set for each truck load. Test one specimen at seven days, test two specimens at 28 days, and retain one specimen in reserve for later testing if required.
 5. If frequency of testing provides fewer than five strength tests for a given class of concrete, conduct tests from at least five randomly selected batches or from each batch if fewer than five are used.
 6. If strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, Contractor is to evaluate operations and provide corrective procedures for protecting and curing in-place concrete.
 7. Strength of each concrete mixture is satisfactory if every average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than **500 psi (3.4 MPa)**.
 8. Report test results in writing to Architect, concrete manufacturer, and Contractor within 48 hours of testing. List Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests in reports of compressive-strength tests.
 9. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect but not be used as sole basis for approval or rejection of concrete.
 10. Additional Tests: Testing and inspecting agency to make additional tests of concrete if test results indicate that slump, compressive strengths, or other requirements have not been met, as directed by Architect.
 - a. Continuous coring of drilled piers may be required, at Contractor's expense, if temporary casings have not been withdrawn within specified time limits or if observations of placement operations indicate deficient concrete quality, presence of voids, segregation, or other possible defects.
 11. Perform additional testing and inspecting, at Contractor's expense, to determine compliance of replaced or additional work with specified requirements.
 12. Correct deficiencies in the Work that test reports and inspections indicate do not comply with the Contract Documents.
- E. An excavation, concrete, or a drilled pier will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports for each drilled pier as follows:
1. Actual top and bottom elevations.
 2. Actual drilled-pier diameter at top, bottom, and bell.
 3. Top of rock elevation.
 4. Description of soil materials.
 5. Description, location, and dimensions of obstructions.
 6. Final top centerline location and deviations from requirements.
 7. Variation of shaft from plumb.
 8. Shaft excavating method.
 9. Design and tested bearing capacity of bottom.
 10. Depth of rock socket.
 11. Levelness of bottom and adequacy of cleanout.
 12. Properties of slurry and slurry test results at time of slurry placement and at time of concrete

- placement.
13. Ground-water conditions and water-infiltration rate, depth, and pumping.
 14. Description, purpose, length, wall thickness, diameter, tip, and top and bottom elevations of temporary or permanent casings. Include anchorage and sealing methods used and condition and weather tightness of splices if any.
 15. Description of soil or water movement, sidewall stability, loss of ground, and means of control.
 16. Bell dimensions and variations from original design.
 17. Date and time of starting and completing excavation.
 18. Inspection report.
 19. Condition of reinforcing steel and splices.
 20. Position of reinforcing steel.
 21. Concrete placing method, including elevation of consolidation and delays.
 22. Elevation of concrete during removal of casings.
 23. Locations of construction joints.
 24. Concrete volume.
 25. Concrete testing results.
 26. Remarks, unusual conditions encountered, and deviations from requirements.
 27. **<Insert requirement>**.

3.7 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Disposal: Remove surplus satisfactory soil and waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off Owner's property.

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Task	Specification	Specification Description
31 41 16 13	31 41 13 00	Drilled Concrete Piers and Shafts



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SECTION 31 50 00 00 - EXCAVATION SUPPORT AND PROTECTION

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes temporary excavation support and protection systems.
- B. Related Requirements:
 - 1. Section 013233 "Photographic Documentation" for recording preexisting conditions and excavation support and protection system progress.
 - 2. Section 312000 "Earth Moving" for excavating and backfilling, for controlling surface-water runoff and ponding, and for dewatering excavations.

1.2 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at **[Project site]<Insert location>**.
 - 1. Review geotechnical report.
 - 2. Review existing utilities and subsurface conditions.
 - 3. Review coordination for interruption, shutoff, capping, and continuation of utility services.
 - 4. Review proposed excavations.
 - 5. Review proposed equipment.
 - 6. Review monitoring of excavation support and protection system.
 - 7. Review coordination with waterproofing.
 - 8. Review abandonment or removal of excavation support and protection system.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, performance properties, and dimensions of individual components and profiles, and calculations for excavation support and protection system.
- B. Shop Drawings: For excavation support and protection system, prepared by or under the supervision of a qualified professional engineer.
 - 1. Include plans, elevations, sections, and details.
 - 2. Show arrangement, locations, and details of soldier piles, piling, lagging, tiebacks, bracing, and other components of excavation support and protection system according to engineering design.
 - 3. Indicate type and location of waterproofing.
 - 4. Include a written plan for excavation support and protection, including sequence of construction of support and protection coordinated with progress of excavation.
- C. Delegated-Design Submittal: For excavation support and protection systems, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For the following:
 - 1. Land surveyor.
 - 2. Professional Engineer: Experience with providing delegated-design engineering services of the type indicated, including documentation that engineer is licensed in the **[jurisdiction][state]** in which Project is located.
- B. Contractor Calculations: For excavation support and protection system. Include analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
- C. Existing Conditions: Using **[photographs][or][video recordings]**, show existing conditions of adjacent construction and site improvements that might be misconstrued as damage caused by inadequate performance of excavation support and protection systems. Submit before Work begins.

1.5 CLOSEOUT SUBMITTALS

- A. Record Drawings: Identify locations and depths of capped utilities, abandoned-in-place support and protection systems, and other subsurface structural, electrical, or mechanical conditions.

1.6 FIELD CONDITIONS

- A. Interruption of Existing Utilities: Do not interrupt any utility-serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility according to requirements indicated:
 - 1. Notify **[Architect][Construction Manager][Owner]** no fewer than **[two]<Insert number>** days in advance of proposed interruption of utility.
 - 2. Do not proceed with interruption of utility without **[Architect's][Construction Manager's][Owner's]** written permission.
- B. Survey Work: Engage a qualified land surveyor or professional engineer to survey adjacent existing buildings, structures, and site improvements; establish exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks, and record existing elevations.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design excavation support and protection systems to resist all lateral loading and surcharge, including but not limited to, retained soil, groundwater pressure, adjacent building loads, adjacent traffic loads, construction traffic loads, material stockpile loads, and seismic loads, based on the following:
 - 1. Compliance with OSHA Standards and interpretations, 29 CFR 1926, Subpart P.
 - 2. Compliance with AASHTO Standard Specification for Highway Bridges or AASHTO LRFD Bridge Design Specification, Customary U.S. Units.
 - 3. Compliance with requirements of authorities having jurisdiction.

4. Compliance with utility company requirements.
5. Compliance with railroad requirements.

2.2 MATERIALS

- A. Provide materials that are either new or in serviceable condition.
- B. Structural Steel: ASTM A36/A36M, ASTM A690/A690M, or ASTM A992/A992M.
- C. Steel Sheet Piling: ASTM A328/A328M, ASTM A572/A572M, or ASTM A690/A690M; with continuous interlocks.
 1. Corners: **[Site-fabricated mechanical interlock][Roll-formed corner shape with continuous interlock]**.
- D. Wood Lagging: Lumber, mixed hardwood, nominal rough thickness of **[size and strength required for application][3 inches (75 mm)][4 inches (100 mm)]<Insert dimension>**.
- E. Shotcrete: Comply with Section 033713 "Shotcrete" for shotcrete materials and mixes, reinforcement, and shotcrete application.
- F. Cast-in-Place Concrete: ACI 301, of compressive strength required for application.
- G. Reinforcing Bars: ASTM A615/A615M, **Grade 60 (Grade 420)**, deformed.
- H. Tiebacks: Steel bars, ASTM A722/A722M.
- I. Tiebacks: Steel strand, ASTM A416/A416M.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards that could develop during excavation support and protection system operations.
 1. Shore, support, and protect utilities encountered.

3.2 INSTALLATION - GENERAL

- A. Locate excavation support and protection systems clear of permanent construction, so that construction and finishing of other work is not impeded.
- B. Install excavation support and protection systems to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.
 1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
 2. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

- C. Install excavation support and protection systems without damaging existing buildings, structures, and site improvements adjacent to excavation.

3.3 SOLDIER PILES AND LAGGING

- A. Install steel soldier piles before starting excavation.
 - 1. Extend soldier piles below excavation grade level to depths adequate to prevent lateral movement.
 - 2. Space soldier piles at regular intervals not to exceed allowable flexural strength of wood lagging.
 - 3. Accurately align exposed faces of flanges to vary not more than **[2 inches (50 mm) from a horizontal line and not more than 1:120 out of vertical alignment]**<Insert tolerances>.
- B. Install wood lagging within flanges of soldier piles as excavation proceeds.
 - 1. Trim excavation as required to install lagging.
 - 2. Fill voids behind lagging with soil, and compact.
- C. Install wales horizontally at locations indicated on Drawings and secure to soldier piles.

3.4 SHEET PILING

- A. Before starting excavation, install one-piece sheet piling lengths and tightly interlock vertical edges to form a continuous barrier.
- B. Accurately place the piling using templates and guide frames unless otherwise recommended in writing by the sheet piling manufacturer.
 - 1. Limit vertical offset of adjacent sheet piling to **60 inches (1500 mm)**.
 - 2. Accurately align exposed faces of sheet piling to vary not more than **[2 inches (50 mm) from a horizontal line and not more than 1:120 out of vertical alignment]**<Insert tolerances>.
- C. Cut tops of sheet piling to uniform elevation at top of excavation.

3.5 TIEBACKS

- A. Drill, install, grout, and tension tiebacks.
- B. Test load-carrying capacity of each tieback, and replace and retest deficient tiebacks.
 - 1. Have test loading observed by a qualified professional engineer responsible for design of excavation support and protection system.
- C. Maintain tiebacks in place until permanent construction is able to withstand lateral earth and hydrostatic pressures.

3.6 BRACING

- A. Locate bracing to clear columns, floor framing construction, and other permanent work. If necessary to move brace, install new bracing before removing original brace.

1. Do not place bracing where it will be cast into or included in permanent concrete work unless otherwise approved by Architect.
2. Install internal bracing if required to prevent spreading or distortion of braced frames.
3. Maintain bracing until structural elements are supported by other bracing or until permanent construction is able to withstand lateral earth and hydrostatic pressures.

3.7 MAINTENANCE

- A. Monitor and maintain excavation support and protection system.
- B. Prevent surface water from entering excavations by grading, dikes, or other means.
- C. Continuously monitor vibrations, settlements, and movements to ensure stability of excavations and constructed slopes and to ensure that damage to permanent structures is prevented.

3.8 FIELD QUALITY CONTROL

- A. Survey-Work Benchmarks: Resurvey benchmarks **[regularly][daily][weekly]<Insert time period>** during installation of excavation support and protection systems, excavation progress, and for as long as excavation remains open.
 1. Maintain an accurate log of surveyed elevations and positions for comparison with original elevations and positions.
 2. Promptly notify Architect if changes in elevations or positions occur or if cracks, sags, or other damage is evident in adjacent construction.
- B. Promptly correct detected bulges, breakage, or other evidence of movement to ensure that excavation support and protection system remains stable.
- C. Promptly repair damages to adjacent facilities caused by installation or faulty performance of excavation support and protection systems.

3.9 REMOVAL AND REPAIRS

- A. Remove excavation support and protection systems when construction has progressed sufficiently to support excavation and earth and hydrostatic pressures.
 1. Remove in stages to avoid disturbing underlying soils and rock or damaging structures, pavements, facilities, and utilities.
 2. Remove excavation support and protection systems to a minimum depth of **[48 (1200)]<Insert dimension> inches (mm)** below overlying construction, and abandon remainder.
 3. Fill voids immediately with approved backfill compacted to density specified in Section 312000 "Earth Moving."
 4. Repair or replace, as approved by Architect, adjacent work damaged or displaced by removing excavation support and protection systems.
- B. Leave excavation support and protection systems permanently in place.

END OF SECTION 31 50 00 00

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Task	Specification	Specification Description
31 52 00 00	31 50 00 00	Excavation Support and Protection
31 52 21 00	31 50 00 00	Excavation Support and Protection



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SECTION 31 62 13 00 - CONCRETE PILES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes **[hollow][solid]**, precast, prestressed concrete piles.

1.2 UNIT PRICES

- A. Contract Sum: Base Contract Sum on number and dimensions of piles indicated from tip to cutoff, plus not less than **12 inches (305 mm)** of overlength for cutting piles at cutoff elevations.
- B. Work of this Section is affected as follows:
1. Additional payment for pile lengths in excess of that indicated, and credit for pile lengths less than that indicated, is calculated at unit prices stated in the Contract, based on net addition or deduction to total pile length as determined by Architect and measured to nearest **12 inches (305 mm)**.
 - a. Additional payment for splices required to extend pile lengths in excess of that indicated is calculated at unit prices stated in the Contract.
 2. Additional payment for number of piles in excess of that indicated, and credit for number of piles less than that indicated, is calculated at unit prices stated in the Contract.
 3. Unit prices include labor, materials, tools, equipment, and incidentals for furnishing, driving, cutting off, capping, and disposing of cutoffs.
 4. Test piles that become part of permanent foundation system are considered as an integral part of the Work.
 5. No payment is made for rejected piles, including piles driven out of tolerance, defective piles, or piles damaged during handling or driving.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at **[Project site]<Insert location>**.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For concrete piles. Prepared by or under the supervision of a qualified professional engineer detailing fabrication and lifting devices necessary for handling and driving piles.
1. Indicate pile dimensions, cross sections, locations, and sizes. Show details of pile splices and shoes.
 2. Indicate types of reinforcement, including prestressing strand, and detail fabricating, bending, and placing.
 3. Indicate layout and dimensions, and identify each pile. Indicate welded connections by AWS standard symbols. Detail cast-in hardware.

4. Indicate transportation, storage, and lifting points.
5. Include arrangement of static pile reaction frame, test and anchor piles, equipment, and instrumentation. Submit structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

C. Delegated Design Submittal: For concrete piles.

1. Indicate compliance with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For **[Installer][manufacturer][professional engineer][and][testing agency]**.
- B. Welding certificates.
- C. Design Mixes: For each concrete mix.
- D. Material Certificates: For **[steel reinforcements][prestressing strand][and][concrete admixtures]**.
- E. Material Test Reports: For concrete materials.
- F. Pile-Driving Equipment Data: Include type, make, and rated energy range; weight of striking part of hammer; weight of drive cap; and, type, size, and properties of hammer cushion.
- G. Static Pile Test Reports: Submit within three days of completing each test.
- H. Pile-Driving Records: Submit within three days of driving each pile.
- I. Certified Piles Survey: Submit within **[seven]<Insert number>** days of pile driving completion.
- J. Field quality-control reports.
- K. Preconstruction Photographs: Photographs or video of existing conditions of adjacent construction. Submit before the Work begins.

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications:
 1. Engineering Responsibility: Assumes engineering responsibility to comply with requirements in "Performance Requirements" Article by engaging a qualified professional engineer to prepare design calculations, Shop Drawings, and other structural data for piles.
 2. PCI Plant Certification Program: Participates in PCI's Plant Certification Program and is designated a PCI-Certified Plant for **[B2][and][C2]** product group and category, or better.
- B. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.
 1. Installer's responsibility includes engaging a qualified professional engineer to prepare pile-driving records.
- C. Testing Agency Qualifications: Qualified according to ASTM C1077 and ASTM E329 for testing

indicated[**and accredited by IAS or ILAC Mutual Recognition Arrangement as complying with ISO/IEC 17025**].

- D. Design Practices: Comply with **ACI 318 (ACI 318M)** and the recommendations in PCI Committee Report: "Recommended Practice for Design, Manufacture and Installation of Prestressed Concrete Piling."
- E. Quality-Control Standard: For manufacturing procedures and testing requirements, quality-control recommendations, and dimensional tolerances for piles, comply with applicable requirements in PCI MNL-116, "Manual for Quality Control for Plants and Production of Structural Precast Concrete Products."
- F. Comply with requirements in ACI 301, "Specifications for Structural Concrete."
- G. Welding Qualifications: Qualify procedures and personnel according to the following:
 - 1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
 - 2. AWS D1.4/D1.4M, "Structural Welding Code - Reinforcing Steel."

1.7 PRECONSTRUCTION TESTING

- A. General: Static pile tests are used to verify driving criteria and pile lengths and to confirm allowable load of piles.
 - 1. Furnish test piles **[60 inches (1524 mm)]<Insert dimension>** longer than production piles.
 - 2. Determination of actual length of piles is based on results of static pile tests.
- B. Pile Tests: Arrange and perform the following pile tests:
 - 1. Axial Compressive Static Load Test: ASTM D1143/D1143M. Procedure A, Quick Test[**and the following Procedures:**][.]
 - a. Procedure B, Maintained Test.
 - b. Procedure C, Loading in Excess of Maintained Test.
 - c. Procedure G, Cyclic Loading Test.
 - 2. Axial Tension Static Load Test: ASTM D3689.
 - 3. Lateral Load Test: ASTM D3966.
- C. Equip each test pile with two telltale rods, according to ASTM D1143/D1143M, for measuring deformation during load test.
- D. Provide pile reaction frame, anchor piles, equipment, and instrumentation with enough reaction capacity to perform tests. Notify Architect at least 48 hours in advance of performing tests. On completion of testing, remove testing structure, anchor piles, equipment, and instrumentation.
 - 1. Allow a minimum of **[seven]<Insert number>** days to elapse after driving test piles before starting pile testing.
 - 2. Number of Test Piles: **[One pile][As indicated]<Insert number>**.
- E. Drive test piles at locations indicated to the minimum penetration or driving resistance indicated. Use test piles identical to those required for Project, and drive with appropriate pile-driving equipment operating at rated driving energy to be used in driving permanent piles.

1. Pile Design Load: **[As indicated]<Insert load>**.

F. Approval Criteria: Allowable load is to be the load acting on the test pile when **[the lesser of]** the following criteria are met, divided by a factor of safety of **[2]<Insert value>**:

1. Net settlement, after deducting rebound, of not more than **0.01 inch/ton (0.25 mm/907 kg)** of test load.
2. Total settlement exceeds the pile elastic compression by **0.15 inch (4 mm)**, plus 1.0 percent of the tip diagonal dimension.
3. A plunging failure or sharp break in the load settlement curve.

G. Test Pile-Driving Records: Prepare driving records for each test pile **[, compiled and attested to by a qualified professional engineer]**. Include same data as required for driving records of permanent piles.

H. Test piles that comply with requirements, including location tolerances, may be used on Project.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Deliver piles to Project site in such quantities and at such times to ensure continuity of installation. Handle and store piles at Project site to prevent cracking, distorting, warping, or other physical damage, and so markings are visible.
- B. Lift and support piles only at designated lifting or supporting points as shown on Shop Drawings.

1.9 FIELD CONDITIONS

- A. Protect structures, underground utilities, and other construction from damage caused by pile driving.
- B. Site Information: A geotechnical report has been prepared for this Project and is **[included][referenced]** elsewhere in the Project Manual for information only.
- C. Preconstruction Photographs: Inventory and record the condition of adjacent structures, underground utilities, and other construction. Document conditions that might be misconstrued as damage caused by pile driving. **[Comply with Section 013233 "Photographic Documentation."]**

PART 2 - PRODUCTS

2.1 CONCRETE PILES

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

1. **<Insert manufacturer's name>**

2.2 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality

Requirements," to design piles, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

- B. Structural Performance: Piles withstand transportation, erection, and driving stresses and design loads within limits indicated and under conditions existing at Project site.

1. Design Loads: **<Insert loads>**.

2.3 MOLD MATERIALS

- A. Molds: Provide molds of metal, plastic, wood, or another material that is nonreactive with concrete and that produces required finish surfaces.

2.4 STEEL REINFORCEMENT

- A. Reinforcing Bars: ASTM A615/A615M, **Grade 60 (Grade 420)**; deformed.

- B. Low-Alloy-Steel Reinforcing Bars: ASTM A706/A706M.

- C. Galvanized Reinforcing Bars: ASTM A767/A767M, Class II zinc coated, hot-dip galvanized after fabrication and bending, as follows:

1. Steel Reinforcement: **[ASTM A615/A615M, Grade 60 (Grade 420)][ASTM A706/A706M]**, deformed.

- D. Epoxy-Coated Reinforcing Bars: ASTM A775/A775M or ASTM A934/A934M, as follows:

1. Steel Reinforcement: **[ASTM A615/A615M, Grade 60 (Grade 420)][ASTM A706/A706M]**, deformed.

- E. Plain and Deformed Steel Wire: ASTM A1064/A1064M, **[as drawn][galvanized]**.

- F. Epoxy-Coated-Steel Wire: ASTM A884/A884M, Class A coated, **[plain][deformed]**.

2.5 PRESTRESSING TENDONS

- A. Prestressing Strand: ASTM A416/A416M, **Grade 250 or 270 (Grade 1725 or 1860)**; uncoated, seven-wire, low-relaxation strand.

2.6 CONCRETE MATERIALS

- A. General: Limit water-soluble chloride ions in concrete to the maximum percentage by mass of cementitious material permitted by **ACI 318 (ACI 318M)**, but not more than 0.06 percent.

- B. Portland Cement: ASTM C150/C150M, **[Type I or Type III][Type II]**, of same type, brand, and source.

1. Fly Ash: ASTM C618, Class C or F.
2. Silica Fume: ASTM C1240, amorphous silica.

- C. Normal-Weight Aggregates: Except as modified by PCI MNL-116, ASTM C33/C33M, with coarse aggregates complying with **[Class 4S][Class 4M][Class 1N]<Insert class>**. Provide aggregates from

single source.

1. Nominal Maximum Size of Aggregate: [1 inch (25 mm)][3/4 inch (19 mm)].

- D. Water: Potable, free of deleterious material that may affect color stability, setting, or strength of concrete, and complying with chemical limits of PCI MNL-116.
- E. Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures.
 1. Air-Entraining Admixture: ASTM C260/C260M.
 2. Water-Reducing Admixture: ASTM C494/C494M, Type A.
 3. Retarding Admixture: ASTM C494/C494M, Type B.
 4. Water-Reducing and Retarding Admixture: ASTM C494/C494M, Type D.
 5. Water-Reducing and Accelerating Admixture: ASTM C494/C494M, Type E.
 6. High-Range, Water-Reducing Admixture: ASTM C494/C494M, Type F.
 7. High-Range, Water-Reducing and Retarding Admixture: ASTM C494/C494M, Type G.
 8. Plasticizing and Retarding Admixture: ASTM C1017/C1017M, Type II.

2.7 PILE ACCESSORIES

- A. Pile Shoes: **1-inch- (25-mm-)** thick minimum, carbon-steel plate fabricated to match shape of pile tip.
- B. Pile Splices: Manufactured from carbon-steel plates or castings and capable of developing strength of continuous pile at splice location.

2.8 CONCRETE MIXES

- A. Prepare design mixes for each type of concrete required.
 1. Limit use of fly ash and silica fume to not exceed, in total, **[25]<Insert number>** percent of portland cement by weight.
- B. Design mixes may be prepared by a qualified independent testing agency or by qualified personnel at precast manufacturing plant at precast manufacturer's option.
- C. Proportion mixes by either laboratory trial batch or field-test data methods according to ACI 211.1, with materials to be used on Project, to provide normal-weight concrete with the following properties:
 1. Compressive Strength (28 Days): **[8000 psi (55.2 MPa)][7000 psi (48.3 MPa)][6000 psi (41.4 MPa)][5000 psi (34.5 MPa)]<Insert value>**.
 2. Maximum Water-Cementitious Material Ratio: 0.40.
- D. Add air-entraining admixture at manufacturer's prescribed rate to result in normal-weight concrete at point of placement having an air content of **[6.0 percent, plus or minus 1.5][2.5 to 4.5]** percent.

2.9 FABRICATION

- A. Molds: Accurately construct molds, mortar tight, of sufficient strength to withstand pressures due to concrete placement and temperature changes and for pretensioning and detensioning operations. Maintain molds to provide completed piles of shapes, lines, and dimensions indicated, within fabrication tolerances specified in PCI MNL-116 and PCI MNL-135.

1. Unless molds are stripped before detensioning, design molds so stresses are not induced in piles due to deformation of concrete under prestress or movement during detensioning.
 2. Chamfer edges and corners of square piles.
- B. Reinforcement: Comply with recommendations in CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement. Clean reinforcement of loose rust and mill scale, earth, and other materials that reduce or destroy bond with concrete.
1. Accurately position, support, and secure reinforcement against displacement by molds, construction, or concrete placement. Locate and support reinforcement by metal chairs, runners, bolsters, spacers, and hangers, as required.
 2. Place reinforcement to obtain at least the minimum coverages for concrete protection. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position while placing concrete. Set wire ties so ends are directed into concrete, not toward exposed concrete surfaces.
- C. Prestress tendons for piles by either pretensioning or post-tensioning methods. Comply with PCI MNL-116.
- D. Pile Shoes: Accurately position and secure pile shoes at pile tips so as to not affect pile alignment during driving. Weld pile shoes to longitudinal reinforcements.
- E. Pile Splices: Accurately position and secure pile-splice segments requiring embedding in tips of piles.
- F. Mix concrete according to PCI MNL-116 and requirements in this Section. After initial concrete batching, no additional water may be added.
- G. Place concrete in a continuous operation to prevent seams or planes of weakness from forming in piles. Comply with requirements in PCI MNL-116 for measuring, mixing, transporting, and placing concrete.
1. Thoroughly consolidate placed concrete by internal and external vibration without dislocating or damaging reinforcement and built-in items. Use equipment and procedures complying with PCI MNL-116.
 2. Comply with ACI 306.1 procedures for cold-weather concrete placement.
 3. Comply with ACI 305R recommendations for hot-weather concrete placement.
- H. Identify pickup points of piles with permanent markings that correspond with markings indicated on Shop Drawings. Imprint casting date on each pile.
- I. Cure concrete, according to requirements in PCI MNL-116, by moisture retention without heat or by accelerated heat curing using low-pressure live steam or radiant heat and moisture.
- J. Delay detensioning piles until concrete has attained at least **[70]<Insert number>** percent of its compressive strength as established by test cylinders cured under the same conditions as concrete.
1. If concrete has been heat cured, detension while concrete is still warm and moist to avoid dimensional changes that may cause cracking or undesirable stresses.
 2. Detension pretensioned tendons either by gradually releasing tensioning jacks or by heat-cutting tendons, using a sequence and pattern to prevent shock or unbalanced loading.
- K. Where ends of strands are not enclosed or covered, cut flush and cover with a high-strength mortar bonded to unit with an epoxy-resin bonding agent.
- L. Fabricate precast, prestressed concrete piles straight and true to size and shape with exposed edges and corners precise and true so each finished unit complies with PCI MNL-116 and PCI MNL-135 product tolerances.



- M. Finish: Fabricate concrete piles with normal plant-run finish produced in forms that impart a smooth finish to concrete. Small surface holes caused by air bubbles, normal color variations, form joint marks, and minor chips and spalls are tolerated. Major or unsightly imperfections, honeycombs, or structural defects are not permitted.
 - 1. Finish unformed surfaces by trowel unless otherwise indicated. Consolidate concrete, bring to proper level with straightedge, float, and trowel to a smooth, uniform finish.
- N. Pile-Length Markings: Mark each pile with horizontal lines at **12-inch (305-mm)** intervals; label the distance from pile tip at **60-inch (1524-mm)** intervals. Maintain markings on piles until driven.

2.10 SOURCE QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to evaluate pile manufacturer's quality-control and testing methods.
 - 1. Allow Owner's testing agency access to material storage areas, concrete production equipment, concrete placement, and curing facilities. Cooperate with Owner's testing agency, and provide samples of materials and concrete mixes as may be requested for additional testing and evaluation.
- B. Testing: Test and inspect piles according to PCI MNL-116.
 - 1. Strength of piles will be considered deficient if units fail to comply with requirements.
- C. If there is evidence that strength of piles may be deficient or may not comply with PCI MNL-116 requirements, Owner will employ an independent testing agency to obtain, prepare, and test cores drilled from hardened concrete to determine compressive strength according to ASTM C42/C42M.
 - 1. A minimum of three representative cores are to be taken from piles of suspect strength, from locations directed by Architect.
 - 2. Cores are to be tested, following immersion in water, in a wet condition in accordance with ACI 301 if piles are wet under service conditions.
 - 3. Cores are to be tested in an air-dry condition in accordance with ACI 301 if piles are dry under service conditions.
 - 4. Strength of concrete for each series of three cores is considered satisfactory if average compressive strength is at least 85 percent of the 28-day design compressive strength and no core compressive strength is less than 75 percent of the 28-day design compressive strength.
 - 5. Test results are to be reported in writing on same day that tests are performed, with copies to Architect, Contractor, and pile manufacturer. Test reports are to include the following:
 - a. Project identification name and number.
 - b. Date when tests were performed.
 - c. Name of precast concrete manufacturer.
 - d. Name of concrete testing agency.
 - e. Identification letter, name, and type of pile represented by core tests; design compressive strength; type of break; compressive strength at break, corrected for length-diameter ratio; and direction of applied load to core in relation to horizontal plane of concrete as placed.
- D. Patching: If core test results are satisfactory and piles comply with requirements, solidly fill core holes with patching mortar and finish to match adjacent pile surfaces.
- E. Piles will be considered defective if they do not pass tests and inspections.

- F. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Site Conditions: Do not start pile-driving operations until earthwork fills have been completed or excavations have reached an elevation of **6 to 12 inches (152 to 305 mm)** above bottom of footing or pile cap.

3.2 DRIVING EQUIPMENT

- A. Pile Hammer: Air-, steam-, hydraulic-, or diesel-powered type capable of consistently delivering adequate peak-force duration and magnitude to develop the ultimate capacity required for type and size of pile driven and character of subsurface material anticipated.
1. Use pile hammer capable of adjustment to deliver reduced impact to maintain tensile stress within 70 percent of yield strength of pile reinforcement.
- B. Hammer Cushions and Driving Caps: Between hammer and top of pile, provide hammer cushion and steel driving cap as recommended by hammer manufacturer and as required to drive pile without damage.
- C. Leads: Use fixed, semifixed, or hanging-type pile-driver leads that hold the full length of pile firmly in position and in axial alignment with hammer.

3.3 DRIVING PILES

- A. General: Continuously drive piles to elevations or penetration resistance indicated[**or established by static load testing of piles**]. Establish and maintain axial alignment of leads and piles before and during driving.
- B. Predrilling: Provide pre-excavated holes where indicated, to depths indicated. Drill holes with a diameter less than the largest cross-section dimension of pile.
1. Firmly seat pile in predrilled hole by driving with reduced energy before starting final driving.
- C. Heaved Piles: Redrive heaved piles to tip elevation at least as deep as original tip elevation with a driving resistance at least as great as original driving resistance.
- D. Pile Splices: Splice piles during installation, and align pile segments concentrically.
- E. Driving Tolerances: Drive piles without exceeding the following tolerances, measured at pile heads:
1. Location: **4 inches (102 mm)** from location indicated after initial driving, and **6 inches (152 mm)** after pile driving is completed.
2. Plumb: Maintain **1 inch (25 mm)** in **48 inches (1219 mm)** from vertical, or a maximum of **4 inches (102 mm)**, measured when pile is aboveground in leads.
3. Batter Angle: Maximum **1 inch (25 mm)** in **48 inches (1219 mm)** from required angle, measured when pile is aboveground in leads.

- F. Withdraw damaged or defective piles and piles that exceed driving tolerances, and install new piles within driving tolerances.
1. Fill holes left by withdrawn piles using cohesionless soil material such as gravel, broken stone, and gravel-sand mixtures. Place and compact in lifts not exceeding **72 inches (1830 mm)**.
 2. Fill holes left by withdrawn piles as directed by Architect.
- G. Abandon and cut off rejected piles as directed by Architect. Leave rejected piles in place, and install new piles in locations as directed by Architect.
- H. Cut off tops of driven piles square with pile axis and at elevations indicated.
- I. Buildups: Construct buildups to elevations indicated of cast-in-place reinforced concrete with compressive strength not less than **[5000 psi (34.5 MPa)]<Insert value>** at 28 days.
- J. Pile-Driving Records: Maintain accurate driving records for each pile[, **compiled and attested to by a qualified professional engineer**]. Include the following data:
1. Project name and number.
 2. Name of Contractor.
 3. Type of pile and date of casting.
 4. Pile location in pile group and designation of pile group.
 5. Sequence of driving in pile group.
 6. Pile dimensions.
 7. Ground elevation.
 8. Elevation of tips after driving.
 9. Final tip and cutoff elevations of piles after driving pile group.
 10. Records of re-driving.
 11. Elevation of splices.
 12. Type, make, model, and rated energy of hammer.
 13. Weight and stroke of hammer.
 14. Type of pile-driving cap used.
 15. Cushion material and thickness.
 16. Actual stroke and blow rate of hammer.
 17. Pile-driving start and finish times, and total driving time.
 18. Time, pile-tip elevation, and reason for interruptions.
 19. Number of blows for every **12 inches (305 mm)** of penetration, and number of blows per **1 inch (25 mm)** for the last **6 inches (152 mm)** of driving.
 20. Pile deviations from location and plumb.
 21. Preboring, jetting, or special procedures used.
 22. Unusual occurrences during pile driving.
- K. Certified Piles Survey: Engage a **[land surveyor][professional engineer]** to prepare a piles survey showing final location of piles in relation to the property survey and existing benchmarks.
1. Notify Architect when deviations from locations exceed allowable tolerances.

3.4 FIELD QUALITY CONTROL

- A. Special Inspections: **[Owner will engage][Engage]** a qualified special inspector to perform the following special inspections:
1. Pile foundations.
 2. **<Insert special inspections>**.

- B. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- C. Tests and Inspections:
 - 1. Dynamic Pile Testing: High-strain dynamic monitoring is to be performed and reported according to ASTM D4945 during initial driving and during restriking on **[five single][3 percent of]<Insert number or percent of>** piles.
 - 2. Low-strain integrity measurement is to be performed and reported for each pile.
- D. Piles will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.

3.5 DISPOSAL

- A. Remove withdrawn piles and cutoff sections of piles from site and legally dispose of them off Owner's property.

END OF SECTION 31 62 13 00

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Task	Specification	Specification Description
31 62 13 23	31 62 13 00	Concrete Piles



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SECTION 31 62 16 00 - STEEL PILES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Steel H piles.

1.2 UNIT PRICES

- A. Contract Sum: Base Contract Sum on number and dimensions of piles indicated from tip to cutoff, plus not less than **12 inches (305 mm)** of overlength for cutting piles at cutoff elevations.

B. Work of this Section is affected as follows:

1. Additional payment for pile lengths in excess of that indicated, and credit for pile lengths less than that indicated, is calculated at unit prices stated in the Contract, based on net addition or deduction to total pile length as determined by Architect and measured to nearest **12 inches (305 mm)**.
 - a. Additional payment for splices required to extend pile lengths in excess of that indicated is calculated at unit prices stated in the Contract.
2. Additional payment for number of piles in excess of that indicated, and credit for number of piles less than that indicated, is calculated at unit prices stated in the Contract.
3. Unit prices include labor, materials, tools, equipment, and incidentals for furnishing, driving, cutting off, capping, and disposing of cutoffs.
4. Test piles that become part of permanent foundation system are considered as an integral part of the Work.
5. No payment is made for rejected piles, including piles driven out of tolerance, defective piles, or piles damaged during handling or driving.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at **[Project site]<Insert location>**.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.

- B. Shop Drawings: For steel H piles. Show fabrication and installation details for piles, including details of driving points, splices, and pile caps.

1. Indicate welds by standard AWS symbols, distinguishing between shop and field welds, and show size, length, and type of each weld.
2. Include arrangement of static pile reaction frame, test and anchor piles, equipment, and instrumentation. Submit structural analysis data signed and sealed by the qualified professional

engineer responsible for their preparation.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For **[Installer][professional engineer][and][testing agency]**.
- B. Welding certificates.
- C. Mill Test Reports: For **[steel H piles][steel castings][and][steel plate]**, signed by manufacturer.
- D. Pile-Driving Equipment Data: Include type, make, and rated energy range; weight of striking part of hammer; weight of drive cap; and, type, size, and properties of hammer cushion.
- E. Static Pile Test Reports: Submit within three days of completing each test.
- F. Pile-Driving Records: Submit within three days of driving each pile.
- G. Certified Piles Survey: Submit within **[seven]<Insert number>** days of pile driving completion.
- H. Field quality-control reports.
- I. Preconstruction Photographs: Photographs or video of existing conditions of adjacent construction. Submit before the Work begins.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.
 - 1. Installer's responsibility includes engaging a qualified professional engineer to prepare pile-driving records.
- B. Testing Agency Qualifications: Qualified according to ASTM E329 for testing indicated **[and accredited by IAS or ILAC Mutual Recognition Arrangement as complying with ISO/IEC 17025]**.
- C. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

1.7 PRECONSTRUCTION TESTING

- A. General: Static pile tests are used to verify driving criteria and pile lengths and to confirm allowable load of piles.
 - 1. Furnish test piles **[60 inches (1524 mm)]<Insert dimension>** longer than production piles.
 - 2. Determination of actual length of piles is based on results of static pile tests.
- B. Pile Tests: Arrange and perform the following pile tests:
 - 1. Axial Compressive Static Load Test: ASTM D1143/D1143M. Procedure A, Quick Test **[and the following Procedures:]**.
 - a. Procedure B, Maintained Test.

- b. Procedure C, Loading in Excess of Maintained Test.
 - c. Procedure G, Cyclic Loading Test.
 2. Axial Tension Static Load Test: ASTM D3689.
 3. Lateral Load Test: ASTM D3966.
 - C. Equip each test pile with two telltale rods, according to ASTM D1143/D1143M, for measuring deformation during load test.
 - D. Provide pile reaction frame, anchor piles, equipment, and instrumentation with enough reaction capacity to perform tests. Notify Architect at least 48 hours in advance of performing tests. On completion of testing, remove testing structure, anchor piles, equipment, and instrumentation.
 1. Allow a minimum of **[seven]<Insert number>** days to elapse after driving test piles before starting pile testing.
 2. Number of Test Piles: **[One pile][As indicated]<Insert number>**.
 - E. Drive test piles at locations indicated to the minimum penetration or driving resistance indicated. Use test piles identical to those required for Project, and drive with appropriate pile-driving equipment operating at rated driving energy to be used in driving permanent piles.
 1. Pile Design Load: **[As indicated]<Insert load>**.
 - F. Approval Criteria: Allowable load shall be the load acting on the test pile when **[the lesser of]** the following criteria are met, divided by a factor of safety of **[2]<Insert value>**:
 1. Net settlement, after deducting rebound, of not more than **0.01 inch/ton (0.25 mm/907 kg)** of test load.
 2. Total settlement exceeds the pile elastic compression by **0.15 inch (4 mm)**, plus 1.0 percent of the tip diagonal dimension.
 3. A plunging failure or sharp break in the load settlement curve.
 - G. Test Pile-Driving Records: Prepare driving records for each test pile, **compiled and attested to by a qualified professional engineer**. Include same data as required for driving records of permanent piles.
 - H. Test piles that comply with requirements, including location tolerances, may be used on Project.
- 1.8 DELIVERY, STORAGE, AND HANDLING
- A. Deliver piles to Project site in such quantities and at such times to ensure continuity of installation. Handle and store piles at Project site to prevent buckling or physical damage.
 1. Painted Piles: Protect finish and touch up paint damage before driving piles.
- 1.9 FIELD CONDITIONS
- A. Protect structures, underground utilities, and other construction from damage caused by pile driving.
 - B. Site Information: A geotechnical report has been prepared for this Project and is **[included][referenced]** elsewhere in the Project Manual for information only.
 - C. Preconstruction Photographs: Inventory and record the condition of adjacent structures, underground

utilities, and other construction. Document conditions that might be misconstrued as damage caused by pile driving. Comply with Section 013233 "Photographic Documentation."

PART 2 - PRODUCTS

2.1 STEEL H PILES

- A. High-Strength, Low-Alloy, Columbium-Vanadium Structural Steel: ASTM A572/A572M, **[Grade 50 (Grade 345)][Grade 60 (Grade 415)]<Insert grade>**.

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

- a. **<Insert, in separate subparagraphs, manufacturer's name>**.

- B. High-Strength, Low-Alloy, Nickel, Copper, Phosphorous Steel H Piles: ASTM A690/A690M.

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

- a. **<Insert, in separate subparagraphs, manufacturer's name>**.

- C. High-Strength, Low-Alloy, Structural Steel: ASTM A588/A588M.

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

- a. **<Insert, in separate subparagraphs, manufacturer's name>**.

2.2 PILE ACCESSORIES

- A. Driving Points: Manufacturer's standard one-piece driving point, fabricated from steel castings as follows to provide full bearing of web and flange of pile tip:

1. Carbon-Steel Castings: ASTM A27/A27M, **[Grade 65-35 (Grade 450-240), heat treated][or][Grade N1]**.
2. High-Strength Steel Castings: ASTM A148/A148M, **[Grade 80-40 (Grade 550-275)][or][Grade 90-60 (Grade 620-415)]**.

- B. Splice Unit: Manufacturer's standard splice unit, fabricated from two connected steel plates, of same material as steel H pile or material of equal strength, shaped to encase web and part of each flange.

2.3 PAINT

- A. Paint: SSPC-Paint 16; self-priming, two-component, coal-tar epoxy polyamide, [black][red][manufacturer's standard color].

2.4 FABRICATION

- A. Fabricate and assemble piles in shop to greatest extent possible.
- B. Pile-Length Markings: Mark each pile with horizontal lines at **12-inch (305-mm)** intervals; label the distance from pile tip at **60-inch (1524-mm)** intervals. Maintain markings on piles until driven.
- C. Fabricate full-length piles to eliminate splicing during driving, with ends square.
- D. Fabricate full-length piles by splicing lengths of steel H pile together. Accurately mill meeting ends of piles and bevel for welding. Maintain axial alignment of pile lengths. Maintain structural properties of pile across splice.
 - 1. Splice Units: Notch web of pile, fit splice unit into position, and weld according to manufacturer's written instructions and AWS D1.1/D1.1M for procedures, appearance and quality of welds, and methods used in correcting welding work.
 - 2. Continuously Welded Splices: Splice piles by continuously welding according to AWS D1.1/D1.1M for procedures, appearance and quality of welds, and methods used in correcting welding work.
 - 3. Splice piles during fabrication[or field installation].
- E. Fit and weld driving points to tip of pile according to manufacturer's written instructions and AWS D1.1/D1.1M for procedures, appearance and quality of welds, and methods used in correcting welding work.

2.5 SHOP PAINTING

- A. General: Shop paint steel pile surfaces, except for surfaces to be encased in concrete, as follows:
 - 1. Extend painting to a depth of **60 inches (1524 mm)** below [finished grade][low-tide level] to top of exposed pile.
- B. Surface Preparation: Clean surfaces to be painted. Remove loose rust and loose mill scale, spatter, slag, and flux deposits. Prepare surfaces according to SSPC-SP 10/NACE No. 2, "Near-White Blast Cleaning."
- C. Painting: Immediately after surface preparation, apply coat of paint according to manufacturer's written instructions to provide a dry film thickness of not less than **8 mils (0.2 mm)**.
 - 1. Apply second coat to provide a dry film thickness of not less than **8 mils (0.2 mm)**, resulting in a two-coat paint system thickness of not less than **16 mils (0.4 mm)**.
 - 2. Apply second and third coats with each coat having a dry film thickness of not less than **8 mils (0.2 mm)**, resulting in a three-coat paint system thickness of not less than **24 mils (0.6 mm)**.
 - 3. Mark pile lengths after shop painting.

PART 3 - EXECUTION**3.1 EXAMINATION**

- A. Site Conditions: Do not start pile-driving operations until earthwork fills have been completed or excavations have reached an elevation of **6 to 12 inches (152 to 305 mm)** above bottom of footing or pile cap.

3.2 DRIVING EQUIPMENT

- A. Pile Hammer: Air-, steam-, hydraulic-, or diesel-powered type capable of consistently delivering adequate peak-force duration and magnitude to develop the ultimate capacity required for type and size of pile driven and character of subsurface material anticipated.
- B. Hammer Cushions and Driving Caps: Between hammer and top of pile, provide hammer cushion and steel driving cap as recommended by hammer manufacturer and as required to drive pile without damage.
- C. Leads: Use fixed, semifixed, or hanging-type pile-driver leads that hold the full length of pile firmly in position and in axial alignment with hammer.

3.3 DRIVING PILES

- A. General: Continuously drive piles to elevations or penetration resistance indicated[**or established by static load testing of piles**]. Establish and maintain axial alignment of leads and piles before and during driving.
- B. Predrilling: Provide pre-excavated holes where indicated, to depths indicated. Drill holes with a diameter less than the largest cross-section dimension of pile.
 - 1. Firmly seat pile in predrilled hole by driving with reduced energy before starting final driving.
- C. Heaved Piles: Redrive heaved piles to tip elevation at least as deep as original tip elevation with a driving resistance at least as great as original driving resistance.
- D. Driving Tolerances: Drive piles without exceeding the following tolerances, measured at pile heads:
 - 1. Location: **4 inches (102 mm)** from location indicated after initial driving, and **6 inches (152 mm)** after pile driving is completed.
 - 2. Plumb: Maintain **1 inch (25 mm)** in **48 inches (1219 mm)** from vertical, or a maximum of **4 inches (102 mm)**, measured when pile is aboveground in leads.
 - 3. Batter Angle: Maximum **1 inch (25 mm)** in **48 inches (1219 mm)** from required angle, measured when pile is aboveground in leads.
- E. Withdraw damaged or defective piles and piles that exceed driving tolerances, and install new piles within driving tolerances.
 - 1. Fill holes left by withdrawn piles using cohesionless soil material such as gravel, broken stone, and gravel-sand mixtures. Place and compact in lifts not exceeding **72 inches (1830 mm)**.
 - 2. Fill holes left by withdrawn piles as directed by Architect.

- F. Abandon and cut off rejected piles as directed by Architect. Leave rejected piles in place, and install new piles in locations as directed by Architect.
- G. Cut off tops of driven piles square with pile axis and at elevations indicated.
- H. Pile-Driving Records: Maintain accurate driving records for each pile[, **compiled and attested to by a qualified professional engineer**]. Include the following data:
 - 1. Project name and number.
 - 2. Name of Contractor.
 - 3. Pile location in pile group and designation of pile group.
 - 4. Sequence of driving in pile group.
 - 5. Pile dimensions.
 - 6. Ground elevation.
 - 7. Elevation of tips after driving.
 - 8. Final tip and cutoff elevations of piles after driving pile group.
 - 9. Records of re-driving.
 - 10. Elevation of splices.
 - 11. Type, make, model, and rated energy of hammer.
 - 12. Weight and stroke of hammer.
 - 13. Type of pile-driving cap used.
 - 14. Cushion material and thickness.
 - 15. Actual stroke and blow rate of hammer.
 - 16. Pile-driving start and finish times, and total driving time.
 - 17. Time, pile-tip elevation, and reason for interruptions.
 - 18. Number of blows for every **12 inches (305 mm)** of penetration, and number of blows per **1 inch (25 mm)** for the last **6 inches (152 mm)** of driving.
 - 19. Pile deviations from location and plumb.
 - 20. Preboring, jetting, or special procedures used.
 - 21. Unusual occurrences during pile driving.
- I. Certified Piles Survey: Engage a [**land surveyor**][**professional engineer**] to prepare a piles survey showing final location of piles in relation to the property survey and existing benchmarks.
 - 1. Notify Architect when deviations from locations exceed allowable tolerances.

3.4 FIELD QUALITY CONTROL

- A. Special Inspections: [**Owner will engage**][**Engage**] a qualified special inspector to perform the following special inspections:
 - 1. Pile foundations.
 - 2. **<Insert special inspections>**.
- B. Testing Agency: [**Owner will engage**][**Engage**] a qualified testing agency to perform tests and inspections.
- C. Tests and Inspections:
 - 1. Dynamic Pile Testing: High-strain dynamic monitoring shall be performed and reported according to ASTM D4945 during initial driving and during restriking on [**five single**][**3 percent of**]**<Insert number or percent of>** piles.
 - 2. Weld Testing: In addition to visual inspection, welds shall be tested and inspected according to AWS D1.1/D1.1M and inspection procedures listed below, at testing agency's option. Correct deficiencies in Work that test reports and inspections indicate do not comply with the Contract

Documents.

- a. Liquid Penetrant Inspection: ASTM E165.
- b. Magnetic Particle Inspection: ASTM E709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration are not accepted.
- c. Radiographic Inspection: ASTM E94, minimum quality level "2-2T."
- d. Ultrasonic Inspection: ASTM E164.

D. Steel H piles will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.5 TOUCHUP PAINTING

A. Clean field welds, splices, and abraded painted areas and field-apply paint according to SSPC-PA 1. Use same paint and apply same number of coats as specified for shop painting.

- 1. Apply touchup paint before driving piles to surfaces that are immersed or inaccessible after driving.

3.6 DISPOSAL

A. Remove withdrawn piles and cutoff sections of piles from site, and legally dispose of them off Owner's property.

END OF SECTION 31 62 16 00



Task	Specification	Specification Description
31 62 16 16	31 62 16 00	Steel Piles
31 62 16 19	31 62 16 00	Steel Piles



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SECTION 31 62 19 00 - TIMBER PILES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes round timber piles.

1.2 UNIT PRICES

- A. Contract Sum: Base Contract Sum on number and dimensions of piles indicated from tip to cutoff, plus not less than **12 inches (305 mm)** of overlength for cutting piles at cutoff elevations.
- B. Work of this Section is affected as follows:
1. Additional payment for pile lengths in excess of that indicated, and credit for pile lengths less than that indicated, is calculated at unit prices stated in the Contract, based on net addition or deduction to total pile length as determined by Architect and measured to nearest **12 inches (305 mm)**.
 - a. Additional payment for splices required to extend pile lengths in excess of that indicated is calculated at unit prices stated in the Contract.
 2. Additional payment for number of piles in excess of that indicated, and credit for number of piles less than that indicated, is calculated at unit prices stated in the Contract.
 3. Unit prices include labor, materials, tools, equipment, and incidentals for furnishing, driving, cutting off, capping, and disposing of cutoffs.
 4. Test piles that become part of permanent foundation system are considered as an integral part of the Work.
 5. No payment is made for rejected piles, including piles driven out of tolerance, defective piles, or piles damaged during handling or driving.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at **[Project site]<Insert location>**.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For timber piles. Show fabrication and installation details for piles, including details of driving shoes, tips or boots, and pile butt protection.
1. Include arrangement of static pile reaction frame, test and anchor piles, equipment, and instrumentation. Submit structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.



1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For **[Installer][professional engineer][and][testing agency]**.
- B. Round timber pile treatment data as follows, including chemical treatment manufacturer's written instructions for handling, storing, installing, and finishing treated material:
 - 1. For each type of preservative-treated timber product, include certification by treating plant stating type of preservative solution and pressure process used, net amount of preservative retained, and compliance with applicable standards.
 - 2. For waterborne-treated products, include statement that moisture content of treated materials was reduced to levels indicated before shipment to Project site.
- C. Pile-Driving Equipment Data: Include type, make, and rated energy range; weight of striking part of hammer; weight of drive cap; and, type, size, and properties of hammer cushion.
- D. Static Pile Test Reports: Submit within three days of completing each test.
- E. Pile-Driving Records: Submit within three days of driving each pile.
- F. Certified Piles Survey: Submit within **[seven]<Insert number>** days of pile driving completion.
- G. Field quality-control reports.
- H. Material Certificates: For preservative-treated piles. Indicate type of preservative used and net amount of preservative retained.
- I. Preconstruction Photographs: Photographs or video of existing conditions of adjacent construction. Submit before the Work begins.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.
 - 1. Installer's responsibility includes engaging a qualified professional engineer to prepare pile-driving records.
- B. Testing Agency Qualifications: Qualified according to ASTM E329 for testing indicated **[and accredited by IAS or ILAC Mutual Recognition Arrangement as complying with ISO/IEC 17025]**.

1.7 PRECONSTRUCTION TESTING

- A. General: Static pile tests are used to verify driving criteria and pile lengths and to confirm allowable load of piles.
 - 1. Furnish test piles **[60 inches (1524 mm)]<Insert dimension>** longer than production piles.
 - 2. Determination of actual length of piles is based on results of static pile tests.
- B. Pile Tests: Arrange and perform the following pile tests:
 - 1. Axial Compressive Static Load Test: ASTM D1143/D1143M. Procedure A, Quick Test **[and the following Procedures:]**[.]

- a. Procedure B, Maintained Test.
 - b. Procedure C, Loading in Excess of Maintained Test.
 - c. Procedure G, Cyclic Loading Test.
 2. Axial Tension Static Load Test: ASTM D3689.
 3. Lateral Load Test: ASTM D3966.
 - C. Equip each test pile with two telltale rods, according to ASTM D1143/D1143M, for measuring deformation during load test.
 - D. Provide pile reaction frame, anchor piles, equipment, and instrumentation with enough reaction capacity to perform tests. Notify Architect at least 48 hours in advance of performing tests. On completion of testing, remove testing structure, anchor piles, equipment, and instrumentation.
 1. Allow a minimum of **[seven]<Insert number>** days to elapse after driving test piles before starting pile testing.
 2. Number of Test Piles: **[One pile][As indicated]<Insert number>**.
 - E. Drive test piles at locations indicated to the minimum penetration or driving resistance indicated. Use test piles identical to those required for Project, and drive with appropriate pile-driving equipment operating at rated driving energy to be used in driving permanent piles.
 1. Pile Design Load: **[As indicated]<Insert load>**.
 - F. Approval Criteria: Allowable load shall be the load acting on the test pile when **[the lesser of]** the following criteria are met, divided by a factor of safety of **[2]<Insert value>**:
 1. Net settlement, after deducting rebound, of not more than **0.01 inch/ton (0.25 mm/907 kg)** of test load.
 2. Total settlement exceeds the pile elastic compression by **0.15 inch (4 mm)**, plus 1.0 percent of the tip diagonal dimension.
 3. A plunging failure or sharp break in the load settlement curve.
 - G. Test Pile-Driving Records: Prepare driving records for each test pile, **compiled and attested to by a qualified professional engineer**. Include same data as required for driving records of permanent piles.
 - H. Test piles that comply with requirements, including location tolerances, may be used on Project.
- 1.8 DELIVERY, STORAGE, AND HANDLING
- A. Deliver piles to Project site in such quantities and at such times to ensure continuity of installation. Handle and store piles at Project site to prevent breaks, cuts, abrasions, or other physical damage and as required by AWP A M4.
 1. Do not drill holes or drive spikes or nails into pile below cutoff elevation.
- 1.9 FIELD CONDITIONS
- A. Protect structures, underground utilities, and other construction from damage caused by pile driving.
 - B. Site Information: A geotechnical report has been prepared for this Project and is **[included][referenced]** elsewhere in the Project Manual for information only.

- C. Preconstruction Photographs: Inventory and record the condition of adjacent structures, underground utilities, and other construction. Document conditions that might be misconstrued as damage caused by pile driving. Comply with Section 013233 "Photographic Documentation."

PART 2 - PRODUCTS**2.1 TIMBER PILES**

- A. Round Timber Piles: ASTM D25, unused, clean peeled, one piece from butt to tip; of the following species and size basis:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **<Insert manufacturer's name>**
 2. Species: **[Coastal Douglas fir][Southern yellow pine]<Insert species>**.
 3. Size Basis: **[Butt circumference][Class A][Class B][Tip circumference][8-inch (203-mm) tip and natural taper]**.
- B. Pressure-treat round timber piles according to AWWA U1 as follows:
1. Service Condition: **[UC4C Ground Contact, Extreme Duty][UC5A Marine Use Northern Waters][UC5B Marine Use Central Waters][UC5C Marine Use Southern Waters]**
 2. Treatment: **[Waterborne preservative][Creosote or creosote solution][Oil-borne preservative][Waterborne preservative, creosote or creosote solution, or oil-borne preservative][Waterborne preservative, severe marine borer hazard][Dual treatment consisting of waterborne preservative, followed by creosote or creosote solution]<Insert treatment>**.

2.2 PILE ACCESSORIES

- A. Driving Shoes: Fabricate from ASTM A1011/A1011M, hot-rolled carbon-steel strip to suit pile-tip diameter, of the following type and thickness, and secure to pile tip so as to not affect pile alignment during driving:
1. Type: **[Flat boot][Arrow point]**.
 2. Thickness: **[3/16 inch (4.8 mm)][1/4 inch (6 mm)]**.

2.3 FABRICATION

- A. Pile Tips: Cut and shape pile tips to accept driving shoes. Fit and fasten driving shoes to pile tips according to manufacturer's written instructions.
- B. Pile Butt: Trim pile butt and cut perpendicular to longitudinal axis of pile. Chamfer and shape butt to fit tightly to driving cap of hammer.
- C. Field-Applied Wood Preservative: Treat field cuts, holes, and other penetrations according to AWWA M4.

1. Coal-tar roofing cement for treating drilled holes or sealing cutoffs shall be free of asbestos.
- D. Pile Splices: Splices are not permitted.
- E. Pile-Length Markings: Mark each pile with horizontal lines at **12-inch (305-mm)** intervals; label the distance from pile tip at **60-inch (1524-mm)** intervals. Maintain markings on piles until driven.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Site Conditions: Do not start pile-driving operations until earthwork fills have been completed or excavations have reached an elevation of **6 to 12 inches (152 to 305 mm)** above bottom of footing or pile cap.

3.2 DRIVING EQUIPMENT

- A. Pile Hammer: Air-, steam-, hydraulic-, or diesel-powered type capable of consistently delivering adequate peak-force duration and magnitude to develop the ultimate capacity required for type and size of pile driven and character of subsurface material anticipated.
- B. Hammer Cushions and Driving Caps: Between hammer and top of pile, provide hammer cushion and steel driving cap as recommended by hammer manufacturer and as required to drive pile without damage.
- C. Leads: Use fixed, semifixed, or hanging-type pile-driver leads that hold the full length of pile firmly in position and in axial alignment with hammer.

3.3 DRIVING PILES

- A. General: Continuously drive piles to elevations or penetration resistance indicated[**or established by static load testing of piles**]. Establish and maintain axial alignment of leads and piles before and during driving.
- B. Spudding: Drive spud piles through overlying highly resistant strata or obstructions and withdraw for reuse.
- C. Predrilling: Provide pre-excavated holes where indicated, to depths indicated. Drill holes with a diameter less than the largest cross-section dimension of pile.
 1. Firmly seat pile in predrilled hole by driving with reduced energy before starting final driving.
- D. Heaved Piles: Redrive heaved piles to tip elevation at least as deep as original tip elevation with a driving resistance at least as great as original driving resistance.
- E. Driving Tolerances: Drive piles without exceeding the following tolerances, measured at pile heads:
 1. Location: **4 inches (102 mm)** from location indicated after initial driving, and **6 inches (152 mm)** after pile driving is completed.
 2. Plumb: Maintain **1 inch (25 mm)** in **48 inches (1219 mm)** from vertical, or a maximum of **4 inches (102 mm)**, measured when pile is aboveground in leads.

3. Batter Angle: Maximum **1 inch (25 mm)** in **48 inches (1219 mm)** from required angle, measured when pile is aboveground in leads.
- F. Withdraw damaged or defective piles and piles that exceed driving tolerances, and install new piles within driving tolerances.
1. Fill holes left by withdrawn piles using cohesionless soil material such as gravel, broken stone, and gravel-sand mixtures. Place and compact in lifts not exceeding **72 inches (1830 mm)**.
 2. Fill holes left by withdrawn piles as directed by Architect.
- G. Abandon and cut off rejected piles as directed by Architect. Leave rejected piles in place and install new piles in locations as directed by Architect.
- H. Cut off butts of driven piles square with pile axis and at elevations indicated.
1. Cover cut-off piling surfaces with **[caps overlapping pile end by minimum 2 inches (51 mm)][minimum three coats of preservative treatment]** according to AWPB M4.
- I. Pile-Driving Records: Maintain accurate driving records for each pile[, **compiled and attested to by a qualified professional engineer**]. Include the following data:
1. Project name and number.
 2. Name of Contractor.
 3. Pile species.
 4. Pile location in pile group and designation of pile group.
 5. Sequence of driving in pile group.
 6. Pile dimensions.
 7. Ground elevation.
 8. Elevation of tips after driving.
 9. Final tip and cutoff elevations of piles after driving pile group.
 10. Records of redriving.
 11. Elevation of splices.
 12. Type, make, model, and rated energy of hammer.
 13. Weight and stroke of hammer.
 14. Type of pile-driving cap used.
 15. Cushion material and thickness.
 16. Actual stroke and blow rate of hammer.
 17. Pile-driving start and finish times, and total driving time.
 18. Time, pile-tip elevation, and reason for interruptions.
 19. Number of blows for every **12 inches (305 mm)** of penetration, and number of blows per **1 inch (25 mm)** for the last **6 inches (152 mm)** of driving.
 20. Pile deviations from location and plumb.
 21. Preboring, jetting, or special procedures used.
 22. Unusual occurrences during pile driving.
- J. Certified Piles Survey: Engage a **[land surveyor][professional engineer]** to prepare a piles survey showing final location of piles in relation to the property survey and existing benchmarks.
1. Notify Architect when deviations from locations exceed allowable tolerances.

3.4 FIELD QUALITY CONTROL

- A. Special Inspections: **[Owner will engage][Engage]** a qualified special inspector to perform the following special inspections:

1. Pile foundations.
 2. **<Insert special inspections>.**
- B. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- C. Tests and Inspections:
1. Dynamic Pile Testing: High-strain dynamic monitoring shall be performed and reported according to ASTM D4945 during initial driving and during restriking on **[five single][3 percent of]<Insert number or percent of>** piles.

3.5 DISPOSAL

- A. Remove withdrawn piles and cutoff sections of piles from site and legally dispose of them off Owner's property.

END OF SECTION 31 62 19 00



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SECTION 31 62 23 00 - COMPOSITE PILES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes concrete-filled [steel-shell][steel pipe] piles.

1.2 UNIT PRICES

- A. Contract Sum: Base Contract Sum on number and dimensions of piles indicated from tip to cutoff, plus not less than **12 inches (305 mm)** of overlength for cutting piles at cutoff elevations.
- B. Work of this Section is affected as follows:
 - 1. Additional payment for pile lengths in excess of that indicated, and credit for pile lengths less than that indicated, is calculated at unit prices stated in the Contract, based on net addition or deduction to total pile length as determined by Architect and measured to nearest **12 inches (305 mm)**.
 - a. Additional payment for splices required to extend pile lengths in excess of that indicated is calculated at unit prices stated in the Contract.
 - 2. Additional payment for number of piles in excess of that indicated, and credit for number of piles less than that indicated, is calculated at unit prices stated in the Contract.
 - 3. Unit prices include labor, materials, tools, equipment, and incidentals for furnishing, driving, cutting off, capping, and disposing of cutoffs.
 - 4. Test piles that become part of permanent foundation system are considered as an integral part of the Work.
 - 5. No payment is made for rejected piles, including piles driven out of tolerance, defective piles, or piles damaged during handling or driving.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at [Project site]<Insert location>.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For composite piles. Show fabrication and installation details for piles, including splices and tip details.
 - 1. Indicate welds by standard AWS symbols, distinguishing between shop and field welds, and show size, length, and type of each weld.
 - 2. Indicate locations, sizes, type, and arrangement of reinforcement.
 - 3. Include arrangement of static pile reaction frame, test and anchor piles, equipment, and instrumentation. Submit structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For **[Installer][professional engineer][and][testing agency]**.
- B. Welding certificates.
- C. Design Mixes: For each concrete mix. Include revised mix proportions when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.
- D. Material Certificates: For **[steel-shell piles and accessories][steel pipe piles and accessories][steel reinforcement][and][concrete admixtures]**.
- E. Material Test Reports: For concrete materials.
- F. Pile-Driving Equipment Data: Include type, make, and rated energy range; weight of striking part of hammer; weight of drive cap; and, type, size, and properties of hammer cushion.
 - 1. Include mandrel type and details.
- G. Static Pile Test Reports: Submit within three days of completing each test.
- H. Pile-Driving Records: Submit within three days of driving each pile.
- I. Certified Piles Survey: Submit within **[seven]<Insert number>** days of pile-driving completion.
- J. Field quality-control reports.
- K. Preconstruction Photographs: Photographs or video of existing conditions of adjacent construction. Submit before the Work begins.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.
 - 1. Installer's responsibility includes engaging a qualified professional engineer to prepare pile-driving records.
- B. Testing Agency Qualifications: Qualified according to ASTM C1077 and ASTM E329 for testing indicated **[and accredited by IAS or ILAC Mutual Recognition Arrangement as complying with ISO/IEC 17025]**.
- C. Comply with requirements in ACI 301, "Specifications for Structural Concrete."
- D. Welding Qualifications: Qualify procedures and personnel according to the following:
 - 1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
 - 2. AWS D1.3/D1.3M, "Structural Welding Code - Sheet Steel."
 - 3. AWS D1.4/D1.4M, "Structural Welding Code - Reinforcing Steel."

1.7 PRECONSTRUCTION TESTING

- A. General: Static pile tests are used to verify driving criteria and pile lengths and to confirm allowable load

of piles.

1. Furnish test piles [60 inches (1524 mm)]<Insert dimension> longer than production piles.
2. Determination of actual length of piles is based on results of static pile tests.

B. Pile Tests: Arrange and perform the following pile tests:

1. Axial Compressive Static Load Test: ASTM D1143/D1143M. Procedure A, Quick Test[and the following Procedures:][.]
 - a. Procedure B, Maintained Test.
 - b. Procedure C, Loading in Excess of Maintained Test.
 - c. Procedure G, Cyclic Loading Test.
2. Axial Tension Static Load Test: ASTM D3689.
3. Lateral Load Test: ASTM D3966.

C. Equip each test pile with two telltale rods, according to ASTM D1143/D1143M, for measuring deformation during load test.

D. Provide pile reaction frame, anchor piles, equipment, and instrumentation with enough reaction capacity to perform tests. Notify Architect at least 48 hours in advance of performing tests. On completion of testing, remove testing structure, anchor piles, equipment, and instrumentation.

1. Allow a minimum of [seven]<Insert number> days to elapse after driving test piles before starting pile testing.
2. Number of Test Piles: [One pile][As indicated]<Insert number>.

E. Drive test piles at locations indicated to the minimum penetration or driving resistance indicated. Use test piles identical to those required for Project and drive with appropriate pile-driving equipment operating at rated driving energy to be used in driving permanent piles.

1. Pile Design Load: [As indicated]<Insert load>.

F. Approval Criteria: Allowable load is to be the load acting on the test pile when[the lesser of] the following criteria are met, divided by a factor of safety of [2]<Insert value>:

1. Net settlement, after deducting rebound, of not more than 0.01 inch/ton (0.25 mm/907 kg) of test load.
2. Total settlement exceeds the pile elastic compression by 0.15 inch (4 mm), plus 1.0 percent of the tip diagonal dimension.
3. A plunging failure or sharp break in the load settlement curve.

G. Test Pile-Driving Records: Prepare driving records for each test pile[, compiled and attested to by a qualified professional engineer]. Include same data as required for driving records of permanent piles.

H. Test piles that comply with requirements, including location tolerances, may be used on Project.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Deliver piles to Project site in such quantities and at such times to ensure continuity of installation. Handle and store piles at Project site to prevent physical damage.

1. Painted Piles: Protect finish and touch up damage before driving piles.

1.9 FIELD CONDITIONS

- A. Protect structures, underground utilities, and other construction from damage caused by pile driving.
- B. Site Information: A geotechnical report has been prepared for this Project and is **[included][referenced]** elsewhere in the Project Manual for information only.
- C. Preconstruction Photographs: Inventory and record the condition of adjacent structures, underground utilities, and other construction. Document conditions that might be misconstrued as damage caused by pile driving. Comply with Section 013233 "Photographic Documentation."

PART 2 - PRODUCTS

2.1 STEEL-SHELL PILES

- A. Fluted Pile Shells: Manufacturer's standard, vertically fluted, pile shells; cold formed from steel sheet; **50,000-psi (345-MPa)** minimum yield strength after forming. Fabricate watertight, uniformly tapered sections with forged-steel conical nose welded to tip.
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Monotube Pile Corporation]**
 - b. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Monotube Pile Corporation]**
 - b. **<Insert manufacturer's name>**
 3. Constant Diameter Extensions: Fabricate with splice overlap capable of telescoping into tapered section.
 4. Taper: **[0.14 inch in 12 inches (1:86)][0.25 inch in 12 inches (1:48)][0.40 inch in 12 inches (1:30)]**.
 5. Thickness: **[0.150 inch (3.80 mm)][0.179 inch (4.55 mm)][0.209 inch (5.31 mm)][0.239 inch (6.07 mm)]**.
- B. Helically Corrugated Pile Shells: Manufacturer's standard, helically corrugated, uniform-diameter, steel sheet shell piles; of enough strength and thickness to remain watertight and resist distortion and buckling due to soil pressure, internal mandrel operation, or redriving. Fabricate in one-piece lengths with minimum **3/16-inch- (4.76-mm-)** thick steel-plate boot continuously welded to tip and as follows:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the**

following]:

- a. **[Contech Engineered Solutions LLC]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[Contech Engineered Solutions LLC]**
 - b. **<Insert manufacturer's name>**
3. Nominal Diameter: **[8-5/8 inches (219 mm)][10-5/8 inches (270 mm)][11-1/8 inches (283 mm)][12-1/4 inches (311 mm)][14 inches (350 mm)][16-1/8 inches (410 mm)]**.
4. Thickness: **[0.048 inch (1.21 mm), minimum][0.060 inch (1.52 mm), minimum][0.075 inch (1.90 mm), minimum][0.105 inch (2.66 mm)]<Insert dimension>**.

2.2 STEEL PIPE PILES

- A. Steel Pipe: ASTM A252, **[Grade 2][Grade 3]**; seamless or welded.

2.3 STEEL REINFORCEMENT

- A. Reinforcing Bars: ASTM A615/A615M, **Grade 60 (Grade 420)**; deformed.
- B. Low-Alloy-Steel Reinforcing Bars: ASTM A706/A706M.
- C. Galvanized Reinforcing Bars: ASTM A767/A767M, Class II zinc coated, hot-dip galvanized after fabrication and bending, as follows:
1. Steel Reinforcement: **[ASTM A615/A615M, Grade 60 (Grade 420)][ASTM A706/A706M]**; deformed.
- D. Epoxy-Coated Reinforcing Bars: ASTM A775/A775M or ASTM A934/A934M, as follows:
1. Steel Reinforcement: **[ASTM A615/A615M, Grade 60 (Grade 420)][ASTM A706/A706M]**; deformed.
- E. Plain and Deformed Steel Wire: ASTM A1064/A1064M, **[as drawn][galvanized]**.
- F. Epoxy-Coated-Steel Wire: ASTM A884/A884M, Class A coated, **[plain][deformed]**.

2.4 CONCRETE MATERIALS

- A. Portland Cement: ASTM C150/C150M, Type I or II.
1. Fly Ash: ASTM C618, Class C or F.
 2. Ground Granulated Blast-Furnace Slag: ASTM C989, Grade 100 or 120.
- B. Blended Hydraulic Cement: ASTM C595/C595M, **[Type IS, portland blast-furnace slag][Type IP, portland-pozzolan][Type I (PM), pozzolan-modified portland][Type I (SM), slag-modified portland]** cement.

- C. Normal-Weight Aggregates: ASTM C33/C33M, **[Class 4S][Class 4M][Class 1N]<Insert class>**, uniformly graded, **3/4-inch (19-mm)** maximum aggregate size. Provide aggregates from a single source.
- D. Water: Potable, complying with ASTM C94/C94M requirements.
- E. Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and to contain no more than 0.1 percent chloride ions by mass of cementitious material.
 - 1. Air-Entraining Admixture: ASTM C260/C260M.
 - 2. Water-Reducing Admixture: ASTM C494/C494M, Type A.
 - 3. Retarding Admixture: ASTM C494/C494M, Type B.
 - 4. Water-Reducing and Retarding Admixture: ASTM C494/C494M, Type D.
 - 5. High-Range, Water-Reducing Admixture: ASTM C494/C494M, Type F.
 - 6. High-Range, Water-Reducing and Retarding Admixture: ASTM C494/C494M, Type G.
 - 7. Plasticizing and Retarding Admixture: ASTM C1017/C1017M, Type II.

2.5 PILE ACCESSORIES

- A. Driving Points: Manufacturer's standard 60-degree conical driving point, with integral reinforcing ribs, to provide full bearing of pipe pile tip. Fabricate from steel castings as follows:
- B. Inside Cutting Shoes: Manufacturer's standard, inside-flanged, open-ended cutting shoe, to provide full bearing of pipe pile tip. Fabricate from steel castings as follows:
- C. Outside Cutting Shoes: Manufacturer's standard, outside-flanged, open-ended cutting shoe, to provide full bearing of pipe pile tip. Fabricate from steel castings as follows:
 - 1. Carbon-Steel Castings: ASTM A27/A27M, **[Grade 65-35 (Grade 450-240), heat treated][or][Grade N1]**.
 - 2. High-Strength Steel Castings: ASTM A148/A148M, **[Grade 80-40 (Grade 550-275)][or][Grade 90-60 (Grade 620-415)]**.
- D. Splice Coupling: Manufacturer's standard splice coupling, rolled from ASTM A36/A36M, carbon-steel bar or cast from heat-treated carbon steel, ASTM A27/A27M, **Grade 65-35 (Grade 450-240)**, with interior stop and internally tapered for friction fit driving.

2.6 PAINT

- A. Paint: SSPC-Paint 16; self-priming, two-component, coal-tar epoxy polyamide, **[black][red][manufacturer's standard color]**.

2.7 CONCRETE MIXES

- A. Prepare concrete design mixes according to ACI 301, determined by either laboratory trial batch or field test data basis.
 - 1. Use a qualified testing agency for preparing and reporting proposed mix designs determined by laboratory trial batch.
- B. Proportion mixes according to ACI 301 to provide normal-weight concrete suitable for piles with the

following properties:

1. Compressive Strength (28 Days): [5000 psi (34.5 MPa)][4000 psi (27.6 MPa)][3000 psi (20.7 MPa)]<Insert value>.
 2. Maximum Water-Cementitious Material Ratio at Point of Placement: [0.45][0.50]<Insert ratio>.
 3. Slump Limit: [5 inches (127 mm)][8 inches (203 mm)]<Insert dimension>, plus or minus 1 inch (25 mm).
- C. Add air-entraining admixture at manufacturer's prescribed rate to result in normal-weight concrete at point of placement having an air content of [6.0 percent, plus or minus 1.5][2.5 to 4.5] percent.
- D. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement according to ACI 301 limits as if concrete were exposed to deicing chemicals.
- E. Limit water-soluble, chloride-ion content in hardened concrete to [0.15][0.30] percent by weight of cement.
- F. Concrete-mix design adjustments may be considered if characteristics of materials, Project conditions, weather, test results, or other circumstances warrant. Resubmit and obtain approval from Architect of proposed changes to concrete-mix proportions.

2.8 FABRICATION

- A. Fabricate and assemble piles in shop to greatest extent possible.
- B. Fabricate full-length piles to eliminate splicing during driving.
- C. Fabricate full-length piles by splicing pile lengths together. Maintain axial alignment of pile lengths. Maintain structural properties of pile across splice.
1. Splice Coupling: Fit splice coupling into position and weld to adjoining steel pipe pile sections according to manufacturer's written instructions and AWS D1.1/D1.1M for procedures, appearance and quality of welds, and methods used in correcting welding work.
 2. Welded Splices, Steel Pipe Piles: Accurately mill meeting ends of steel pipe piles, and bevel for welding. Continuously weld pile according to AWS D1.1/D1.1M for procedures, appearance and quality of welds, and methods used in correcting welding work.
 3. Welded Splices, Steel-Shell Piles: Continuously weld steel-shell pile according to manufacturer's written instructions and AWS D1.1/D1.1M [and AWS D1.3/D1.3M] for procedures, appearance and quality of welds, and methods used in correcting welding work.
 4. Splice piles during fabrication or field installation.
- D. Fit and weld driving points to tip of pile according to manufacturer's written instructions and AWS D1.1/D1.1M for procedures, appearance and quality of welds, and methods used in correcting welding work.
- E. Fit and weld cutting shoes to tip of pile according to manufacturer's written instructions and AWS D1.1/D1.1M for procedures, appearance and quality of welds, and methods used in correcting welding work.
- F. Pile-Length Markings: Mark each pile with horizontal lines at 12-inch (305-mm) intervals; label the distance from pile tip at 60-inch (1524-mm) intervals. Maintain markings on piles until driven.

2.9 SHOP PAINTING

- A. General: Shop paint steel pile surfaces, except for surfaces to be encased in concrete, as follows:
 - 1. Extend painting to a depth of **60 inches (1524 mm)** below **[finished grade][low-tide level]** to top of exposed pile.
- B. Surface Preparation: Clean surfaces to be painted. Remove loose rust and loose mill scale, and remove spatter, slag, or flux deposits. Prepare surfaces according to SSPC-SP 10/NACE No. 2, "Near-White Blast Cleaning."
- C. Painting: Immediately after surface preparation, apply coat of paint according to manufacturer's written instructions to provide a dry film thickness of not less than **8 mils (0.2 mm)**.
 - 1. Apply second coat to provide a dry film thickness of not less than **8 mils (0.2 mm)**, resulting in a two-coat paint system thickness of not less than **16 mils (0.4 mm)**.
 - 2. Apply second and third coats with each coat having a dry film thickness of not less than **8 mils (0.2 mm)**, resulting in a three-coat paint system thickness of not less than **24 mils (0.6 mm)**.
 - 3. Mark pile lengths after shop painting.

2.10 CONCRETE MIXING

- A. Ready-Mixed Concrete: Comply with ASTM C94/C94M.
 - 1. Do not add water to concrete mix after mixing.
 - 2. Maintain concrete temperature to not exceed **90 deg F (32 deg C)**.

PART 3 - EXECUTION**3.1 EXAMINATION**

- A. Site Conditions: Do not start pile-driving operations until earthwork fills have been completed or excavations have reached an elevation of **6 to 12 inches (152 to 305 mm)** above bottom of footing or pile cap.

3.2 DRIVING EQUIPMENT

- A. Pile Hammer: Air-, steam-, hydraulic-, or diesel-powered type capable of consistently delivering adequate peak-force duration and magnitude to develop the ultimate capacity required for type and size of pile driven and character of subsurface material anticipated.
- B. Hammer Cushions and Driving Caps: Between hammer and top of pile, provide hammer cushion and steel driving cap as recommended by hammer manufacturer and as required to drive pile without damage.
- C. Leads: Use fixed, semifixed, or hanging-type pile-driver leads that hold the full length of pile firmly in position and in axial alignment with hammer.
- D. Mandrel: Expandable mandrel, capable of distributing driving energy throughout length of steel-shell pile.

3.3 INSTALLATION OF STEEL REINFORCEMENT

- A. Comply with recommendations in CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.
- B. Clean reinforcement of loose rust and mill scale, earth, and other materials that reduce or destroy bond with concrete.
- C. Fabricate and install reinforcement cages symmetrically about axis of pile **[shell][pipe]** in a single unit.
- D. Accurately position, support, and secure reinforcement against displacement during concreting. Maintain minimum cover on reinforcement.
- E. Protect exposed ends of extended reinforcement, dowels, or anchor bolts from mechanical damage and exposure to weather.

3.4 CONCRETE PLACEMENT

- A. Do not place concrete until other piles within a radius of **[20 feet (6 m)]<Insert value>** have been driven and approved.
- B. Inspection: Before placing concrete, allow testing and inspecting agency to visually inspect and verify that each pile **[shell][pipe]** is clean, watertight, plumb, and free of distortion or other defects.
- C. Place concrete in a continuous operation and without segregation immediately after cleaning out pile **[shell][pipe]**.
- D. Place concrete by means of bottom discharge bucket, flexible drop chute, or steep-sided funnel hopper or tremie or pump concrete into place.
- E. Place concrete in a dry pile **[shell][pipe]** unless placement underwater is approved by Architect.
 - 1. Place concrete underwater by tremie method or pumping. Control placement operations to ensure tremie is embedded no less than **60 inches (1524 mm)** into concrete, and flow of tremied concrete is continuous from bottom to top of pile **[shell][pipe]**.
 - 2. Other methods of depositing concrete may be used if approved by Architect.
- F. Consolidate final **10 feet (3 m)** of concrete during placement to ensure that concrete is thoroughly worked around steel reinforcement and into corners.
- G. Screed concrete level at cutoff elevation and apply a scoured, rough finish.

3.5 DRIVING PILES

- A. General: Continuously drive piles to elevations or penetration resistance indicated[**or established by static load testing of piles**]. Establish and maintain axial alignment of leads and piles before and during driving.
- B. Predrilling: Provide pre-excavated holes where indicated, to depths indicated. Drill holes with a diameter less than the largest cross-section dimension of pile.
 - 1. Firmly seat pile in predrilled hole by driving with reduced energy before starting final driving.

- C. Heaved Piles: Redrive heaved piles to tip elevation at least as deep as original tip elevation with a driving resistance at least as great as original driving resistance.
- D. Pile Splices: Splice piles during installation and align pile segments concentrically.
- E. Driving Tolerances: Drive piles without exceeding the following tolerances, measured at pile heads:
 - 1. Location: **4 inches (102 mm)** from location indicated after initial driving, and **6 inches (152 mm)** after pile driving is completed.
 - 2. Plumb: Maintain **1 inch (25 mm)** in **48 inches (1219 mm)** from vertical, or a maximum of **4 inches (102 mm)**, measured when pile is aboveground in leads.
 - 3. Batter Angle: Maximum **1 inch (25 mm)** in **48 inches (1219 mm)** from required angle, measured when pile is aboveground in leads.
- F. Excavation: Clean out steel pipe pile by removing soil and debris from inside pile before placing steel reinforcement or concrete.
- G. Withdraw damaged or defective piles and piles that exceed driving tolerances, and install new piles within driving tolerances.
 - 1. Fill holes left by withdrawn piles using cohesionless soil material such as gravel, broken stone, and gravel-sand mixtures. Place and compact in lifts not exceeding **72 inches (1830 mm)**.
 - 2. Fill holes left by withdrawn piles as directed by Architect.
- H. Abandon and cut off rejected piles as directed by Architect. Leave rejected piles in place, and install new piles in locations as directed by Architect.
- I. Cut off tops of driven piles square with pile axis and at elevations indicated.
- J. Pile-Driving Records: Maintain accurate driving records for each pile[, **compiled and attested to by a qualified professional engineer**]. Include the following data:
 - 1. Project name and number.
 - 2. Name of Contractor.
 - 3. Pile location in pile group and designation of pile group.
 - 4. Sequence of driving in pile group.
 - 5. Pile dimensions.
 - 6. Ground elevation.
 - 7. Elevation of tips after driving.
 - 8. Final tip and cutoff elevations of piles after driving pile group.
 - 9. Records of redriving.
 - 10. Elevation of splices.
 - 11. Type, make, model, and rated energy of hammer.
 - 12. Weight and stroke of hammer.
 - 13. Type of pile-driving cap used.
 - 14. Cushion material and thickness.
 - 15. Actual stroke and blow rate of hammer.
 - 16. Pile-driving start and finish times, and total driving time.
 - 17. Time, pile-tip elevation, and reason for interruptions.
 - 18. Number of blows for every **12 inches (305 mm)** of penetration, and number of blows per **1 inch (25 mm)** for the last **6 inches (152 mm)** of driving.
 - 19. Pile deviations from location and plumb.
 - 20. Preboring, jetting, or special procedures used.
 - 21. Unusual occurrences during pile driving.

- K. Certified Piles Survey: Engage a **[land surveyor][professional engineer]** to prepare a piles survey showing final location of piles in relation to the property survey and existing benchmarks.

1. Notify Architect when deviations from locations exceed allowable tolerances.

3.6 FIELD QUALITY CONTROL

- A. Special Inspections: **[Owner will engage][Engage]** a qualified special inspector to perform the following special inspections:

1. Pile foundations.
2. **<Insert special inspections>**.

- B. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.

- C. Tests and Inspections:

1. Dynamic Pile Testing: High-strain dynamic monitoring is to be performed and reported according to ASTM D4945 during initial driving and during restriking on **[five single][3 percent of]<Insert number or percent of>** piles.
2. Low-strain integrity measurement is to be performed and reported for each pile.
3. Weld Testing: In addition to visual inspection, welds are to be tested and inspected according to AWS D1.1/D1.1M and the inspection procedures listed in subparagraphs below, at testing agency's option. Correct deficiencies in Work that test reports and inspections indicate does not comply with the Contract Documents.
 - a. Liquid Penetrant Inspection: ASTM E165.
 - b. Magnetic Particle Inspection: ASTM E709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration are not accepted.
 - c. Radiographic Inspection: ASTM E94; minimum quality level "2-2T."
 - d. Ultrasonic Inspection: ASTM E164.
4. Concrete: Sampling and testing of concrete for quality control is to include the following:
 - a. Sampling Fresh Concrete: ASTM C172/C172M, except modified for slump to comply with ASTM C94/C94M.
 - 1) Slump: ASTM C143/C143M; one test at point of placement for each compressive-strength test, but no fewer than one test for each concrete load.
 - 2) Concrete Temperature: ASTM C1064/C1064M; one test hourly when air temperature is **40 deg F (5 deg C)** and below or when **80 deg F (27 deg C)** and above, and one test for each set of compressive-strength specimens.
 - 3) Compression Test Specimens: ASTM C31/C31M; one set of **[four]<Insert number>** standard cylinders for each compressive-strength test unless otherwise indicated. Mold and store cylinders for laboratory-cured test specimens unless field-cured test specimens are required.
 - 4) Compressive-Strength Tests: ASTM C39/C39M; one set for each truck load. One specimen is to be tested at seven days, two specimens are to be tested at 28 days, and one specimen is to be retained in reserve for later testing if required.
 - b. When frequency of testing provides fewer than five strength tests for a given class of concrete, testing is to be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
 - c. When strength of field-cured cylinders is less than 85 percent of companion laboratory-

cured cylinders, evaluate current operations and provide corrective procedures for protecting and curing in-place concrete.

- d. Strength level of concrete is considered satisfactory if averages of sets of three consecutive strength test results equal or exceed specified compressive strength and no individual strength test result falls below specified compressive strength by more than **500 psi (3.45 MPa)**.
- e. Test results are to be reported in writing to Architect, concrete manufacturer, and Contractor within 24 hours of testing. Reports of compressive-strength tests are to contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, concrete type and class, location of concrete batch in piles, design compressive strength at 28 days, concrete-mix proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.
- f. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted but is not to be used as sole basis for acceptance or rejection.
- g. Additional Tests: Testing and inspecting agency is to make additional tests of concrete when test results indicate concrete strengths or other requirements have not been met.

D. Concrete-filled steel piles will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.7 TOUCHUP PAINTING

A. Clean field welds, splices, and abraded painted areas and field-apply paint according to SSPC-PA 1. Use same paint and apply same number of coats as specified for shop painting.

- 1. Apply touchup paint before driving piles to surfaces that are immersed or inaccessible after driving.

3.8 DISPOSAL

A. Remove withdrawn piles and cutoff sections of piles from site, and legally dispose of them off Owner's property.

END OF SECTION 31 62 23 00



Task	Specification	Specification Description
31 62 23 13	31 62 23 00	Composite Piles
31 64 13 00	31 41 13 00	Drilled Concrete Piers and Shafts
31 68 13 00	31 41 13 00	Drilled Concrete Piers and Shafts



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Task	Specification	Specification Description
32 01 11 53	07 18 00 00	Traffic Coatings
32 01 11 53	32 12 16 00	Asphalt Paving
32 01 11 53	32 13 13 00	Concrete Paving
32 01 13 61	32 12 16 00	Asphalt Paving
32 01 16 74	32 12 16 00	Asphalt Paving
32 01 17 61	32 12 16 00	Asphalt Paving
32 01 17 63	32 12 16 00	Asphalt Paving
32 12 13 13	32 12 16 00	Asphalt Paving
32 12 13 19	32 12 16 00	Asphalt Paving



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SECTION 32 12 16 00 - ASPHALT PAVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Hot-mix asphalt paving.
2. Hot-mix asphalt overlay.
3. Cold milling of existing asphalt pavement.
4. Hot-mix asphalt patching.
5. Asphalt curbs.
6. Asphalt traffic-calming devices.
7. Asphalt surface treatments.

B. Related Requirements:

1. **[Section 024116 "Structure Demolition"]**[and]**[Section 024119 "Selective Demolition"]** for demolition and removal of existing asphalt pavement.
2. Section 312000 "Earth Moving" for subgrade preparation, fill material, separation geotextiles, unbound-aggregate subbase and base courses, and aggregate pavement shoulders.
3. Section 321313 "Concrete Paving" for concrete pavement and for separate concrete curbs, gutters, and driveway aprons.
4. Section 321373 "Concrete Paving Joint Sealants" for joint sealants and fillers at pavement terminations.
5. Section 321400 "Unit Paving" for bituminous setting bed for pavers and for stone and precast concrete curbs.

1.2 UNIT PRICES

- A. Work of this Section is affected by <Insert name of unit price>.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at **[Project site]**<Insert location>.

1. Review methods and procedures related to hot-mix asphalt paving including, but not limited to, the following:
 - a. Review proposed sources of paving materials, including capabilities and location of plant that will manufacture hot-mix asphalt.
 - b. Review requirements for protecting paving work, including restriction of traffic during installation period and for remainder of construction period.

1.4 ACTION SUBMITTALS

- A. Product Data: Include technical data and tested physical and performance properties.

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1. Herbicide.
2. Paving geotextile.
3. Joint sealant.

B. Hot-Mix Asphalt Designs:

1. Certification, by authorities having jurisdiction, of approval of each hot-mix asphalt design proposed for the Work.
2. For each hot-mix asphalt design proposed for the Work.

C. Sustainable Design Submittals:

1. Product Data: For recycled content, indicating postconsumer and preconsumer recycled content and cost.

D. Samples for Verification: For the following product, in manufacturer's standard sizes unless otherwise indicated:

1. Paving Geotextile: **12 by 12 inches (300 by 300 mm)** minimum.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For **[paving-mix manufacturer][and][testing agency]**.

B. Material Certificates: **[Include statement that mixes containing recycled materials will perform equal to mixes produced from all new materials.]**

1. Aggregates.
2. Asphalt binder.
3. Asphalt cement.
4. Cutback prime coat.
5. Emulsified asphalt prime coat.
6. Tack coat.
7. Fog seal.
8. Undersealing asphalt.

C. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: **[A paving-mix manufacturer registered with and approved by authorities having jurisdiction or the DOT of state in which Project is located]<Insert requirement>**.

B. Testing Agency Qualifications: Qualified in accordance with ASTM D3666 for testing indicated.

C. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of **<Insert applicable standards>** of **<Insert name of state or local DOT>** for asphalt paving work.

1. Measurement and payment provisions and safety program submittals included in standard specifications do not apply to this Section.

1.7 FIELD CONDITIONS

- A. Environmental Limitations: Do not apply asphalt materials if subgrade is wet or excessively damp, if rain is imminent or expected before time required for adequate cure, or if the following conditions are not met:
1. Prime Coat: Minimum surface temperature of **60 deg F (15.6 deg C)**.
 2. Tack Coat: Minimum surface temperature of **60 deg F (15.6 deg C)**.
 3. Slurry Coat: Comply with weather limitations in ASTM D3910.
 4. Asphalt Base Course[**and Binder Course**]: Minimum surface temperature of **40 deg F (4.4 deg C)** and rising at time of placement.
 5. Asphalt Surface Course: Minimum surface temperature of **60 deg F (15.6 deg C)** at time of placement.

PART 2 - PRODUCTS

2.1 AGGREGATES

- A. General: Use materials and gradations that have performed satisfactorily in previous installations.
- B. Coarse Aggregate: ASTM D692/D692M, sound; angular crushed stone, crushed gravel, or cured, crushed blast-furnace slag.
- C. Fine Aggregate: [**ASTM D1073**][or][**AASHTO M 29**], sharp-edged natural sand or sand prepared from stone, gravel, cured blast-furnace slag, or combinations thereof.
1. For hot-mix asphalt, limit natural sand to a maximum of 20 percent by weight of the total aggregate mass.
- D. Mineral Filler: [**ASTM D242/D242M**][or][**AASHTO M 17**], rock or slag dust, hydraulic cement, or other inert material.

2.2 ASPHALT MATERIALS

- A. Asphalt Binder: [**ASTM D6373**][or][**AASHTO M 320**] binder designation [**PG 58-28**][**PG 64-22**][**PG 70-22**]<Insert performance grade>.
- B. Asphalt Cement: [**ASTM D3381/D3381M for viscosity-graded material**][**ASTM D946/D946M for penetration-graded material**].
- C. Cutback Prime Coat: ASTM D2027/D2027M, medium-curing cutback asphalt, [**MC-30 or MC-70**][**MC-250**].
- D. Emulsified Asphalt Prime Coat: [**ASTM D977**][or][**AASHTO M 140**] emulsified asphalt, or [**ASTM D2397/D2397M**][or][**AASHTO M 208**] cationic emulsified asphalt, slow setting, diluted in water, of suitable grade and consistency for application.
- E. Tack Coat: [**ASTM D977**][or][**AASHTO M 140**] emulsified asphalt, or [**ASTM D2397/D2397M**][or][**AASHTO M 208**] cationic emulsified asphalt, slow setting, diluted in water, of suitable grade and consistency for application.
- F. Fog Seal: [**ASTM D977**][or][**AASHTO M 140**] emulsified asphalt, or [**ASTM**

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D2397/D2397M][or][**AASHTO M 208**] cationic emulsified asphalt, slow setting, factory diluted in water, of suitable grade and consistency for application.

- G. Water: Potable.
- H. Undersealing Asphalt: ASTM D3141/D3141M; pumping consistency.

2.3 AUXILIARY MATERIALS

- A. Recycled Materials for Hot-Mix Asphalt Mixes: Reclaimed asphalt pavement; reclaimed, unbound-aggregate base material; and recycled **[tires][asphalt shingles][or][glass]** from sources and gradations that have performed satisfactorily in previous installations, equal to performance of required hot-mix asphalt paving produced from all new materials.
- B. Herbicide: Commercial chemical for weed control, registered by the EPA, and not classified as "restricted use" for locations and conditions of application. Provide in granular, liquid, or wettable powder form.
- C. Sand: **[ASTM D1073][or][AASHTO M 29]**, Grade No. 2 or No. 3.
- D. Paving Geotextile: AASHTO M 288 paving fabric; nonwoven polypropylene; resistant to chemical attack, rot, and mildew; and specifically designed for paving applications.
- E. Joint Sealant: ASTM D6690, **[Type I][Type II or III][Type IV]**, hot-applied, single-component, polymer-modified bituminous sealant.

2.4 MIXES

- A. Recycled Content of Hot-Mix Asphalt: Postconsumer recycled content plus one-half of preconsumer recycled content not less than **[10][20][40]<Insert value>** percent or more than **[15][25][50]<Insert value>** percent by weight.
 - 1. Surface Course Limit: Recycled content no more than **[10]<Insert number>** percent by weight.
- B. Hot-Mix Asphalt: Dense-graded, hot-laid, hot-mix asphalt plant mixes **[approved by authorities having jurisdiction]; designed in accordance with procedures in AI MS-2, "Asphalt Mix Design Methods";** and complying with the following requirements:
 - 1. Provide mixes with a history of satisfactory performance in geographical area where Project is located.
 - 2. Base Course: **<Insert mix designation>**.
 - 3. Binder Course: **<Insert mix designation>**.
 - 4. Surface Course: **<Insert mix designation>**.
- C. Emulsified-Asphalt Slurry: ASTM D3910, **[Type 1][Type 2][Type 3]**.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that subgrade is dry and in suitable condition to begin paving.
- B. Proceed with paving only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Protection: Provide protective materials, procedures, and worker training to prevent asphalt materials from spilling, coating, or building up on curbs, driveway aprons, manholes, and other surfaces adjacent to the Work.
- B. Proof-roll subgrade below pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.
 - 1. Completely proof-roll subgrade in one direction[, **repeating proof-rolling in direction perpendicular to first direction**]. Limit vehicle speed to **3 mph (5 km/h)**.
 - 2. Proof-roll with a loaded 10-wheel, tandem-axle dump truck weighing not less than **15 tons (13.6 tonnes)**.
 - 3. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Architect, and replace with compacted backfill or fill as directed.

3.3 COLD MILLING

- A. Clean existing pavement surface of loose and deleterious material immediately before cold milling. Remove existing asphalt pavement by cold milling to grades and cross sections indicated.
 - 1. Mill to a depth of **[1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension>**.
 - 2. Mill to a uniform finished surface free of excessive gouges, grooves, and ridges.
 - 3. Control rate of milling to prevent tearing of existing asphalt course.
 - 4. Repair or replace curbs, driveway aprons, manholes, and other construction damaged during cold milling.
 - 5. Excavate and trim unbound-aggregate base course, if encountered, and keep material separate from milled hot-mix asphalt.
 - 6. Patch surface depressions deeper than **1 inch (25 mm)** after milling, before wearing course is laid.
 - 7. Handle milled asphalt material in accordance with approved waste management plan required in Section 017419 "Construction Waste Management and Disposal."
 - 8. Keep milled pavement surface free of loose material and dust.
 - 9. Do not allow milled materials to accumulate on-site.

3.4 PATCHING

- A. Asphalt Pavement: Saw cut perimeter of patch and excavate existing pavement section to sound base. Excavate rectangular or trapezoidal patches, extending **12 inches (300 mm)** into perimeter of adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Remove excavated material. Recompact existing unbound-aggregate base course to form new subgrade.

- B. Portland Cement Concrete Pavement: Break cracked slabs and roll as required to reseat concrete pieces firmly.
 - 1. Undersealing: Pump hot undersealing asphalt under rocking slab until slab is stabilized or, if necessary, crack slab into pieces and roll to reseat pieces firmly.
 - 2. Remove disintegrated or badly cracked pavement. Excavate rectangular or trapezoidal patches, extending into perimeter of adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Recompact existing unbound-aggregate base course to form new subgrade.
- C. Tack Coat: Before placing patch material, apply tack coat uniformly to vertical asphalt surfaces abutting the patch. Apply at a rate of **0.05 to 0.15 gal./sq. yd. (0.2 to 0.7 L/sq. m)**.
 - 1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
 - 2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.
- D. Placing Single-Course Patch Material: Fill excavated pavement areas with hot-mix asphalt base mix for full thickness of patch and, while still hot, compact flush with adjacent surface.
- E. Placing Two-Course Patch Material: Partially fill excavated pavements with hot-mix asphalt base course mix and, while still hot, compact. Cover asphalt base course with compacted layer of hot-mix asphalt surface course, finished flush with adjacent surfaces.

3.5 REPAIRS

- A. Leveling Course: Install and compact leveling course consisting of hot-mix asphalt surface course to level sags and fill depressions deeper than **1 inch (25 mm)** in existing pavements.
 - 1. Install leveling wedges in compacted lifts not exceeding **3 inches (75 mm)** thick.
- B. Crack and Joint Filling: Remove existing joint filler material from cracks or joints to a depth of [**1/4 inch (6 mm)**]**<Insert dimension>**.
 - 1. Clean cracks and joints in existing hot-mix asphalt pavement.
 - 2. Use emulsified-asphalt slurry to seal cracks and joints less than **1/4 inch (6 mm)** wide. Fill flush with surface of existing pavement and remove excess.
 - 3. Use hot-applied joint sealant to seal cracks and joints more than **1/4 inch (6 mm)** wide. Fill flush with surface of existing pavement and remove excess.

3.6 SURFACE PREPARATION

- A. Ensure that prepared subgrade has been proof-rolled and is ready to receive paving. Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces.
- B. Herbicide Treatment: Apply herbicide in accordance with manufacturer's recommended rates and written application instructions. Apply to dry, prepared subgrade or surface of compacted-aggregate base before applying paving materials.
 - 1. Mix herbicide with prime coat if formulated by manufacturer for that purpose.
- C. Cutback Prime Coat: Apply uniformly over surface of compacted unbound-aggregate base course at a rate of **0.15 to 0.50 gal./sq. yd. (0.7 to 2.3 L/sq. m)**. Apply enough material to penetrate and seal, but

not flood, surface. Allow prime coat to cure.

1. If prime coat is not entirely absorbed within 24 hours after application, spread sand over surface to blot excess asphalt. Use enough sand to prevent pickup under traffic. Remove loose sand by sweeping before pavement is placed and after volatiles have evaporated.
 2. Protect primed substrate from damage until ready to receive paving.
- D. Emulsified Asphalt Prime Coat: Apply uniformly over surface of compacted unbound-aggregate base course at a rate of **0.10 to 0.30 gal./sq. yd. per inch depth (0.5 to 1.40 L/sq. m per 25 mm depth)**. Apply enough material to penetrate and seal, but not flood, surface. Allow prime coat to cure.
1. If prime coat is not entirely absorbed within 24 hours after application, spread sand over surface to blot excess asphalt. Use enough sand to prevent pickup under traffic. Remove loose sand by sweeping before pavement is placed and after volatiles have evaporated.
 2. Protect primed substrate from damage until ready to receive paving.
- E. Tack Coat: Apply uniformly to surfaces of existing pavement at a rate of **0.05 to 0.15 gal./sq. yd. (0.2 to 0.7 L/sq. m)**.
1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
 2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

3.7 INSTALLATION OF PAVING GEOTEXTILE

- A. Apply [**tack coat**][**asphalt binder**][**asphalt cement**] uniformly to existing pavement surfaces at a rate of **0.20 to 0.30 gal./sq. yd. (0.8 to 1.2 L/sq. m)**.
- B. Place paving geotextile promptly in accordance with manufacturer's written instructions. Broom or roll geotextile smooth and free of wrinkles and folds. Overlap longitudinal joints **4 inches (100 mm)** and transverse joints **6 inches (150 mm)**.
- C. Protect paving geotextile from traffic and other damage, and place hot-mix asphalt overlay the same day.

3.8 HOT-MIX ASPHALT PLACEMENT

- A. Machine place hot-mix asphalt on prepared surface, spread uniformly, and strike off. Place asphalt mix by hand in areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted.
 1. Place hot-mix asphalt base course[**and binder course**] in number of lifts and thicknesses indicated.
 2. Place hot-mix asphalt surface course in single lift.
 3. Spread mix at a minimum temperature of **250 deg F (121 deg C)**.
 4. Begin applying mix along centerline of crown for crowned sections and on high side of one-way slopes unless otherwise indicated.
 5. Regulate paver machine speed to obtain smooth, continuous surface free of pulls and tears in asphalt-paving mat.
- B. Place paving in consecutive strips not less than **10 feet (3 m)** wide unless infill edge strips of a lesser width are required.
 1. After first strip has been placed and rolled, place succeeding strips and extend rolling to overlap

previous strips. Overlap mix placement about **1 to 1-1/2 inches (25 to 38 mm)** from strip to strip to ensure proper compaction of mix along longitudinal joints.

2. Complete a section of asphalt base course[**and binder course**] before placing asphalt surface course.

- C. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.

3.9 JOINTS

- A. Construct joints to ensure a continuous bond between adjoining paving sections. Construct joints free of depressions, with same texture and smoothness as other sections of hot-mix asphalt course.

1. Clean contact surfaces and apply tack coat to joints.
2. Offset longitudinal joints, in successive courses, a minimum of **6 inches (150 mm)**.
3. Offset transverse joints, in successive courses, a minimum of **24 inches (600 mm)**.
4. Construct transverse joints at each point where paver ends a day's work and resumes work at a subsequent time. Construct these joints **[using either "bulkhead" or "papered" method in accordance with AI MS-22, for both "Ending a Lane" and "Resumption of Paving Operations."][as indicated on Drawings.]<Insert joint requirement.>**
5. Compact joints as soon as hot-mix asphalt will bear roller weight without excessive displacement.
6. Compact asphalt at joints to a density within 2 percent of specified course density.

3.10 COMPACTION

- A. General: Begin compaction as soon as placed hot-mix paving will bear roller weight without excessive displacement. Compact hot-mix paving with hot hand tampers or with vibratory-plate compactors in areas inaccessible to rollers.

1. Complete compaction before mix temperature cools to **185 deg F (85 deg C)**.

- B. Breakdown Rolling: Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Correct laydown and rolling operations to comply with requirements.

- C. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling while hot-mix asphalt is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt course has been uniformly compacted to the following density:

1. Average Density, Marshall Test Method: 96 percent of reference laboratory density in accordance with **[ASTM D6927][or][AASHTO T 245]**, but not less than 94 percent or greater than 100 percent.
2. Average Density, Rice Test Method: 92 percent of reference maximum theoretical density in accordance with ASTM D2041/D2041M, but not less than 90 percent or greater than 96 percent.

- D. Finish Rolling: Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.

- E. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while asphalt is still hot; compact thoroughly.

- F. Repairs: Remove paved areas that are defective or contaminated with foreign materials and replace with fresh, hot-mix asphalt. Compact by rolling to specified density and surface smoothness.

- G. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.
- H. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

3.11 ASPHALT CURBS

- A. Construct hot-mix asphalt curbs over compacted pavement surfaces. Apply a light tack coat unless pavement surface is still tacky and free from dust. Spread hot-mix asphalt at a minimum temperature of **250 deg F (121 deg C)**.
 - 1. Hot-Mix Asphalt: Same as pavement surface-course mix.
- B. Place hot-mix asphalt to curb cross section indicated or, if not indicated, to local standard shapes, by machine or by hand in wood or metal forms. Tamp hand-placed materials and screed to smooth finish. Remove forms after hot-mix asphalt has cooled.

3.12 ASPHALT TRAFFIC-CALMING DEVICES

- A. Construct hot-mix asphalt speed **[bumps][humps][cushions][and][tables]** over compacted pavement surfaces. Apply a tack coat unless pavement surface is still tacky and free from dust. Spread hot-mix asphalt at a minimum temperature of **250 deg F (121 deg C)**.
 - 1. Tack Coat Application: Apply uniformly to surfaces of existing pavement at a rate of **0.05 to 0.15 gal./sq. yd. (0.2 to 0.7 L/sq. m)**.
 - 2. Hot-Mix Asphalt: Same as pavement surface-course mix.
 - 3. Before installation, mill pavement that will be in contact with bottom of traffic-calming device. Mill to a depth of **1 inch (25 mm)** from top of pavement to a clean, rough profile.
- B. Place and compact hot-mix asphalt to cross section indicated, by machine or by hand in wood or metal forms. Tamp hand-placed materials and screed to smooth finish. Remove forms after hot-mix asphalt has cooled.

3.13 INSTALLATION TOLERANCES

- A. Pavement Thickness: Compact each course to produce thickness indicated within the following tolerances:
 - 1. Base Course **[and Binder Course]**: Plus or minus **1/2 inch (13 mm)**.
 - 2. Surface Course: Plus **1/4 inch (6 mm)**, no minus.
- B. Pavement Surface Smoothness: Compact each course to produce surface smoothness within the following tolerances as determined by using a **10-foot (3-m)** straightedge applied transversely or longitudinally to paved areas:
 - 1. Base Course **[and Binder Course]**: **[1/4 inch (6 mm)]<Insert dimension>**.
 - 2. Surface Course: **[1/8 inch (3 mm)]<Insert dimension>**.
 - 3. Crowned Surfaces: Test with crowned template centered and at right angle to crown. Maximum allowable variance from template is **1/4 inch (6 mm)**.
- C. Asphalt Traffic-Calming Devices: Compact and form asphalt to the shapes indicated and within a tolerance of plus or minus **1/8 inch (3 mm)** of height indicated above pavement surface.

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3.14 SURFACE TREATMENTS

- A. Fog Seals: Apply fog seal at a rate of **0.10 to 0.15 gal./sq. yd. (0.45 to 0.7 L/sq. m)** to existing asphalt pavement and allow to cure. With fine sand, lightly dust areas receiving excess fog seal.
- B. Slurry Seals: Apply slurry coat in a uniform thickness in accordance with ASTM D3910 and allow to cure.
 - 1. Roll slurry seal to remove ridges and provide a uniform, smooth surface.

3.15 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Thickness: In-place compacted thickness of hot-mix asphalt courses will be determined in accordance with ASTM D3549/D3549M.
- C. Surface Smoothness: Finished surface of each hot-mix asphalt course will be tested for compliance with smoothness tolerances.
- D. Asphalt Traffic-Calming Devices: Finished height of traffic-calming devices above pavement will be measured for compliance with tolerances.
- E. In-Place Density: Testing agency will take samples of uncompacted paving mixtures and compacted pavement in accordance with **[ASTM D979/D979M][or][AASHTO T 168]**.
 - 1. Reference maximum theoretical density will be determined by averaging results from four samples of hot-mix asphalt-paving mixture delivered daily to site, prepared in accordance with ASTM D2041/D2041M, and compacted in accordance with job-mix specifications.
 - 2. In-place density of compacted pavement will be determined by testing core samples in accordance with ASTM D1188 or ASTM D2726/D2726M.
 - a. One core sample will be taken for every **1000 sq. yd. (836 sq. m)** or less of installed pavement, with no fewer than three cores taken.
 - b. Field density of in-place compacted pavement may also be determined by nuclear method in accordance with ASTM D2950/D2950M and coordinated with ASTM D1188 or ASTM D2726/D2726M.
- F. Replace and compact hot-mix asphalt where core tests were taken.
- G. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.

3.16 WASTE HANDLING

- A. General: Handle asphalt-paving waste in accordance with approved waste management plan required in Section 017419 "Construction Waste Management and Disposal."

END OF SECTION 32 12 16 00

SECTION 32 12 16 00A - IMPRINTED ASPHALT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. Imprinting new paving.
2. Imprinting existing paving.

B. Related Requirements:

1. Section 321216 "Asphalt Paving" for new asphalt paving.

1.2 UNIT PRICES

- A. Work of this Section is affected by **<Insert name of unit price>**.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at **[Project site]<Insert location>**.

1.4 ACTION SUBMITTALS

A. Product Data:

1. Wire templates.
2. Coating system.
3. Thermoplastic marking material.

B. Shop Drawings:

1. Indicate imprinted patterns, colors, and dimensions to adjacent work.

C. Samples for Initial Selection: For each type of product requiring color selection.

D. Samples for Verification: For each pattern and color[**with thermoplastic marking material**], in manufacturer's standard sizes.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: Imprinted-asphalt manufacturer's authorized Installer who is trained and

approved for installation of imprinted asphalt required for this Project.

- B. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of **<Insert applicable standards>** of **<Insert name of state or local DOT>** for imprinted asphalt work.
 - 1. Measurement and payment provisions and safety program submittals included in standard specifications do not apply to this Section.

1.7 FIELD CONDITIONS

- A. Environmental Limitations: Proceed with coating imprinted paving only when air temperature is at least **50 deg F (10 deg C)** and rising and will not drop below **50 deg F (10 deg C)** within eight hours of coating application. Proceed only if no precipitation is expected within two hours after applying the final layer of coating.

PART 2 - PRODUCTS

2.1 IMPRINTED ASPHALT

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Ennis-Flint, Inc.]**
 - 2. **[Pattern Paving Products]**
 - 3. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Ennis-Flint, Inc.]**
 - 2. **[Pattern Paving Products]**
 - 3. **<Insert manufacturer's name>**
- C. Source Limitations: Obtain imprinted asphalt materials from single source from single manufacturer.

2.2 MATERIALS

- A. Wire Templates: Imprinted-asphalt manufacturer's standard, **3/8-inch- (9.5-mm-)** diameter, rigid wire rope templates for imprinting pattern into hot asphalt paving.
 - 1. Pattern: **[Running bond brick][Cobblestone][Custom pattern indicated on Drawings]<Insert pattern>**.
- B. Coating System: Imprinted-asphalt manufacturer's standard system formulated for exterior application on asphalt paving surfaces.
 - 1. Base Coating: Portland cement and epoxy-modified acrylic polymer blended with sand and aggregate, formulated for exterior application on asphalt paving surfaces.
 - 2. Top Coating: Epoxy-modified acrylic polymer blended with sand and aggregate, formulated for

- exterior application on asphalt paving surfaces.
 3. Colorant: UV-stable pigment blend, added to each coating layer.
 4. Color: **[White][Yellow]<Insert color>**.
- C. Thermoplastic Marking Material: Imprinted-asphalt manufacturer's standard, reflectorized, thermoplastic marking material, **90-mil (2.3-mm)** minimum thickness, formulated for exterior application on imprinted, asphalt paving surfaces, and precut to match the imprinted pattern of wire templates.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that asphalt paving is dry and in suitable condition to begin imprinting process in accordance with manufacturer's written instructions.
1. Remove existing pavement markings without damaging asphalt paving.
- B. Proceed with asphalt imprinting only after unsatisfactory conditions have been corrected.
- C. Verify that utilities, traffic loop detectors, and other items requiring a cut and installation beneath the asphalt surface or repairs to the asphalt surface have been completed and that asphalt surface is flush with adjacent asphalt prior to beginning installation of imprinted asphalt.

3.2 IMPRINTING ASPHALT

- A. General: Imprint asphalt in accordance with manufacturer's written instructions, using manufacturer's recommended equipment.
- B. Freshly Laid Asphalt: Immediately after hot-mix asphalt has been laid and compacted but still plastic, begin the surface-imprinting process.
1. Monitor hot-mix asphalt surface temperature to comply with imprinted-asphalt manufacturer's written instructions to ensure required temperature to perform surface imprinting.
 2. Reheat hot-mix asphalt if surface temperature drops below that required.
- C. Reheating Asphalt: Soften asphalt paving surface by heating to a depth of at least **1/2 inch (13 mm)** without burning asphalt.
1. Heat to a temperature of **300 to 325 deg F (149 to 163 deg C)** immediately before applying wire templates.
 2. Regularly monitor the pavement temperature to prevent overheating.
 3. Direct flame heaters are not permitted.
 4. If paving is overheated and begins to emit black smoke, remove damaged paving by milling down **1 inch (25 mm)** and replace removed paving with new, compacted hot-mix asphalt surface course before resuming imprinting work.
- D. Imprinting Asphalt Paving: Apply and imprint wire templates to a minimum depth **[of 1/4 inch (6 mm)][as required to embed thermoplastic marking material flush or barely beneath pavement surface]**.
- E. Applying Coating: After imprinted surface has cooled, apply **[two layers of base coating followed by two layers][four layers]** of top coating. Do not allow traffic until coating has completely dried and cured.

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- F. Applying Thermoplastic Marking Material: Position thermoplastic marking material aligned with imprinted pattern and slowly heat to a temperature no higher than **325 deg F (163 deg C)** until marking material begins to liquefy and flow. Do not allow traffic until installed marking material has cooled to ambient temperature.
- G. Repairs: Perform repairs to defective locations in accordance with imprinted-asphalt manufacturer's written instructions.

END OF SECTION 32 12 16 00A



32 - Exterior Improvements

Task	Specification	Specification Description
32 12 16 13	32 12 16 00	Asphalt Paving
32 12 16 13	32 12 16 00a	Imprinted Asphalt
32 12 16 19	32 12 16 00	Asphalt Paving
32 12 16 19	32 12 16 00a	Imprinted Asphalt
32 12 16 39	32 12 16 00	Asphalt Paving
32 12 16 39	32 12 16 00a	Imprinted Asphalt
32 12 16 43	32 12 16 00	Asphalt Paving
32 12 16 43	32 12 16 00a	Imprinted Asphalt
32 12 33 00	32 12 16 00	Asphalt Paving
32 12 36 13	32 12 16 00	Asphalt Paving
32 12 36 16	32 12 16 00	Asphalt Paving
32 12 73 00	32 13 13 00	Concrete Paving



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SECTION 32 13 13 00 - CONCRETE PAVING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes concrete paving[.][**including the following:**]
 - 1. Driveways.
 - 2. Roadways.
 - 3. Parking lots.
 - 4. Curbs and gutters.
 - 5. Walks.
- B. Related Requirements:
 - 1. Section 033000 "Cast-in-Place Concrete" for general building applications of concrete.
 - 2. Section 321316 "Decorative Concrete Paving" for stamped concrete other than stamped detectable warnings.
 - 3. Section 321373 "Concrete Paving Joint Sealants" for joint sealants in expansion and contraction joints within concrete paving and in joints between concrete paving and asphalt paving or adjacent construction.
 - 4. Section 321713 "Parking Bumpers."
 - 5. Section 321716 "Manufactured Traffic-Calming Devices."
 - 6. Section 321723 "Pavement Markings."
 - 7. Section 321726 "Tactile Warning Surfacing" for detectable warning [tiles][mats][and][pavers].

1.2 DEFINITIONS

- A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, fly ash, slag cement, and other pozzolans.
- B. W/C Ratio: The ratio by weight of water to cementitious materials.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at **[Project site]<Insert location>**.
 - 1. Review methods and procedures related to concrete paving, including but not limited to, the following:
 - a. Concrete mixture design.
 - b. Quality control of concrete materials and concrete paving construction practices.
 - c. **<Insert agenda item>**.
 - 2. Require representatives of each entity directly concerned with concrete paving to attend, including the following:
 - a. Contractor's superintendent.
 - b. Independent testing agency responsible for concrete design mixtures.

- c. Ready-mix concrete manufacturer.
- d. Concrete paving Subcontractor.
- e. Manufacturer's representative of stamped concrete paving system used for stamped detectable warnings.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Sustainable Design Submittals:
 - 1. Product Data: For recycled content, indicating postconsumer and preconsumer recycled content and cost.
 - 2. Product Certificates: For regional materials, indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project and cost for each regional material.
 - 3. Environmental Product Declaration (EPD): For each product.
 - 4. Product Certificates: For indigenous materials, indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project, means of transportation, and cost for each indigenous material.
 - 5. Environmental Product Declaration: For each product.
 - 6. Product Certificates: For regional materials, indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project, means of transportation, and cost for each regional material.
 - 7. Environmental Product Declaration: For each product.
 - 8. Environmental Product Declaration: For each product.
 - 9. Third-Party Certifications: For each product.
 - 10. Third-Party Certified Life Cycle Assessment: For each product.
 - 11. Laboratory Test Reports: For concrete paving mixtures, documentation indicating that cured concrete complies with Solar Reflectance Index requirements.
 - 12. Laboratory Test Reports: For concrete paving mixtures, documentation indicating that cured concrete complies with Solar Reflectance Index requirements.
- C. Samples for Initial Selection: For each type of product, ingredient, or admixture requiring color selection.
- D. Samples for Verification: For each type of product or exposed finish, prepared as Samples of size indicated below:
 - 1. Exposed Aggregate: **[10-lb (4.5-kg)]<Insert weight>** Sample of each mix.
- E. Design Mixtures: For each concrete paving mixture. Include alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified **[Installer of stamped detectable warnings][ready-mix concrete manufacturer][and][testing agency]**.
- B. Material Certificates: For the following, from manufacturer:
 - 1. Cementitious materials.
 - 2. Steel reinforcement and reinforcement accessories.

3. Fiber reinforcement.
4. Admixtures.
5. Curing compounds.
6. Applied finish materials.
7. Bonding agent or epoxy adhesive.
8. Joint fillers.

C. Material Test Reports: For each of the following:

1. Aggregates: [**Include service-record data indicating absence of deleterious expansion of concrete due to alkali-aggregate reactivity.**]

D. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Stamped Detectable Warning Installer Qualifications: An employer of workers trained and approved by manufacturer of stamped concrete paving systems.

B. Ready-Mix-Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C94/C94M requirements for production facilities and equipment.

1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities" (Quality Control Manual - Section 3, "Plant Certification Checklist").

C. Testing Agency Qualifications: Qualified according to ASTM C1077 and ASTM E329 for testing indicated.

1. Personnel conducting field tests must be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-1 or an equivalent certification program.

D. Mockups: Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.

1. Build mockups of full-thickness sections of concrete paving to demonstrate typical joints; surface finish, texture, and color; curing; and standard of workmanship.
2. Build mockups of concrete paving in the location and of the size indicated or, if not indicated, build mockups where directed by Architect and not less than **[96 inches (2400 mm) by 96 inches (2400 mm)]<Insert dimensions>.** [**Include full-size detectable warning.**]
3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.7 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Engage a qualified independent testing agency to perform preconstruction testing on concrete paving mixtures.

1.8 FIELD CONDITIONS

- A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.
- B. Cold-Weather Concrete Placement: Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing, or low temperatures. Comply with ACI 306.1 and the following:
 - 1. When air temperature has fallen to or is expected to fall below **40 deg F (4.4 deg C)**, uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than **50 deg F (10 deg C)** and not more than **80 deg F (27 deg C)** at point of placement.
 - 2. Do not use frozen materials or materials containing ice or snow.
 - 3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in design mixtures.
- C. Hot-Weather Concrete Placement: Comply with **ACI 301 (ACI 301M)** and as follows when hot-weather conditions exist:
 - 1. Cool ingredients before mixing to maintain concrete temperature below **90 deg F (32 deg C)** at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated in total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
 - 2. Cover steel reinforcement with water-soaked burlap, so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
 - 3. Fog-spray forms[, **steel reinforcement**,] and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

PART 2 - PRODUCTS

2.1 CONCRETE, GENERAL

- A. ACI Publications: Comply with **ACI 301 (ACI 301M)** unless otherwise indicated.

2.2 FORMS

- A. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, and smooth exposed surfaces.
 - 1. Use flexible or uniformly curved forms for curves with a radius of **100 feet (30.5 m)** or less.[**Do not use notched and bent forms.**]
- B. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and that will not impair subsequent treatments of concrete surfaces.

2.3 STEEL REINFORCEMENT

- A. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than **[25][60]<Insert value>** percent.
- B. Plain-Steel Welded-Wire Reinforcement: ASTM A1064/A1064M, fabricated from [as-

drawn][galvanized-]steel wire into flat sheets.

- C. Deformed-Steel Welded-Wire Reinforcement: ASTM A1064/A1064M, flat sheet.
- D. Epoxy-Coated Welded-Wire Reinforcement: ASTM A884/A884M, Class A, plain steel.
- E. Reinforcing Bars: ASTM A615/A615M, **Grade 60 (Grade 420)**; deformed.
- F. Galvanized Reinforcing Bars: ASTM A767/A767M, Class II zinc coated, hot-dip galvanized after fabrication and bending; with ASTM A615/A615M, **Grade 60 (Grade 420)** deformed bars.
- G. Epoxy-Coated Reinforcing Bars: ASTM A775/A775M or ASTM A934/A934M; with ASTM A615/A615M, **Grade 60 (Grade 420)** deformed bars.
- H. Steel Bar Mats: ASTM A184/A184M; with ASTM A615/A615M, **Grade 60 (Grade 420)** deformed bars; assembled with clips.
- I. Plain-Steel Wire: ASTM A1064/A1064M, [**as drawn][galvanized]**.
- J. Deformed-Steel Wire: ASTM A1064/A1064M.
- K. Epoxy-Coated-Steel Wire: ASTM A884/A884M, Class A; coated, [**plain][deformed]**.
- L. Joint Dowel Bars: ASTM A615/A615M, **Grade 60 (Grade 420)** plain-steel bars[; **zinc coated (galvanized) after fabrication according to ASTM A767/A767M, Class I coating]**. Cut bars true to length with ends square and free of burrs.
- M. Epoxy-Coated, Joint Dowel Bars: ASTM A775/A775M; with ASTM A615/A615M, **Grade 60 (Grade 420)** plain-steel bars.
- N. Tie Bars: ASTM A615/A615M, **Grade 60 (Grade 420)**; deformed.
- O. Hook Bolts: **ASTM A307, Grade A (ASTM F568M, Property Class 4.6)**, internally and externally threaded. Design hook-bolt joint assembly to hold coupling against paving form and in position during concreting operations, and to permit removal without damage to concrete or hook bolt.
- P. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars, welded-wire reinforcement, and dowels in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete of greater compressive strength than concrete specified, and as follows:
 - 1. Equip wire bar supports with sand plates or horizontal runners where base material will not support chair legs.
 - 2. For epoxy-coated reinforcement, use epoxy-coated or other dielectric-polymer-coated wire bar supports.
- Q. Epoxy Repair Coating: Liquid, two-part, epoxy repair coating, compatible with epoxy coating on reinforcement.
- R. Zinc Repair Material: ASTM A780/A780M.

2.4 CONCRETE MATERIALS

- A. Regional Materials: Concrete shall be manufactured within **500 miles (800 km)** of Project site from

aggregates[**and cementitious materials**] that have been extracted, harvested, or recovered, as well as manufactured, within **500 miles (800 km)** of Project site.

- B. Regional Materials: Concrete shall be manufactured within **500 miles (800 km)** of Project site.
- C. Regional Materials: Concrete shall be manufactured within **100 miles (160 km)** of Project site from aggregates[**and cementitious materials**] that have been extracted, harvested, or recovered, as well as manufactured, within **100 miles (160 km)** of Project site.
- D. Indigenous Materials: Concrete shall be manufactured within **500 miles (800 km)** of Project site from aggregates[**and cementitious materials**] that have been extracted, harvested, or recovered, as well as manufactured, within **500 miles (800 km)** of Project site. If materials are transported by rail or water, the distance transported by rail or water shall be multiplied by 0.25 to determine the distance to Project site.
- E. Regional Materials: Concrete shall be manufactured within **500 miles (800 km)** of Project site from aggregates[**and cementitious materials**] that have been extracted, harvested, or recovered, as well as manufactured, within **500 miles (800 km)** of Project site. If materials are transported by rail or water, the distance transported by rail or water shall be multiplied by 0.25 to determine the distance to Project site.
- F. Cementitious Materials: Use the following cementitious materials, of same type, brand, and source throughout Project:
 - 1. Portland Cement: ASTM C150/C150M, [gray][white] portland cement [Type I][Type II][Type I/II][Type III][Type V].
 - 2. Fly Ash: ASTM C618, [Class C][or][Class F].
 - 3. Slag Cement: ASTM C989/C989M, Grade 100 or 120.
 - 4. Blended Hydraulic Cement: ASTM C595/C595M, [Type IS, portland blast-furnace slag][Type IP, portland-pozzolan][Type IL, Portland-limestone][Type IT, ternary blended] cement.
- G. Normal-Weight Aggregates: ASTM C33/C33M, [Class 4S][Class 4M][Class 1N]<Insert class>, uniformly graded. Provide aggregates from a single source[**with documented service-record data of at least 10 years' satisfactory service in similar paving applications and service conditions using similar aggregates and cementitious materials**].
 - 1. Maximum Coarse-Aggregate Size: [1-1/2 inches (38 mm)][1 inch (25 mm)][3/4 inch (19 mm)] nominal.
 - 2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.
- H. Exposed Aggregate: Selected, hard, and durable; washed; free of materials with deleterious reactivity to cement or that cause staining; from a single source, with gap-graded coarse aggregate as follows:
 - 1. Aggregate Sizes: [3/4 to 1 inch (19 to 25 mm)][1/2 to 3/4 inch (13 to 19 mm)][3/8 to 5/8 inch (10 to 16 mm)]<Insert dimensions> nominal.
 - 2. Aggregate Source, Shape, and Color: <Insert requirements>.
- I. Air-Entraining Admixture: ASTM C260/C260M.
- J. Chemical Admixtures: Admixtures certified by manufacturer to be compatible with other admixtures and to contain not more than 0.1 percent water-soluble chloride ions by mass of cementitious material.
 - 1. Water-Reducing Admixture: ASTM C494/C494M, Type A.
 - 2. Retarding Admixture: ASTM C494/C494M, Type B.
 - 3. Water-Reducing and Retarding Admixture: ASTM C494/C494M, Type D.
 - 4. High-Range, Water-Reducing Admixture: ASTM C494/C494M, Type F.
 - 5. High-Range, Water-Reducing and Retarding Admixture: ASTM C494/C494M, Type G.

6. Plasticizing and Retarding Admixture: ASTM C1017/C1017M, Type II.
- K. Color Pigment: ASTM C979/C979M, synthetic mineral-oxide pigments or colored water-reducing admixtures; color stable, **[free of carbon black,]** nonfading, and resistant to lime and other alkalis.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
- a. **[Alabama Pigments Company, LLC]**
 - b. **[Bon Tool Co.]**
 - c. **[Brickform; a division of Solomon Colors]**
 - d. **[Butterfield Color, Inc.]**
 - e. **[Dynamic Color Solutions, Inc]**
 - f. **[Euclid Chemical Company (The); a subsidiary of RPM International, Inc.]**
 - g. **[Hoover Color Corporation]**
 - h. **[Lambert Corporation]**
 - i. **[Lanxess Corporation]**
 - j. **[Matcrete Inc.]**
 - k. **[NewLook International, Inc.]**
 - l. **[Proline Concrete Tools, Inc.]**
 - m. **[QC Construction Products]**
 - n. **[Scofield, a Business Unit of Sika Corporation]**
 - o. **[Solomon Colors Inc.]**
 - p. **[Stampcrete International, Ltd]**
 - q. **[SureCrete Design Products, a Fenix Group SPC Company]**
 - r. **[Venator Materials PLC]**
 - s. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
- a. **[Alabama Pigments Company, LLC]**
 - b. **[Bon Tool Co.]**
 - c. **[Brickform; a division of Solomon Colors]**
 - d. **[Butterfield Color, Inc.]**
 - e. **[Dynamic Color Solutions, Inc]**
 - f. **[Euclid Chemical Company (The); a subsidiary of RPM International, Inc.]**
 - g. **[Hoover Color Corporation]**
 - h. **[Lambert Corporation]**
 - i. **[Lanxess Corporation]**
 - j. **[Matcrete Inc.]**
 - k. **[NewLook International, Inc.]**
 - l. **[Proline Concrete Tools, Inc.]**
 - m. **[QC Construction Products]**
 - n. **[Scofield, a Business Unit of Sika Corporation]**
 - o. **[Solomon Colors Inc.]**
 - p. **[Stampcrete International, Ltd]**
 - q. **[SureCrete Design Products, a Fenix Group SPC Company]**
 - r. **[Venator Materials PLC]**
 - s. **<Insert manufacturer's name>**
3. Color: **[As indicated by manufacturer's designation][Match Architect's sample][As selected by Architect from manufacturer's full range]<Insert color>**.

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- L. Water: Potable and complying with ASTM C94/C94M.

2.5 FIBER REINFORCEMENT

- A. Synthetic Fiber, Monofilament Fibers: Monofilament polypropylene fibers engineered and designed for use in decorative concrete paving, complying with ASTM C1116/C1116M, Type III, [1/2 to 1-1/2 inches (13 to 38 mm)]<Insert dimensions> long.

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Euclid Chemical Company (The); a subsidiary of RPM International, Inc.]
 - b. [FORTA Corporation]
 - c. [FullForce by ABC Polymer Industries, LLC]
 - d. [GCP Applied Technologies Inc.]
 - e. [Nycon Corporation]
 - f. [Propex Operating Company, LLC]
 - g. [Sika Corporation]
 - h. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Euclid Chemical Company (The); a subsidiary of RPM International, Inc.]
 - b. [FORTA Corporation]
 - c. [FullForce by ABC Polymer Industries, LLC]
 - d. [GCP Applied Technologies Inc.]
 - e. [Nycon Corporation]
 - f. [Propex Operating Company, LLC]
 - g. [Sika Corporation]
 - h. <Insert manufacturer's name>

- B. Synthetic Fiber, Fibrillated Fibers: Fibrillated polypropylene fibers engineered and designed for use in decorative concrete paving, complying with ASTM C1116/C1116M, Type III, [1/2 to 1-1/2 inches (13 to 38 mm)]<Insert dimensions> long.

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Euclid Chemical Company (The); a subsidiary of RPM International, Inc.]
 - b. [FORTA Corporation]
 - c. [FullForce by ABC Polymer Industries, LLC]
 - d. [GCP Applied Technologies Inc.]
 - e. [Nycon Corporation]
 - f. [Propex Operating Company, LLC]
 - g. [Sika Corporation]
 - h. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert

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

- a. [Euclid Chemical Company (The); a subsidiary of RPM International, Inc.]
- b. [FORTA Corporation]
- c. [FullForce by ABC Polymer Industries, LLC]
- d. [GCP Applied Technologies Inc.]
- e. [Nycon Corporation]
- f. [Propex Operating Company, LLC]
- g. [Sika Corporation]
- h. <Insert manufacturer's name>

2.6 CURING MATERIALS

- A. Absorptive Cover: AASHTO M 182, [Class 3, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. (305 g/sq. m) dry][or][cotton mats].
- B. Moisture-Retaining Cover: ASTM C171, polyethylene film or white burlap-polyethylene sheet.
- C. Water: Potable.
- D. Evaporation Retarder: Waterborne, monomolecular, film forming, manufactured for application to fresh concrete.

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

- a. [Bon Tool Co.]
- b. [Brickform; a division of Solomon Colors]
- c. [ChemMasters, Inc]
- d. [Dayton Superior Corporation]
- e. [Euclid Chemical Company (The); a subsidiary of RPM International, Inc.]
- f. [Kaufman Products, Inc]
- g. [Lambert Corporation]
- h. [Laticrete International, Inc.]
- i. [Master Builders Solutions]
- j. [Metalcrete Industries]
- k. [Nox-Crete Products Group]
- l. [Sika Corporation]
- m. [SpecChem, LLC]
- n. [TK Products Construction Coatings, a Fenix Group SPC Company]
- o. [Vexcon Chemicals Inc.]
- p. [W. R. Meadows, Inc]
- q. <Insert manufacturer's name>

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

- a. [Bon Tool Co.]
- b. [Brickform; a division of Solomon Colors]
- c. [ChemMasters, Inc]
- d. [Dayton Superior Corporation]

- e. [Euclid Chemical Company (The); a subsidiary of RPM International, Inc.]
- f. [Kaufman Products, Inc]
- g. [Lambert Corporation]
- h. [Laticrete International, Inc.]
- i. [Master Builders Solutions]
- j. [Metalcrete Industries]
- k. [Nox-Crete Products Group]
- l. [Sika Corporation]
- m. [SpecChem, LLC]
- n. [TK Products Construction Coatings, a Fenix Group SPC Company]
- o. [Vexcon Chemicals Inc.]
- p. [W. R. Meadows, Inc]
- q. <Insert manufacturer's name>

E. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C309, Type 1, Class B, dissipating.

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

- a. [Anti-Hydro International, Inc]
- b. [ChemMasters, Inc]
- c. [Dayton Superior Corporation]
- d. [Euclid Chemical Company (The); a subsidiary of RPM International, Inc.]
- e. [Kaufman Products, Inc]
- f. [Lambert Corporation]
- g. [Laticrete International, Inc.]
- h. [Nox-Crete Products Group]
- i. [Right Pointe]
- j. [SpecChem, LLC]
- k. [TK Products Construction Coatings, a Fenix Group SPC Company]
- l. [Unitex; a Brand of Dayton Superior Corporation]
- m. [Vexcon Chemicals Inc.]
- n. [W. R. Meadows, Inc]
- o. <Insert manufacturer's name>

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

- a. [Anti-Hydro International, Inc]
- b. [ChemMasters, Inc]
- c. [Dayton Superior Corporation]
- d. [Euclid Chemical Company (The); a subsidiary of RPM International, Inc.]
- e. [Kaufman Products, Inc]
- f. [Lambert Corporation]
- g. [Laticrete International, Inc.]
- h. [Nox-Crete Products Group]
- i. [Right Pointe]
- j. [SpecChem, LLC]
- k. [TK Products Construction Coatings, a Fenix Group SPC Company]
- l. [Unitex; a Brand of Dayton Superior Corporation]
- m. [Vexcon Chemicals Inc.]
- n. [W. R. Meadows, Inc]

- ## 2.7 RELATED MATERIALS

- 2026

freshly mixed concrete to hardened concrete.

- E. Chemical Surface Retarder: Water-soluble, liquid, set retarder with color dye, for horizontal concrete surface application, capable of temporarily delaying final hardening of concrete to a depth of 1/8 to 1/4 inch (3 to 6 mm).
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[ChemMasters, Inc]**
 - b. **[Dayton Superior Corporation]**
 - c. **[Euclid Chemical Company (The); a subsidiary of RPM International, Inc.]**
 - d. **[Kaufman Products, Inc]**
 - e. **[Nox-Crete Products Group]**
 - f. **[QC Construction Products]**
 - g. **[Scofield, a Business Unit of Sika Corporation]**
 - h. **[Sika Corporation]**
 - i. **[SpecChem, LLC]**
 - j. **[TK Products Construction Coatings, a Fenix Group SPC Company]**
 - k. **[Vexcon Chemicals Inc.]**
 - l. **[W. R. Meadows, Inc]**
 - m. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ChemMasters, Inc]**
 - b. **[Dayton Superior Corporation]**
 - c. **[Euclid Chemical Company (The); a subsidiary of RPM International, Inc.]**
 - d. **[Kaufman Products, Inc]**
 - e. **[Nox-Crete Products Group]**
 - f. **[QC Construction Products]**
 - g. **[Scofield, a Business Unit of Sika Corporation]**
 - h. **[Sika Corporation]**
 - i. **[SpecChem, LLC]**
 - j. **[TK Products Construction Coatings, a Fenix Group SPC Company]**
 - k. **[Vexcon Chemicals Inc.]**
 - l. **[W. R. Meadows, Inc]**
 - m. **<Insert manufacturer's name>**
- F. Pigmented Mineral Dry-Shake Hardener: Factory-packaged, dry combination of portland cement, graded quartz aggregate, color pigments, and plasticizing admixture. Use color pigments that are finely ground, nonfading mineral oxides interground with cement.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Anti-Hydro International, Inc]**
 - b. **[Bon Tool Co.]**
 - c. **[Brickform; a division of Solomon Colors]**

- d. [Butterfield Color, Inc.]
 - e. [Dayton Superior Corporation]
 - f. [Decosup Inc.]
 - g. [Dynamic Color Solutions, Inc.]
 - h. [Euclid Chemical Company (The); a subsidiary of RPM International, Inc.]
 - i. [H&C Decorative Concrete Products; a brand of Sherwin-Williams Co.]
 - j. [Kaufman Products, Inc.]
 - k. [Lambert Corporation]
 - l. [Laticrete International, Inc.]
 - m. [Metalcrete Industries]
 - n. [Proline Concrete Tools, Inc.]
 - o. [QC Construction Products]
 - p. [Scofield, a Business Unit of Sika Corporation]
 - q. [Specialty Concrete Products, Inc.]
 - r. [Stampcrete International, Ltd]
 - s. [Super Stone, Inc.]
 - t. [SureCrete Design Products, a Fenix Group SPC Company]
 - u. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Anti-Hydro International, Inc]
 - b. [Bon Tool Co.]
 - c. [Brickform; a division of Solomon Colors]
 - d. [Butterfield Color, Inc.]
 - e. [Dayton Superior Corporation]
 - f. [Decosup Inc.]
 - g. [Dynamic Color Solutions, Inc]
 - h. [Euclid Chemical Company (The); a subsidiary of RPM International, Inc.]
 - i. [H&C Decorative Concrete Products; a brand of Sherwin-Williams Co.]
 - j. [Kaufman Products, Inc]
 - k. [Lambert Corporation]
 - l. [Laticrete International, Inc.]
 - m. [Metalcrete Industries]
 - n. [Proline Concrete Tools, Inc.]
 - o. [QC Construction Products]
 - p. [Scofield, a Business Unit of Sika Corporation]
 - q. [Specialty Concrete Products, Inc]
 - r. [Stampcrete International, Ltd]
 - s. [Super Stone, Inc.]
 - t. [SureCrete Design Products, a Fenix Group SPC Company]
 - u. <Insert manufacturer's name>
3. Color: [As indicated by manufacturer's designation][Match Architect's sample][As selected by Architect from manufacturer's full range]<Insert color>.
- G. Rock Salt: Sodium chloride crystals, kiln dried, coarse gradation with 100 percent passing 3/8-inch (9.5-mm) sieve and 85 percent retained on a No. 8 (2.36-mm) sieve.

2.8 STAMPED DETECTABLE WARNING MATERIALS

- A. Detectable Warning Stamp: Semirigid polyurethane mats with formed underside capable of imprinting detectable warning pattern on plastic concrete; perforated with a vent hole at each dome.

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Advanced Surfaces Inc.]**
 - b. **[Butterfield Color, Inc.]**
 - c. **[Stampcrete International, Ltd]**
 - d. **[Transpo Industries, Inc.]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Advanced Surfaces Inc.]**
 - b. **[Butterfield Color, Inc.]**
 - c. **[Stampcrete International, Ltd]**
 - d. **[Transpo Industries, Inc.]**
 - e. **<Insert manufacturer's name>**
3. Size of Stamp: One piece, **[matching detectable warning area shown on Drawings][24 by 24 inches (610 by 610 mm)][24 by 36 inches (610 by 914 mm)][24 by 48 inches (610 by 1220 mm)][26 by 26 inches (660 by 660 mm)][26 by 36 inches (660 by 914 mm)]<Insert dimensions>**.

B. Liquid Release Agent: Manufacturer's standard, clear, evaporating formulation designed to facilitate release of stamp mats.

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Advanced Surfaces Inc.]**
 - b. **[Artcrete, Inc]**
 - c. **[Bon Tool Co.]**
 - d. **[Brickform; a division of Solomon Colors]**
 - e. **[Butterfield Color, Inc.]**
 - f. **[Decosup Inc.]**
 - g. **[Matcrete Inc.]**
 - h. **[Proline Concrete Tools, Inc.]**
 - i. **[QC Construction Products]**
 - j. **[Scofield, a Business Unit of Sika Corporation]**
 - k. **[Specialty Concrete Products, Inc]**
 - l. **[Stampcrete International, Ltd]**
 - m. **[Super Stone, Inc.]**
 - n. **[Venator Materials PLC]**
 - o. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Advanced Surfaces Inc.]**

- b. [Artcrete, Inc]
- c. [Bon Tool Co.]
- d. [Brickform; a division of Solomon Colors]
- e. [Butterfield Color, Inc.]
- f. [Decosup Inc.]
- g. [Matcrete Inc.]
- h. [Proline Concrete Tools, Inc.]
- i. [QC Construction Products]
- j. [Scofield, a Business Unit of Sika Corporation]
- k. [Specialty Concrete Products, Inc]
- l. [Stampcrete International, Ltd]
- m. [Super Stone, Inc.]
- n. [Venator Materials PLC]
- o. <Insert manufacturer's name>

2.9 CONCRETE MIXTURES

- A. Prepare design mixtures, proportioned according to **ACI 301 (ACI 301M)**, for each type and strength of normal-weight concrete, and as determined by either laboratory trial mixtures or field experience.
 - 1. Use a qualified independent testing agency for preparing and reporting proposed concrete design mixtures for the trial batch method.
 - 2. When automatic machine placement is used, determine design mixtures and obtain laboratory test results that comply with or exceed requirements.
- B. Cementitious Materials: [**Use fly ash, pozzolan, slag cement, and silica fume as needed to reduce the total amount of portland cement, which would otherwise be used, by not less than 40 percent.**] [**Limit percentage, by weight, of cementitious materials other than portland cement in concrete as follows:**]
 - 1. Fly Ash or Pozzolan: 25 percent.
 - 2. Slag Cement: 50 percent.
 - 3. Combined Fly Ash or Pozzolan, and Slag Cement: 50 percent, with fly ash or pozzolan not exceeding 25 percent.
- C. Add air-entraining admixture at manufacturer's prescribed rate to result in normal-weight concrete at point of placement having an air content as follows:
 - 1. Air Content, **1-1/2-inch (38-mm)** Nominal Maximum Aggregate Size: [**5-1/2**][**4-1/2**][**2-1/2**] percent plus or minus 1-1/2 percent.
 - 2. Air Content, **1-inch (25-mm)** Nominal Maximum Aggregate Size: [**6**][**4-1/2**][**3**] percent plus or minus 1-1/2 percent.
 - 3. Air Content, **3/4-inch (19-mm)** Nominal Maximum Aggregate Size: [**6**][**5**][**3-1/2**] percent plus or minus 1-1/2 percent.
- D. Limit water-soluble, chloride-ion content in hardened concrete to [**0.15**][**0.30**] percent by weight of cement.
- E. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.
 - 1. Use [**water-reducing admixture**][**high-range, water-reducing admixture**][**high-range, water-reducing and retarding admixture**][**plasticizing and retarding admixture**] in concrete as required for placement and workability.
 - 2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.

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- F. Synthetic Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than [1.0 lb/cu. yd. (0.60 kg/cu. m)][1.5 lb/cu. yd. (0.90 kg/cu. m)]<Insert requirement>.
- G. Color Pigment: Add color pigment to concrete mixture according to manufacturer's written instructions and to result in hardened concrete color consistent with approved mockup.
- H. Concrete Mixtures: Normal-weight concrete.
 - 1. Compressive Strength (28 Days): [4500 psi (31 MPa)][4000 psi (27.6 MPa)][3500 psi (24.1 MPa)][3000 psi (20.7 MPa)]<Insert strength>.
 - 2. Maximum W/C Ratio at Point of Placement: [0.45][0.50]<Insert ratio>.
 - 3. Slump Limit: [4 inches (100 mm)][5 inches (125 mm)][8 inches (200 mm)]<Insert dimension>, plus or minus 1 inch (25 mm).
 - 4. Solar Reflectance Index: Not less than 29.
 - 5. Solar Reflectance (SR): Three-year-aged SR value of at least 0.28 or initial SR of at least 0.33.
 - 6. Solar Reflectance (SR): At least 0.30.
 - 7. Solar Reflectance Index: At least 25.

2.10 CONCRETE MIXING

- A. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to ASTM C94/C94M [and ASTM C1116/C1116M]. Furnish batch certificates for each batch discharged and used in the Work.
 - 1. When air temperature is between 85 and 90 deg F (30 and 32 deg C), reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F (32 deg C), reduce mixing and delivery time to 60 minutes.
- B. Project-Site Mixing: Measure, batch, and mix concrete materials and concrete according to ASTM C94/C94M. Mix concrete materials in appropriate drum-type batch machine mixer.
 - 1. For concrete batches of 1 cu. yd. (0.76 cu. m) or smaller, continue mixing at least 1-1/2 minutes, but not more than 5 minutes after ingredients are in mixer, before any part of batch is released.
 - 2. For concrete batches larger than 1 cu. yd. (0.76 cu. m), increase mixing time by 15 seconds for each additional 1 cu. yd. (0.76 cu. m).
 - 3. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mixture type, mixing time, quantity, and amount of water added.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine exposed subgrades and subbase surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.
- B. Proof-roll prepared subbase surface below [concrete paving]<Insert locations> to identify soft pockets and areas of excess yielding.
 - 1. Completely proof-roll subbase in one direction [and repeat in perpendicular direction]. Limit vehicle speed to 3 mph (5 km/h).

2. Proof-roll with a pneumatic-tired and loaded, 10-wheel, tandem-axle dump truck weighing not less than **15 tons (13.6 tonnes)**.
 3. Correct subbase with soft spots and areas of pumping or rutting exceeding depth of **[1/2 inch (13 mm)]<Insert dimension>** according to requirements in Section 312000 "Earth Moving."
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Remove loose material from compacted subbase surface immediately before placing concrete.

3.3 EDGE FORMS AND SCREED CONSTRUCTION

- A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.
- B. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

3.4 INSTALLATION OF STEEL REINFORCEMENT

- A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.
- B. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.
- C. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Maintain minimum cover to reinforcement.
- D. Install welded-wire reinforcement in lengths as long as practicable. Lap adjoining pieces at least one full mesh, and lace splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.
- E. Zinc-Coated Reinforcement: Use galvanized-steel wire ties to fasten zinc-coated reinforcement. Repair cut and damaged zinc coatings with zinc repair material.
- F. Epoxy-Coated Reinforcement: Use epoxy-coated steel wire ties to fasten epoxy-coated reinforcement. Repair cut and damaged epoxy coatings with epoxy repair coating according to ASTM D3963/D3963M.
- G. Install fabricated bar mats in lengths as long as practicable. Handle units to keep them flat and free of distortions. Straighten bends, kinks, and other irregularities, or replace units as required before placement. Set mats for a minimum **2-inch (50-mm)** overlap of adjacent mats.

3.5 JOINTS

- A. General: Form construction, isolation, and contraction joints and tool edges true to line, with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline unless otherwise indicated.
1. When joining existing paving, place transverse joints to align with previously placed joints unless

otherwise indicated.

- B. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than one-half hour unless paving terminates at isolation joints.
 - 1. Continue steel reinforcement across construction joints unless otherwise indicated. Do not continue reinforcement through sides of paving strips unless otherwise indicated.
 - 2. Provide tie bars at sides of paving strips where indicated.
 - 3. Butt Joints: Use **[bonding agent][epoxy-bonding adhesive]** at joint locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
 - 4. Keyed Joints: Provide preformed keyway-section forms or bulkhead forms with keys unless otherwise indicated. Embed keys at least **1-1/2 inches (38 mm)** into concrete.
 - 5. Doweled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.
- C. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, other fixed objects, and where indicated.
 - 1. Locate expansion joints at intervals of **[50 feet (15.25 m)]<Insert dimension>** unless otherwise indicated.
 - 2. Extend joint fillers full width and depth of joint.
 - 3. Terminate joint filler not less than **1/2 inch (13 mm)** or more than **1 inch (25 mm)** below finished surface if joint sealant is indicated.
 - 4. Place top of joint filler flush with finished concrete surface if joint sealant is not indicated.
 - 5. Furnish joint fillers in one-piece lengths. Where more than one length is required, lace or clip joint-filler sections together.
 - 6. During concrete placement, protect top edge of joint filler with metal, plastic, or other temporary preformed cap. Remove protective cap after concrete has been placed on both sides of joint.
- D. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness, as follows[, **to match jointing of existing adjacent concrete paving**]:
 - 1. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint with grooving tool to a **[1/4-inch (6-mm)][3/8-inch (10-mm)]** radius. Repeat grooving of contraction joints after applying surface finishes.[**Eliminate grooving-tool marks on concrete surfaces.**]
 - a. Tolerance: Ensure that grooved joints are within **[3 inches (75 mm)]<Insert dimension>** either way from centers of dowels.
 - 2. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut **1/8-inch- (3-mm-)** wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before developing random contraction cracks.
 - a. Tolerance: Ensure that sawed joints are within **[3 inches (75 mm)]<Insert dimension>** either way from centers of dowels.
 - 3. Doweled Contraction Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.
- E. Edging: After initial floating, tool edges of paving, gutters, curbs, and joints in concrete with an edging tool to a **[1/4-inch (6-mm)][3/8-inch (10-mm)]** radius. Repeat tooling of edges after applying surface

finishes.[**Eliminate edging-tool marks on concrete surfaces.**]

3.6 CONCRETE PLACEMENT

- A. Before placing concrete, inspect and complete formwork installation[, **steel reinforcement**,] and items to be embedded or cast-in.
- B. Remove snow, ice, or frost from subbase surface[**and steel reinforcement**] before placing concrete. Do not place concrete on frozen surfaces.
- C. Moisten subbase to provide a uniform dampened condition at time concrete is placed. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.
- D. Comply with **ACI 301 (ACI 301M)** requirements for measuring, mixing, transporting, and placing concrete.
- E. Do not add water to concrete during delivery or at Project site. Do not add water to fresh concrete after testing.
- F. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.
- G. Consolidate concrete according to **ACI 301 (ACI 301M)** by mechanical vibrating equipment supplemented by hand spading, rodding, or tamping.
 - 1. Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from joint assemblies[, **reinforcement**,] or side forms. Use only square-faced shovels for hand spreading and consolidation. Consolidate with care to prevent dislocating [**reinforcement**][**dowels**][**and**] joint devices.
- H. Screed paving surface with a straightedge and strike off.
- I. Commence initial floating using bull floats or darbies to impart an open-textured and uniform surface plane before excess moisture or bleedwater appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.
- J. Curbs and Gutters: Use design mixture for automatic machine placement. Produce curbs and gutters to required cross section, lines, grades, finish, and jointing.
- K. Slip-Form Paving: Use design mixture for automatic machine placement. Produce paving to required thickness, lines, grades, finish, and jointing.
 - 1. Compact subbase and prepare subgrade of sufficient width to prevent displacement of slip-form paving machine during operations.

3.7 FLOAT FINISHING

- A. General: Do not add water to concrete surfaces during finishing operations.
- B. Float Finish: Begin the second floating operation when bleedwater sheen has disappeared and concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats or by hand floating if area is small or inaccessible to power units. Finish surfaces to true planes. Cut down high spots and fill low spots. Refloat surface immediately to uniform granular texture.

1. Burlap Finish: Drag a seamless strip of damp burlap across float-finished concrete, perpendicular to line of traffic, to provide a uniform, gritty texture.
2. Medium-to-Fine-Textured Broom Finish: Draw a soft-bristle broom across float-finished concrete surface, perpendicular to line of traffic, to provide a uniform, fine-line texture.
3. Medium-to-Coarse-Textured Broom Finish: Provide a coarse finish by striating float-finished concrete surface **1/16 to 1/8 inch (1.6 to 3 mm)** deep with a stiff-bristled broom, perpendicular to line of traffic.

3.8 SPECIAL FINISHES

- A. Monolithic Exposed-Aggregate Finish: Expose coarse aggregate in paving surface as follows:
 1. Immediately after float finishing, spray-apply chemical surface retarder to paving according to manufacturer's written instructions.
 2. Cover paving surface with plastic sheeting, sealing laps with tape, and remove when ready to continue finishing operations.
 3. Without dislodging aggregate, remove mortar concealing the aggregate by lightly brushing surface with a stiff, nylon-bristle broom. Do not expose more than one-third of the average diameter of the aggregate and not more than one-half of the diameter of the smallest aggregate.
 4. Fine-spray surface with water and brush. Repeat cycle of water flushing and brushing until cement film is removed from aggregate surfaces to depth required.
- B. Seeded Exposed-Aggregate Finish: Immediately after initial floating, spread a single layer of aggregate uniformly on paving surface. Tamp aggregate into plastic concrete and float finish to entirely embed aggregate with mortar cover of **1/16 inch (1.6 mm)**.
 1. Spray-apply chemical surface retarder to paving according to manufacturer's written instructions.
 2. Cover paving surface with plastic sheeting, sealing laps with tape, and remove sheeting when ready to continue finishing operations.
 3. Without dislodging aggregate, remove mortar concealing the aggregate by lightly brushing surface with a stiff, nylon-bristle broom. Do not expose more than one-third of the average diameter of the aggregate and not more than one-half of the diameter of the smallest aggregate.
 4. Fine-spray surface with water and brush. Repeat cycle of water flushing and brushing until cement film is removed from aggregate surfaces to depth required.
- C. Slip-Resistive Aggregate Finish: Before final floating, spread slip-resistive aggregate finish on paving surface according to manufacturer's written instructions and as follows:
 1. Uniformly spread **[25 lb/100 sq. ft. (12 kg/10 sq. m)][40 lb/100 sq. ft. (19.5 kg/10 sq. m)][60 lb/100 sq. ft. (29 kg/10 sq. m)]<Insert rate of application>** of dampened, slip-resistive aggregate over paving surface in two applications. Tamp aggregate flush with surface using a steel trowel, but do not force below surface.
 2. Uniformly distribute approximately two-thirds of slip-resistive aggregate over paving surface with mechanical spreader, allow to absorb moisture, and embed by power floating. Follow power floating with a second slip-resistive aggregate application, uniformly distributing remainder of material at right angles to first application to ensure uniform coverage, and embed by power floating.
 3. Cure concrete with curing compound recommended by slip-resistive aggregate manufacturer. Apply curing compound immediately after final finishing.
 4. After curing, lightly work surface with a steel-wire brush or abrasive stone and water to expose nonslip aggregate.
- D. Rock-Salt Finish: After initial **[floating][troweling][brooming]**, uniformly spread rock salt over paving surface at the rate of **5 lb/100 sq. ft. (0.2 kg/10 sq. m)**.

1. Embed rock salt into plastic concrete with **[roller][or][magnesium float]<Insert tool>**.
 2. Cover paving surface with **1-mil- (0.025-mm-)** thick polyethylene sheet and remove sheet when concrete has hardened and seven-day curing period has elapsed.
 3. After seven-day curing period, saturate concrete with water and broom-sweep surface to dissolve remaining rock salt, thereby leaving pits and holes.
- E. Pigmented Mineral Dry-Shake Hardener Finish: After initial floating, apply dry-shake materials to paving surface according to manufacturer's written instructions and as follows:
1. Uniformly spread dry-shake hardener at a rate of **[100 lb/100 sq. ft. (49 kg/10 sq. m)]<Insert rate of application>** unless greater amount is recommended by manufacturer to match paving color required.
 2. Uniformly distribute approximately two-thirds of dry-shake hardener over the concrete surface with mechanical spreader; allow hardener to absorb moisture and embed it by power floating. Follow power floating with a second application of pigmented mineral dry-shake hardener, uniformly distributing remainder of material at right angles to first application to ensure uniform color, and embed hardener by final power floating.
 3. After final power floating, apply a hand-troweled finish followed by a broom finish.
 4. Cure concrete with curing compound recommended by dry-shake hardener manufacturer. Apply curing compound immediately after final finishing.

3.9 INSTALLATION OF DETECTABLE WARNINGS

- A. Blockouts: Form blockouts in concrete for installation of detectable paving units specified in Section 321726 "Tactile Warning Surfacing."
1. Tolerance for Opening Size: **[Plus 1/4 inch (6 mm), no minus]<Insert requirement>**.
- B. Cast-in-Place Detectable Warning Tiles: Form blockouts in concrete for installation of tiles specified in Section 321726 "Tactile Warning Surfacing." Screed surface of concrete where tiles are to be installed to elevation, so that edges of installed tiles will be flush with surrounding concrete paving. Embed tiles in fresh concrete to comply with Section 321726 "Tactile Warning Surfacing" immediately after screeding concrete surface.
- C. Stamped Detectable Warnings: Install stamped detectable warnings as part of a continuous concrete paving placement and according to stamp-mat manufacturer's written instructions.
1. Before using stamp mats, verify that the vent holes are unobstructed.
 2. Apply liquid release agent to the concrete surface and the stamp mat.
 3. Stamping: **[While initially finished concrete is plastic][After application and final floating of pigmented mineral dry-shake hardener]**, accurately align and place stamp mats in sequence. Uniformly load, gently vibrate, and press mats into concrete to produce imprint pattern on concrete surface. Load and tamp mats directly perpendicular to the stamp-mat surface to prevent distortion in shape of domes. Press and tamp until mortar begins to come through all of the vent holes. Gently remove stamp mats.
 4. Trimming: After **[24]<Insert number>** hours, cut off the tips of mortar formed by the vent holes.
 5. Remove residual release agent according to manufacturer's written instructions, but no fewer than three days after stamping concrete. High-pressure-wash surface and joint patterns, taking care not to damage stamped concrete. Control, collect, and legally dispose of runoff.

3.10 CONCRETE PROTECTION AND CURING

- A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.

- B. Comply with ACI 306.1 for cold-weather protection.
- C. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching **0.2 lb/sq. ft. x h (1 kg/sq. m x h)** before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete but before float finishing.
- D. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.
- E. Curing Methods: Cure concrete by **[moisture curing][moisture-retaining-cover curing][curing compound][or][a combination of these]** as follows:
 - 1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:
 - a. Water.
 - b. Continuous water-fog spray.
 - c. Absorptive cover, water saturated and kept continuously wet. Cover concrete surfaces and edges with **12-inch (300-mm)** lap over adjacent absorptive covers.
 - 2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover, placed in widest practicable width, with sides and ends lapped at least **12 inches (300 mm)**, and sealed by waterproof tape or adhesive. Immediately repair any holes or tears occurring during installation or curing period, using cover material and waterproof tape.
 - 3. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating, and repair damage during curing period.

3.11 PAVING TOLERANCES

- A. Comply with tolerances in **ACI 117 (ACI 117M)** and as follows:
 - 1. Elevation: **3/4 inch (19 mm)**.
 - 2. Thickness: Plus **3/8 inch (10 mm)**, minus **1/4 inch (6 mm)**.
 - 3. Surface: Gap below **10-feet- (3-m-)** long; unleveled straightedge not to exceed **1/2 inch (13 mm)**.
 - 4. Alignment of Tie-Bar End Relative to Line Perpendicular to Paving Edge: **1/2 inch per 12 inches (13 mm per 300 mm)** of tie bar.
 - 5. Lateral Alignment and Spacing of Dowels: **1 inch (25 mm)**.
 - 6. Vertical Alignment of Dowels: **1/4 inch (6 mm)**.
 - 7. Alignment of Dowel-Bar End Relative to Line Perpendicular to Paving Edge: **1/4 inch per 12 inches (6 mm per 300 mm)** of dowel.
 - 8. Joint Spacing: **3 inches (75 mm)**.
 - 9. Contraction Joint Depth: Plus **1/4 inch (6 mm)**, no minus.
 - 10. Joint Width: Plus **1/8 inch (3 mm)**, no minus.

3.12 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Testing Services: Testing and inspecting of composite samples of fresh concrete obtained according to ASTM C172/C172M will be performed according to the following requirements:

1. Testing Frequency: Obtain at least one composite sample for each [100 cu. yd. (76 cu. m)][5000 sq. ft. (465 sq. m)] or fraction thereof of each concrete mixture placed each day.
 - a. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing to be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
 2. Slump: ASTM C143/C143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture. Perform additional tests when concrete consistency appears to change.
 3. Air Content: ASTM C231/C231M, pressure method; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
 4. Concrete Temperature: ASTM C1064/C1064M; one test hourly when air temperature is **40 deg F (4.4 deg C)** and below and when it is **80 deg F (27 deg C)** and above, and one test for each composite sample.
 5. Compression Test Specimens: ASTM C31/C31M; cast and laboratory cure one set of three standard cylinder specimens for each composite sample.
 6. Compressive-Strength Tests: ASTM C39/C39M; test one specimen at seven days and two specimens at 28 days.
 - a. A compressive-strength test to be the average compressive strength from two specimens obtained from same composite sample and tested at 28 days.
 - C. Strength of each concrete mixture will be satisfactory if average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than **500 psi (3.4 MPa)**.
 - D. Test results to be reported in writing to Architect, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests to contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.
 - E. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect but will not be used as sole basis for approval or rejection of concrete.
 - F. Additional Tests: Testing and inspecting agency will make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Architect.
 - G. Concrete paving will be considered defective if it does not pass tests and inspections.
 - H. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
 - I. Prepare test and inspection reports.
- 3.13 REPAIR AND PROTECTION
- A. Remove and replace concrete paving that is broken, damaged, or defective or that does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved by Architect.
 - B. Drill test cores, where directed by Architect, when necessary to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory paving areas with portland cement concrete

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bonded to paving with epoxy adhesive.

- C. Protect concrete paving from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.
- D. Maintain concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep paving not more than two days before date scheduled for Substantial Completion inspections.

END OF SECTION 32 13 13 00



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Task	Specification	Specification Description
32 13 13 33	32 13 13 00	Concrete Paving
32 13 13 33	32 13 16 00	Decorative Concrete Paving



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SECTION 32 13 16 00 - DECORATIVE CONCRETE PAVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Colored concrete paving.
2. Stamped concrete paving.
3. Stenciled concrete paving.
4. Stained concrete paving.

B. Related Requirements:

1. **[Section 033000 "Cast-in-Place Concrete"]**[Section 033053 "Miscellaneous Cast-in-Place Concrete"] for general building applications of concrete.
2. Section 321313 "Concrete Paving" for cast-in-place concrete paving with other finishes, curbs and gutters, and stamped detectable warnings.
3. Section 321373 "Concrete Paving Joint Sealants" for joint sealants in expansion and contraction joints within decorative concrete paving and in joints between decorative concrete paving and other paving or adjacent construction.

1.2 DEFINITIONS

- A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, fly ash, slag cement, and other pozzolans.
- B. W/C Ratio: The ratio by weight of water to cementitious materials.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at **[Project site]**<Insert location>.

1. Review methods and procedures related to decorative concrete paving, including but not limited to, the following:
 - a. Concrete mixture design.
 - b. Quality control of concrete materials and decorative concrete paving construction practices.
 - c. <Insert agenda item>.
2. Require representatives of each entity directly concerned with decorative concrete paving to attend, including the following:
 - a. Contractor's superintendent.
 - b. Independent testing agency responsible for concrete design mixtures.
 - c. Ready-mix concrete manufacturer.
 - d. Decorative concrete paving Installer.
 - e. Manufacturer's representative of decorative concrete paving system.

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1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Sustainable Design Submittals:
 - 1. Product Data: For recycled content, indicating postconsumer and preconsumer recycled content and cost.
 - 2. Product Certificates: For regional materials, indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project and cost for each regional material.
 - 3. Environmental Product Declaration (EPD): For each product.
 - 4. Product Certificates: For indigenous materials, indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project, means of transportation, and cost for each indigenous material.
 - 5. Environmental Product Declaration: For each product.
 - 6. Product Certificates: For regional materials, indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project, means of transportation, and cost for each regional material.
 - 7. Environmental Product Declaration: For each product.
 - 8. Environmental Product Declaration: For each product.
 - 9. Third-Party Certifications: For each product.
 - 10. Third-Party Certified Life Cycle Assessment: For each product.
- C. Samples for Initial Selection: For each type of product, ingredient, or admixture requiring color, pattern, or texture selection.
- D. Samples for Verification: For each type of exposed color, pattern, or texture indicated.
- E. Design Mixtures: For each decorative concrete paving mixture. Include alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified **[Installer][ready-mix concrete manufacturer][and][testing agency]**.
- B. Material Certificates: For the following, from manufacturer:
 - 1. Cementitious materials.
 - 2. Steel reinforcement and reinforcement accessories.
 - 3. Fiber reinforcement.
 - 4. Admixtures.
 - 5. Curing compounds.
 - 6. Applied finish materials.
 - 7. Bonding agent or epoxy adhesive.
 - 8. Joint fillers.
- C. Material Test Reports: For each of the following:
 - 1. Aggregates. **[Include service-record data indicating absence of deleterious expansion of concrete due to alkali-aggregate reactivity.]**
- D. Field quality-control reports.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: An employer of workers trained and approved by manufacturer of decorative concrete paving systems.
- B. Ready-Mix-Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C94/C94M requirements for production facilities and equipment.
 - 1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities" (Quality Control Manual - Section 3, "Plant Certification Checklist").
- C. Testing Agency Qualifications: Qualified according to ASTM C1077 and ASTM E329 for testing indicated.
 - 1. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-1 or an equivalent certification program.
- D. Mockups: Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.
 - 1. Build mockups of full-thickness sections of decorative concrete paving to demonstrate typical joints; surface color, pattern, and texture; curing; and standard of workmanship.
 - 2. Build mockups of decorative concrete paving in the location and of the size indicated or, if not indicated, build mockups where directed by Architect and not less than **[96 inches (2400 mm) by 96 inches (2400 mm)]<Insert dimensions>**.
 - 3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
 - 4. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.7 PRECONSTRUCTION TESTING

- A. Preconstruction Testing Service: Engage a qualified independent testing agency to perform preconstruction testing on decorative concrete paving mixtures.

1.8 FIELD CONDITIONS

- A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.
- B. Cold-Weather Concrete Placement: Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing, or low temperatures. Comply with ACI 306.1 and the following:
 - 1. When air temperature has fallen to or is expected to fall below **40 deg F (4.4 deg C)**, uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than **50 deg F (10 deg C)** and not more than **80 deg F (27 deg C)** at point of placement.
 - 2. Do not use frozen materials or materials containing ice or snow.
 - 3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in design mixtures.
- C. Hot-Weather Concrete Placement: Comply with **ACI 301 (ACI 301M)** and as follows when hot-weather conditions exist:

1. Cool ingredients before mixing to maintain concrete temperature below **90 deg F (32 deg C)** at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated in total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
2. Cover steel reinforcement with water-soaked burlap, so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
3. Fog-spray forms[, **steel reinforcement**,] and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

PART 2 - PRODUCTS

2.1 CONCRETE, GENERAL

- A. ACI Publications: Comply with **ACI 301 (ACI 301M)** unless otherwise indicated.

2.2 FORMS

- A. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, and smooth exposed surfaces.
 1. Use flexible or uniformly curved forms for curves of a radius of **100 feet (30.5 m)** or less. [**Do not use notched and bent forms.**]
- B. Forms for Textured Finish Concrete: Units of face design, size, arrangement, and configuration indicated. Provide solid backing and form supports to ensure stability of textured form liners.
- C. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and that will not impair subsequent treatments of concrete surfaces.

2.3 STEEL REINFORCEMENT

- A. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than **[25][60]<Insert value>** percent.
- B. Plain-Steel Welded-Wire Reinforcement: ASTM A1064/A1064M, fabricated from as-drawn steel wire into flat sheets.
- C. Reinforcing Bars: ASTM A615/A615M, **Grade 60 (Grade 420)**; deformed.
- D. Steel Bar Mats: ASTM A184/A184M; with ASTM A615/A615M, **Grade 60 (Grade 420)** deformed bars; assembled with clips.
- E. Plain-Steel Wire: ASTM A1064/A1064M, as drawn.
- F. Joint Dowel Bars: ASTM A615/A615M, **Grade 60 (Grade 420)** plain-steel bars. Cut bars true to length with ends square and free of burrs.
- G. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars, welded-wire reinforcement, and dowels in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete of greater

compressive strength than concrete specified, and as follows:

1. Equip wire bar supports with sand plates or horizontal runners where base material will not support chair legs.

2.4 CONCRETE MATERIALS

- A. Regional Materials: Concrete shall be manufactured within **500 miles (800 km)** of Project site from aggregates[**and cementitious materials**] that have been extracted, harvested, or recovered, as well as manufactured, within **500 miles (800 km)** of Project site.
- B. Regional Materials: Concrete shall be manufactured within **500 miles (800 km)** of Project site.
- C. Regional Materials: Concrete shall be manufactured within **100 miles (160 km)** of Project site from aggregates[**and cementitious materials**] that have been extracted, harvested, or recovered, as well as manufactured, within **100 miles (160 km)** of Project site.
- D. Indigenous Materials: Concrete shall be manufactured within **500 miles (800 km)** of Project site from aggregates[**and cementitious materials**] that have been extracted, harvested, or recovered, as well as manufactured, within **500 miles (800 km)** of Project site. If materials are transported by rail or water, the distance transported by rail or water shall be multiplied by 0.25 to determine the distance to Project site.
- E. Regional Materials: Concrete shall be manufactured within **500 miles (800 km)** of Project site from aggregates[**and cementitious materials**] that have been extracted, harvested, or recovered, as well as manufactured, within **500 miles (800 km)** of Project site. If materials are transported by rail or water, the distance transported by rail or water shall be multiplied by 0.25 to determine the distance to Project site.
- F. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, obtain aggregate from single source, and obtain admixtures from single source from single manufacturer.
- G. Cementitious Materials:
 1. Portland Cement: ASTM C150/C150M, [gray][white] portland cement [Type I][Type II][Type I/II][Type III][Type V].
 2. Fly Ash: ASTM C618, Class C or F.
 3. Slag Cement: ASTM C989/C989M, Grade 100 or 120.
 4. Blended Hydraulic Cement: ASTM C595/C595M, [Type IS, portland blast-furnace slag][Type IP, portland-pozzolan][Type IL, Portland-limestone][Type IT, ternary blended] cement.
- H. Normal-Weight Aggregates: ASTM C33/C33M, [Class 4S][Class 4M][Class 1N]<Insert class>, uniformly graded. Provide aggregates from a single source[**with documented service-record data of at least 10 years' satisfactory service in similar paving applications and service conditions using similar aggregates and cementitious materials**].
 1. Maximum Coarse-Aggregate Size: [1-1/2 inches (38 mm)][1 inch (25 mm)][3/4 inch (19 mm)]<Insert dimension> nominal.
 2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.
- I. Air-Entraining Admixture: ASTM C260/C260M.
- J. Chemical Admixtures: Admixtures certified by manufacturer to be compatible with other admixtures and to contain not more than 0.1 percent water-soluble chloride ions by mass of cementitious material.
 1. Water-Reducing Admixture: ASTM C494/C494M, Type A[, colored].

2. Water-Reducing and Retarding Admixture: ASTM C494/C494M, Type D[, **colored**].
 3. Water-Reducing and Accelerating Admixture: ASTM C494/C494M, Type E.
- K. Color Pigment: ASTM C979/C979M, synthetic mineral-oxide pigments or colored water-reducing admixtures; color stable[, **free of carbon black**,] nonfading, and resistant to lime and other alkalis.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Alabama Pigments Company, LLC]**
 - b. **[Bon Tool Co.]**
 - c. **[Brickform; a division of Solomon Colors]**
 - d. **[Butterfield Color, Inc.]**
 - e. **[Dynamic Color Solutions, Inc]**
 - f. **[Euclid Chemical Company (The); a subsidiary of RPM International, Inc.]**
 - g. **[Hoover Color Corporation]**
 - h. **[Lambert Corporation]**
 - i. **[Lanxess Corporation]**
 - j. **[Matcrete Inc.]**
 - k. **[NewLook International, Inc.]**
 - l. **[Proline Concrete Tools, Inc.]**
 - m. **[QC Construction Products]**
 - n. **[Scofield, a Business Unit of Sika Corporation]**
 - o. **[Solomon Colors Inc.]**
 - p. **[Stampcrete International, Ltd]**
 - q. **[SureCrete Design Products, a Fenix Group SPC Company]**
 - r. **[Venator Materials PLC]**
 - s. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Alabama Pigments Company, LLC]**
 - b. **[Bon Tool Co.]**
 - c. **[Brickform; a division of Solomon Colors]**
 - d. **[Butterfield Color, Inc.]**
 - e. **[Dynamic Color Solutions, Inc]**
 - f. **[Euclid Chemical Company (The); a subsidiary of RPM International, Inc.]**
 - g. **[Hoover Color Corporation]**
 - h. **[Lambert Corporation]**
 - i. **[Lanxess Corporation]**
 - j. **[Matcrete Inc.]**
 - k. **[NewLook International, Inc.]**
 - l. **[Proline Concrete Tools, Inc.]**
 - m. **[QC Construction Products]**
 - n. **[Scofield, a Business Unit of Sika Corporation]**
 - o. **[Solomon Colors Inc.]**
 - p. **[Stampcrete International, Ltd]**
 - q. **[SureCrete Design Products, a Fenix Group SPC Company]**
 - r. **[Venator Materials PLC]**
 - s. **<Insert manufacturer's name>**

- L. Water: Potable and complying with ASTM C94/C94M.

2.5 FIBER REINFORCEMENT

- A. Synthetic Fiber, Monofilament Fibers: Monofilament polypropylene fibers engineered and designed for use in decorative concrete paving, complying with ASTM C1116/C1116M, Type III, [1/2 to 1-1/2 inches (13 to 38 mm)]<Insert dimensions> long.

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Euclid Chemical Company (The); a subsidiary of RPM International, Inc.]
 - b. [FORTA Corporation]
 - c. [FullForce by ABC Polymer Industries, LLC]
 - d. [GCP Applied Technologies Inc.]
 - e. [Nycon Corporation]
 - f. [Propex Operating Company, LLC]
 - g. [Sika Corporation]
 - h. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Euclid Chemical Company (The); a subsidiary of RPM International, Inc.]
 - b. [FORTA Corporation]
 - c. [FullForce by ABC Polymer Industries, LLC]
 - d. [GCP Applied Technologies Inc.]
 - e. [Nycon Corporation]
 - f. [Propex Operating Company, LLC]
 - g. [Sika Corporation]
 - h. <Insert manufacturer's name>

- B. Synthetic Fiber, Fibrillated Fibers: Fibrillated polypropylene fibers engineered and designed for use in decorative concrete paving, complying with ASTM C1116/C1116M, Type III, [1/2 to 1-1/2 inches (13 to 38 mm)]<Insert dimensions> long.

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Euclid Chemical Company (The); a subsidiary of RPM International, Inc.]
 - b. [FORTA Corporation]
 - c. [FullForce by ABC Polymer Industries, LLC]
 - d. [GCP Applied Technologies Inc.]
 - e. [Nycon Corporation]
 - f. [Propex Operating Company, LLC]
 - g. [Sika Corporation]
 - h. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the

following:

- a. [Euclid Chemical Company (The); a subsidiary of RPM International, Inc.]
- b. [FORTA Corporation]
- c. [FullForce by ABC Polymer Industries, LLC]
- d. [GCP Applied Technologies Inc.]
- e. [Nycon Corporation]
- f. [Propex Operating Company, LLC]
- g. [Sika Corporation]
- h. <Insert manufacturer's name>

2.6 SURFACE COLORING MATERIALS

- A. Pigmented Mineral Dry-Shake Hardener: Factory-packaged, dry combination of portland cement, graded quartz aggregate, color pigments, and plasticizing admixture. Use color pigments that are finely ground, nonfading mineral oxides interground with cement.

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

- a. [Anti-Hydro International, Inc]
- b. [Artcrete, Inc]
- c. [Bomanite Co]
- d. [Bon Tool Co.]
- e. [Brickform; a division of Solomon Colors]
- f. [Butterfield Color, Inc.]
- g. [Decosup Inc.]
- h. [Dynamic Color Solutions, Inc]
- i. [Euclid Chemical Company (The); a subsidiary of RPM International, Inc.]
- j. [H&C Decorative Concrete Products; a brand of Sherwin-Williams Co.]
- k. [Kaufman Products, Inc]
- l. [Lambert Corporation]
- m. [Laticrete International, Inc.]
- n. [Metalcrete Industries]
- o. [Proline Concrete Tools, Inc.]
- p. [QC Construction Products]
- q. [Scofield, a Business Unit of Sika Corporation]
- r. [Specialty Concrete Products, Inc]
- s. [Stampcrete International, Ltd]
- t. [Super Stone, Inc.]
- u. [SureCrete Design Products, a Fenix Group SPC Company]
- v. <Insert manufacturer's name>

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

- a. [Anti-Hydro International, Inc]
- b. [Artcrete, Inc]
- c. [Bomanite Co]
- d. [Bon Tool Co.]
- e. [Brickform; a division of Solomon Colors]

- f. [Butterfield Color, Inc.]
 - g. [Decosup Inc.]
 - h. [Dynamic Color Solutions, Inc.]
 - i. [Euclid Chemical Company (The); a subsidiary of RPM International, Inc.]
 - j. [H&C Decorative Concrete Products; a brand of Sherwin-Williams Co.]
 - k. [Kaufman Products, Inc.]
 - l. [Lambert Corporation]
 - m. [Laticrete International, Inc.]
 - n. [Metalcrete Industries]
 - o. [Proline Concrete Tools, Inc.]
 - p. [QC Construction Products]
 - q. [Scofield, a Business Unit of Sika Corporation]
 - r. [Specialty Concrete Products, Inc.]
 - s. [Stampcrete International, Ltd]
 - t. [Super Stone, Inc.]
 - u. [SureCrete Design Products, a Fenix Group SPC Company]
 - v. <Insert manufacturer's name>
- B. Pigmented Powder Release Agent: Factory-packaged, dry combination of surface-conditioning and dispersing agents interground with color pigments that facilitates release of stamp mats. Use color pigments that are finely ground, nonfading mineral oxides interground with cement.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. [Advanced Surfaces Inc.]
 - b. [Artcrete, Inc]
 - c. [Bomanite Co]
 - d. [Bon Tool Co.]
 - e. [Brickform; a division of Solomon Colors]
 - f. [Butterfield Color, Inc.]
 - g. [Decosup Inc.]
 - h. [Dynamic Color Solutions, Inc]
 - i. [H&C Decorative Concrete Products; a brand of Sherwin-Williams Co.]
 - j. [Proline Concrete Tools, Inc.]
 - k. [QC Construction Products]
 - l. [Scofield, a Business Unit of Sika Corporation]
 - m. [Specialty Concrete Products, Inc]
 - n. [Stampcrete International, Ltd]
 - o. [Super Stone, Inc.]
 - p. [SureCrete Design Products, a Fenix Group SPC Company]
 - q. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. [Advanced Surfaces Inc.]
 - b. [Artcrete, Inc]
 - c. [Bomanite Co]
 - d. [Bon Tool Co.]
 - e. [Brickform; a division of Solomon Colors]
 - f. [Butterfield Color, Inc.]
 - g. [Decosup Inc.]

- h. [Dynamic Color Solutions, Inc]
- i. [H&C Decorative Concrete Products; a brand of Sherwin-Williams Co.]
- j. [Proline Concrete Tools, Inc.]
- k. [QC Construction Products]
- l. [Scofield, a Business Unit of Sika Corporation]
- m. [Specialty Concrete Products, Inc]
- n. [Stampcrete International, Ltd]
- o. [Super Stone, Inc.]
- p. [SureCrete Design Products, a Fenix Group SPC Company]
- q. <Insert manufacturer's name>

C. Liquid Release Agent: Manufacturer's standard, clear, evaporating formulation that facilitates release of stamp mats and texture rollers.

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

- a. [Advanced Surfaces Inc.]
- b. [Artcrete, Inc]
- c. [Bon Tool Co.]
- d. [Brickform; a division of Solomon Colors]
- e. [Butterfield Color, Inc.]
- f. [Decosup Inc.]
- g. [Matcrete Inc.]
- h. [Proline Concrete Tools, Inc.]
- i. [QC Construction Products]
- j. [Scofield, a Business Unit of Sika Corporation]
- k. [Specialty Concrete Products, Inc]
- l. [Stampcrete International, Ltd]
- m. [Super Stone, Inc.]
- n. <Insert manufacturer's name>

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

- a. [Advanced Surfaces Inc.]
- b. [Artcrete, Inc]
- c. [Bon Tool Co.]
- d. [Brickform; a division of Solomon Colors]
- e. [Butterfield Color, Inc.]
- f. [Decosup Inc.]
- g. [Matcrete Inc.]
- h. [Proline Concrete Tools, Inc.]
- i. [QC Construction Products]
- j. [Scofield, a Business Unit of Sika Corporation]
- k. [Specialty Concrete Products, Inc]
- l. [Stampcrete International, Ltd]
- m. [Super Stone, Inc.]
- n. <Insert manufacturer's name>

2.7 STAMPING DEVICES

- A. Stamp Mats: Semirigid polyurethane mats with projecting textured and ridged underside capable of imprinting texture and joint patterns on plastic concrete.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Advanced Surfaces Inc.]**
 - b. **[Bomanite Co]**
 - c. **[Bon Tool Co.]**
 - d. **[Brickform; a division of Solomon Colors]**
 - e. **[Butterfield Color, Inc.]**
 - f. **[Matcrete Inc.]**
 - g. **[Proline Concrete Tools, Inc.]**
 - h. **[Scofield, a Business Unit of Sika Corporation]**
 - i. **[Specialty Concrete Products, Inc]**
 - j. **[Stampcrete International, Ltd]**
 - k. **[Super Stone, Inc.]**
 - l. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Advanced Surfaces Inc.]**
 - b. **[Bomanite Co]**
 - c. **[Bon Tool Co.]**
 - d. **[Brickform; a division of Solomon Colors]**
 - e. **[Butterfield Color, Inc.]**
 - f. **[Matcrete Inc.]**
 - g. **[Proline Concrete Tools, Inc.]**
 - h. **[Scofield, a Business Unit of Sika Corporation]**
 - i. **[Specialty Concrete Products, Inc]**
 - j. **[Stampcrete International, Ltd]**
 - k. **[Super Stone, Inc.]**
 - l. **<Insert manufacturer's name>**
- B. Stamp Tools: Open-grid, aluminum or rigid-plastic stamp tool capable of imprinting joint patterns on plastic concrete.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Matcrete Inc.]**
 - b. **[Scofield, a Business Unit of Sika Corporation]**
 - c. **[Super Stone, Inc.]**
 - d. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

- a. **[Matcrete Inc.]**
- b. **[Scofield, a Business Unit of Sika Corporation]**
- c. **[Super Stone, Inc.]**
- d. **<Insert manufacturer's name>**

C. Rollers: Manually controlled, water-filled aluminum rollers with projecting ridges on drum capable of imprinting texture and joint patterns on plastic concrete.

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

- a. **[Bon Tool Co.]**
- b. **<Insert manufacturer's name>**

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

- a. **[Bon Tool Co.]**
- b. **<Insert manufacturer's name>**

D. Texture Rollers: Manually controlled, abrasion-resistant polyurethane rollers capable of imprinting texture on plastic concrete.

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

- a. **[Artcrete, Inc]**
- b. **[Bon Tool Co.]**
- c. **[Butterfield Color, Inc.]**
- d. **[Proline Concrete Tools, Inc.]**
- e. **<Insert manufacturer's name>**

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

- a. **[Artcrete, Inc]**
- b. **[Bon Tool Co.]**
- c. **[Butterfield Color, Inc.]**
- d. **[Proline Concrete Tools, Inc.]**
- e. **<Insert manufacturer's name>**

2.8 STENCIL MATERIALS

A. Stencils: Manufacturer's standard, moisture-resistant paper or reusable plastic stencils, designed for use on plastic concrete.

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

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

- a. [Artcrete, Inc]
 - b. [Bon Tool Co.]
 - c. [Brickform; a division of Solomon Colors]
 - d. [Butterfield Color, Inc.]
 - e. [Specialty Concrete Products, Inc]
 - f. [SureCrete Design Products, a Fenix Group SPC Company]
 - g. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Artcrete, Inc]
 - b. [Bon Tool Co.]
 - c. [Brickform; a division of Solomon Colors]
 - d. [Butterfield Color, Inc.]
 - e. [Specialty Concrete Products, Inc]
 - f. [SureCrete Design Products, a Fenix Group SPC Company]
 - g. <Insert manufacturer's name>

2.9 STAIN MATERIALS

- A. Reactive Stain: Acidic-based stain with wetting agents and high-grade, UV-stable metallic salts that react with calcium hydroxide in cured concrete to produce permanent, variegated, or translucent color effects.

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Americrete, Inc.]
 - b. [Artcrete, Inc]
 - c. [Bomanite Co]
 - d. [Bon Tool Co.]
 - e. [Brickform; a division of Solomon Colors]
 - f. [Butterfield Color, Inc.]
 - g. [Decosup Inc.]
 - h. [EPMAR Corporation; a Quaker Houghton company]
 - i. [H&C Decorative Concrete Products; a brand of Sherwin-Williams Co.]
 - j. [QC Construction Products]
 - k. [Scofield, a Business Unit of Sika Corporation]
 - l. [Specialty Concrete Products, Inc]
 - m. [Stampcrete International, Ltd]
 - n. [Super Stone, Inc.]
 - o. [SureCrete Design Products, a Fenix Group SPC Company]
 - p. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [Americrete, Inc.]
- b. [Artcrete, Inc]
- c. [Bomanite Co]
- d. [Bon Tool Co.]
- e. [Brickform; a division of Solomon Colors]
- f. [Butterfield Color, Inc.]
- g. [Decosup Inc.]
- h. [EPMAR Corporation; a Quaker Houghton company]
- i. [H&C Decorative Concrete Products; a brand of Sherwin-Williams Co.]
- j. [QC Construction Products]
- k. [Scofield, a Business Unit of Sika Corporation]
- l. [Specialty Concrete Products, Inc]
- m. [Stampcrete International, Ltd]
- n. [Super Stone, Inc.]
- o. [SureCrete Design Products, a Fenix Group SPC Company]
- p. <Insert manufacturer's name>

B. Penetrating Stain: Water-based, acrylic latex, penetrating stain with colorfast pigments.

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. [Americrete, Inc.]
 - b. [AmeriPolish]
 - c. [Bomanite Co]
 - d. [Bon Tool Co.]
 - e. [Brickform; a division of Solomon Colors]
 - f. [Butterfield Color, Inc.]
 - g. [Duckback Products]
 - h. [H&C Decorative Concrete Products; a brand of Sherwin-Williams Co.]
 - i. [Scofield, a Business Unit of Sika Corporation]
 - j. [Super Stone, Inc.]
 - k. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. [Americrete, Inc.]
 - b. [AmeriPolish]
 - c. [Bomanite Co]
 - d. [Bon Tool Co.]
 - e. [Brickform; a division of Solomon Colors]
 - f. [Butterfield Color, Inc.]
 - g. [Duckback Products]
 - h. [H&C Decorative Concrete Products; a brand of Sherwin-Williams Co.]
 - i. [Scofield, a Business Unit of Sika Corporation]
 - j. [Super Stone, Inc.]
 - k. <Insert manufacturer's name>

2.10 CURING AND SEALING MATERIALS

- A. Curing Paper: Nonstaining, waterproof paper, consisting of two layers of kraft paper cemented together and reinforced with fiber, and complying with ASTM C171.
- B. Evaporation Retarder: Waterborne, monomolecular, film forming, manufactured for application to fresh concrete.
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Bon Tool Co.]**
 - b. **[Brickform; a division of Solomon Colors]**
 - c. **[ChemMasters, Inc]**
 - d. **[Dayton Superior Corporation]**
 - e. **[Euclid Chemical Company (The); a subsidiary of RPM International, Inc.]**
 - f. **[Kaufman Products, Inc]**
 - g. **[Lambert Corporation]**
 - h. **[Laticrete International, Inc.]**
 - i. **[Metalcrete Industries]**
 - j. **[Nox-Crete Products Group]**
 - k. **[Sika Corporation]**
 - l. **[SpecChem, LLC]**
 - m. **[TK Products Construction Coatings, a Fenix Group SPC Company]**
 - n. **[Vexcon Chemicals Inc.]**
 - o. **[W. R. Meadows, Inc]**
 - p. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Bon Tool Co.]**
 - b. **[Brickform; a division of Solomon Colors]**
 - c. **[ChemMasters, Inc]**
 - d. **[Dayton Superior Corporation]**
 - e. **[Euclid Chemical Company (The); a subsidiary of RPM International, Inc.]**
 - f. **[Kaufman Products, Inc]**
 - g. **[Lambert Corporation]**
 - h. **[Laticrete International, Inc.]**
 - i. **[Metalcrete Industries]**
 - j. **[Nox-Crete Products Group]**
 - k. **[Sika Corporation]**
 - l. **[SpecChem, LLC]**
 - m. **[TK Products Construction Coatings, a Fenix Group SPC Company]**
 - n. **[Vexcon Chemicals Inc.]**
 - o. **[W. R. Meadows, Inc]**
 - p. **<Insert manufacturer's name>**
- C. Waterborne, Membrane-Forming, Curing Compound: ASTM C309, Type 1, Class B, nondissipating, non-yellowing, manufactured for use with colored concrete.
 - 1. Curing compound shall be pigmented type matching color of integrally colored concrete and shall be approved by coloring admixture manufacturer.

2. For concrete indicated to be sealed, curing compound shall be compatible with sealer.
 3. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Anti-Hydro International, Inc]**
 - b. **[ChemMasters, Inc]**
 - c. **[Dayton Superior Corporation]**
 - d. **[Euclid Chemical Company (The); a subsidiary of RPM International, Inc.]**
 - e. **[Kaufman Products, Inc]**
 - f. **[Lambert Corporation]**
 - g. **[Laticrete International, Inc.]**
 - h. **[Metalcrete Industries]**
 - i. **[Nox-Crete Products Group]**
 - j. **[SpecChem, LLC]**
 - k. **[TK Products Construction Coatings, a Fenix Group SPC Company]**
 - l. **[Vexcon Chemicals Inc.]**
 - m. **[W. R. Meadows, Inc]**
 - n. **<Insert manufacturer's name>**
 4. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Anti-Hydro International, Inc]**
 - b. **[ChemMasters, Inc]**
 - c. **[Dayton Superior Corporation]**
 - d. **[Euclid Chemical Company (The); a subsidiary of RPM International, Inc.]**
 - e. **[Kaufman Products, Inc]**
 - f. **[Lambert Corporation]**
 - g. **[Laticrete International, Inc.]**
 - h. **[Metalcrete Industries]**
 - i. **[Nox-Crete Products Group]**
 - j. **[SpecChem, LLC]**
 - k. **[TK Products Construction Coatings, a Fenix Group SPC Company]**
 - l. **[Vexcon Chemicals Inc.]**
 - m. **[W. R. Meadows, Inc]**
 - n. **<Insert manufacturer's name>**
- D. High-Solids, Waterborne, Membrane-Forming, Curing Compound: ASTM C309, Type 1, Class B, 18 to 25 percent solids, nondissipating, non-yellowing, manufactured for use with colored concrete.
1. Curing compound shall be pigmented type matching color of integrally colored concrete and shall be approved by coloring admixture manufacturer.
 2. For concrete indicated to be sealed, curing compound shall be compatible with sealer.
 3. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ChemMasters, Inc]**
 - b. **[Dayton Superior Corporation]**
 - c. **[Euclid Chemical Company (The); a subsidiary of RPM International, Inc.]**
 - d. **[Kaufman Products, Inc]**

- e. [Lambert Corporation]
 - f. [Laticrete International, Inc.]
 - g. [Metalcrete Industries]
 - h. [Nox-Crete Products Group]
 - i. [SpecChem, LLC]
 - j. [V-Seal Concrete Sealers & Specialty Coatings]
 - k. [Vexcon Chemicals Inc.]
 - l. [W. R. Meadows, Inc]
 - m. <Insert manufacturer's name>
4. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [ChemMasters, Inc]
 - b. [Dayton Superior Corporation]
 - c. [Euclid Chemical Company (The); a subsidiary of RPM International, Inc.]
 - d. [Kaufman Products, Inc]
 - e. [Lambert Corporation]
 - f. [Laticrete International, Inc.]
 - g. [Metalcrete Industries]
 - h. [Nox-Crete Products Group]
 - i. [SpecChem, LLC]
 - j. [V-Seal Concrete Sealers & Specialty Coatings]
 - k. [Vexcon Chemicals Inc.]
 - l. [W. R. Meadows, Inc]
 - m. <Insert manufacturer's name>
- E. Clear, Solvent-Borne, Membrane-Forming, Curing and Sealing Compound: ASTM C1315, Type 1, Class A, manufactured for use with colored concrete.
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
- a. [ChemMasters, Inc]
 - b. [Concrete Sealers USA]
 - c. [Dayton Superior Corporation]
 - d. [Euclid Chemical Company (The); a subsidiary of RPM International, Inc.]
 - e. [Kaufman Products, Inc]
 - f. [Lambert Corporation]
 - g. [Laticrete International, Inc.]
 - h. [Metalcrete Industries]
 - i. [Nox-Crete Products Group]
 - j. [Right Pointe]
 - k. [SpecChem, LLC]
 - l. [TK Products Construction Coatings, a Fenix Group SPC Company]
 - m. [Vexcon Chemicals Inc.]
 - n. [W. R. Meadows, Inc]
 - o. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. [ChemMasters, Inc]
 - b. [Concrete Sealers USA]
 - c. [Dayton Superior Corporation]
 - d. [Euclid Chemical Company (The); a subsidiary of RPM International, Inc.]
 - e. [Kaufman Products, Inc]
 - f. [Lambert Corporation]
 - g. [Laticrete International, Inc.]
 - h. [Metalcrete Industries]
 - i. [Nox-Crete Products Group]
 - j. [Right Pointe]
 - k. [SpecChem, LLC]
 - l. [TK Products Construction Coatings, a Fenix Group SPC Company]
 - m. [Vexcon Chemicals Inc.]
 - n. [W. R. Meadows, Inc]
 - o. <Insert manufacturer's name>
3. Products shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 4. Products shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 5. Products shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 16.5 mcg/cu. m or 13.5 ppb, whichever is less.
 6. Products shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 7. Products shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- F. Clear, Waterborne, Membrane-Forming, Curing and Sealing Compound: ASTM C1315, Type 1, Class A, manufactured for use with colored concrete.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. [ChemMasters, Inc]
 - b. [Concrete Sealers USA]
 - c. [Dayton Superior Corporation]
 - d. [Euclid Chemical Company (The); a subsidiary of RPM International, Inc.]
 - e. [Kaufman Products, Inc]
 - f. [Lambert Corporation]
 - g. [Laticrete International, Inc.]
 - h. [Metalcrete Industries]
 - i. [Nox-Crete Products Group]
 - j. [Right Pointe]
 - k. [SpecChem, LLC]
 - l. [TK Products Construction Coatings, a Fenix Group SPC Company]
 - m. [Vexcon Chemicals Inc.]
 - n. [W. R. Meadows, Inc]

- o. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [ChemMasters, Inc]
 - b. [Concrete Sealers USA]
 - c. [Dayton Superior Corporation]
 - d. [Euclid Chemical Company (The); a subsidiary of RPM International, Inc.]
 - e. [Kaufman Products, Inc]
 - f. [Lambert Corporation]
 - g. [Laticrete International, Inc.]
 - h. [Metalcrete Industries]
 - i. [Nox-Crete Products Group]
 - j. [Right Pointe]
 - k. [SpecChem, LLC]
 - l. [TK Products Construction Coatings, a Fenix Group SPC Company]
 - m. [Vexcon Chemicals Inc.]
 - n. [W. R. Meadows, Inc]
 - o. <Insert manufacturer's name>
 3. Products shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 4. Products shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 5. Products shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 16.5 mcg/cu. m or 13.5 ppb, whichever is less.
 6. Products shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 7. Products shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- G. Clear Acrylic Sealer, Low-to-Medium Gloss: Manufacturer's standard, waterborne, non-yellowing and UV-resistant, membrane-forming, acrylic copolymer emulsion or epoxy-modified acrylic emulsion, manufactured for colored concrete, containing not less than 15 percent solids by volume.
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Advanced Surfaces Inc.]
 - b. [Bomanite Co]
 - c. [Concrete Sealers USA]
 - d. [Duckback Products]
 - e. [EPMAR Corporation; a Quaker Houghton company]
 - f. [Euclid Chemical Company (The); a subsidiary of RPM International, Inc.]
 - g. [H&C Decorative Concrete Products; a brand of Sherwin-Williams Co.]
 - h. [QC Construction Products]

- i. [Scofield, a Business Unit of Sika Corporation]
- j. [United Gilsonite Laboratories (UGL)]
- k. <Insert manufacturer's name>

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

- a. [Advanced Surfaces Inc.]
- b. [Bomanite Co]
- c. [Concrete Sealers USA]
- d. [Duckback Products]
- e. [EPMAR Corporation; a Quaker Houghton company]
- f. [Euclid Chemical Company (The); a subsidiary of RPM International, Inc.]
- g. [H&C Decorative Concrete Products; a brand of Sherwin-Williams Co.]
- h. [QC Construction Products]
- i. [Scofield, a Business Unit of Sika Corporation]
- j. [United Gilsonite Laboratories (UGL)]
- k. <Insert manufacturer's name>

- H. Clear Acrylic Sealer, High Gloss: Manufacturer's standard, waterborne, non-yellowing and UV-resistant, membrane-forming, high-gloss, acrylic copolymer emulsion solution, manufactured for colored concrete, containing not less than 25 percent solids by volume.

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

- a. [Advanced Surfaces Inc.]
- b. [Bomanite Co]
- c. [Concrete Sealers USA]
- d. [Duckback Products]
- e. [EPMAR Corporation; a Quaker Houghton company]
- f. [Euclid Chemical Company (The); a subsidiary of RPM International, Inc.]
- g. [H&C Decorative Concrete Products; a brand of Sherwin-Williams Co.]
- h. [Scofield, a Business Unit of Sika Corporation]
- i. <Insert manufacturer's name>

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

- a. [Advanced Surfaces Inc.]
- b. [Bomanite Co]
- c. [Concrete Sealers USA]
- d. [Duckback Products]
- e. [EPMAR Corporation; a Quaker Houghton company]
- f. [Euclid Chemical Company (The); a subsidiary of RPM International, Inc.]
- g. [H&C Decorative Concrete Products; a brand of Sherwin-Williams Co.]
- h. [Scofield, a Business Unit of Sika Corporation]
- i. <Insert manufacturer's name>

- I. Slip-Resistance-Enhancing Additive: Manufacturer's standard finely graded aggregate or polymer additive, designed to be added to clear acrylic sealer to enhance slip resistance of sealed paving

surface.

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Advanced Surfaces Inc.]**
 - b. **[Bomanite Co]**
 - c. **[Bon Tool Co.]**
 - d. **[Dayton Superior Corporation]**
 - e. **[H&C Decorative Concrete Products; a brand of Sherwin-Williams Co.]**
 - f. **[QC Construction Products]**
 - g. **[Vexcon Chemicals Inc.]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Advanced Surfaces Inc.]**
 - b. **[Bomanite Co]**
 - c. **[Bon Tool Co.]**
 - d. **[Dayton Superior Corporation]**
 - e. **[H&C Decorative Concrete Products; a brand of Sherwin-Williams Co.]**
 - f. **[QC Construction Products]**
 - g. **[Vexcon Chemicals Inc.]**
 - h. **<Insert manufacturer's name>**

2.11 RELATED MATERIALS

- A. Joint Fillers: **[ASTM D1751, asphalt-saturated cellulosic fiber][ASTM D1752, cork or self-expanding cork][or][ASTM D8139, semirigid, closed-cell polypropylene foam]** in preformed strips.
- B. Bonding Agent: ASTM C1059/C1059M, Type II, non-redispersible, acrylic emulsion or styrene butadiene.
- C. Epoxy-Bonding Adhesive: ASTM C881/C881M, two-component epoxy resin capable of humid curing and bonding to damp surfaces; of class suitable for application temperature, of grade complying with requirements, and of the following types:
 1. **[Types I and II, nonload bearing][Types IV and V, load bearing]**, for bonding hardened or freshly mixed concrete to hardened concrete.
- D. Polyethylene Film: ASTM D4397, **1 mil (0.025 mm)** thick, clear.

2.12 CONCRETE MIXTURES

- A. Obtain each color, size, type, and variety of concrete mixture from single manufacturer with resources to provide concrete of consistent quality in appearance and physical properties.
- B. Prepare design mixtures, proportioned according to **ACI 301 (ACI 301M)**, for each type and strength of normal-weight concrete, and as determined by either laboratory trial mixtures or field experience.

1. Use a qualified independent testing agency for preparing and reporting proposed concrete design mixtures for the trial batch method.
- C. Cementitious Materials: **[Use fly ash, pozzolan, slag cement, and silica fume as needed to reduce the total amount of portland cement, which would otherwise be used, by not less than 40 percent.][Limit percentage, by weight, of cementitious materials other than portland cement in concrete as follows:]**
 1. Fly Ash or Pozzolan: 25 percent.
 2. Slag Cement: 50 percent.
 3. Combined Fly Ash or Pozzolan, and Slag Cement: 50 percent, with fly ash or pozzolan not exceeding 25 percent.
- D. Add air-entraining admixture at manufacturer's prescribed rate to result in normal-weight concrete at point of placement having an air content as follows:
 1. Air Content:
 - a. **[5-1/2][4-1/2][2-1/2]** percent plus or minus 1.5 percent for **1-1/2-inch (38-mm)** nominal maximum aggregate size.
 - b. **[6][4-1/2][3]** percent plus or minus 1.5 percent for **1-inch (25-mm)** nominal maximum aggregate size.
 - c. **[6][5][3-1/2]** percent plus or minus 1.5 percent for **3/4-inch (19-mm)** nominal maximum aggregate size.
- E. Limit water-soluble, chloride-ion content in hardened concrete to **[0.15][0.30]** percent by weight of cement.
- F. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.
 1. Use **[water-reducing admixture][water-reducing and retarding admixture][water-reducing and accelerating admixture]** in concrete as required for placement and workability.
 2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.
- G. Synthetic Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than **[1.0 lb/cu. yd. (0.60 kg/cu. m)]<Insert requirement>**.
- H. Color Pigment: Add color pigment to concrete mixture according to manufacturer's written instructions and to result in hardened concrete color consistent with approved mockup.
- I. Concrete Mixtures: Normal-weight concrete.
 1. Compressive Strength (28 Days): **[4500 psi (31 MPa)][4000 psi (27.6 MPa)][3500 psi (24.1 MPa)][3000 psi (20.7 MPa)]<Insert strength>**.
 2. Maximum W/C Ratio at Point of Placement: **[0.45][0.50]<Insert ratio>**.
 3. Slump Limit: **[4 inches (100 mm)][5 inches (125 mm)]<Insert dimension>**, plus or minus **1 inch (25 mm)**.

2.13 CONCRETE MIXING

- A. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to ASTM C94/C94M **[and ASTM C1116/C1116M]**. Furnish batch certificates for each batch discharged and used in the Work.

1. When air temperature is between **85 and 90 deg F (30 and 32 deg C)**, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above **90 deg F (32 deg C)**, reduce mixing and delivery time to 60 minutes.
- B. Project-Site Mixing: Measure, batch, and mix concrete materials and concrete according to ASTM C94/C94M. Mix concrete materials in appropriate drum-type batch machine mixer.
 1. For concrete batches of **1 cu. yd. (0.76 cu. m)** or smaller, continue mixing at least 1-1/2 minutes, but not more than 5 minutes after ingredients are in mixer, before any part of batch is released.
 2. For concrete batches larger than **1 cu. yd. (0.76 cu. m)**, increase mixing time by 15 seconds for each additional **1 cu. yd. (0.76 cu. m)**.
 3. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mixture type, mixing time, quantity, and amount of water added.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine exposed subgrades and subbase surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.
- B. Proof-roll prepared subbase surface below [**decorative concrete paving**]<Insert locations> to identify soft pockets and areas of excess yielding.
 1. Completely proof-roll subbase in one direction[**and repeat in perpendicular direction**]. Limit vehicle speed to **3 mph (5 km/h)**.
 2. Proof-roll with a pneumatic-tired and loaded, 10-wheel, tandem-axle dump truck weighing not less than **15 tons (13.6 tonnes)**.
 3. Correct subbase with soft spots and areas of pumping or rutting exceeding depth of [**1/2 inch (13 mm)**]<Insert dimension> according to requirements in Section 312000 "Earth Moving."
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Remove loose material from compacted subbase surface immediately before placing concrete.
- B. Protect adjacent construction from discoloration and spillage during application of color hardeners, release agents, stains, curing compounds, and sealers.

3.3 EDGE FORMS AND SCREED CONSTRUCTION

- A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.
- B. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

32 - Exterior Improvements

3.4 INSTALLATION OF STEEL REINFORCEMENT

- A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.
- B. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.
- C. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Maintain minimum cover to reinforcement.
- D. Install welded-wire reinforcement in lengths as long as practicable. Lap adjoining pieces at least one full mesh, and lace splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.
- E. Install fabricated bar mats in lengths as long as practicable. Handle units to keep them flat and free of distortions. Straighten bends, kinks, and other irregularities, or replace units as required before placement. Set mats for a minimum **2-inch (50-mm)** overlap to adjacent mats.

3.5 JOINTS

- A. General: Form construction, isolation, and contraction joints and tool edges true to line, with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline unless otherwise indicated.
 - 1. When joining existing paving, place transverse joints to align with previously placed joints unless otherwise indicated.
- B. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than one-half hour unless paving terminates at isolation joints.
 - 1. Continue steel reinforcement across construction joints unless otherwise indicated. Do not continue reinforcement through sides of paving strips unless otherwise indicated.
 - 2. Butt Joints: Use **[bonding agent][epoxy-bonding adhesive]** at joint locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
 - 3. Keyed Joints: Provide preformed keyway-section forms or bulkhead forms with keys unless otherwise indicated. Embed keys at least **1-1/2 inches (38 mm)** into concrete.
 - 4. Doweled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.
- C. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, walks, other fixed objects, and where indicated.
 - 1. Locate expansion joints at intervals of **[50 feet (15.25 m)]<Insert dimension>** unless otherwise indicated.
 - 2. Extend joint fillers full width and depth of joint.
 - 3. Terminate joint filler not less than **1/2 inch (13 mm)** or more than **1 inch (25 mm)** below finished surface if joint sealant is indicated.
 - 4. Place top of joint filler flush with finished concrete surface if joint sealant is not indicated.
 - 5. Furnish joint fillers in one-piece lengths. Where more than one length is required, lace or clip joint-filler sections together.
 - 6. During concrete placement, protect top edge of joint filler with metal, plastic, or other temporary preformed cap. Remove protective cap after concrete has been placed on both sides of joint.

- D. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness, as follows[, **to match jointing of existing adjacent decorative concrete paving**]:
1. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint with grooving tool to a **[1/4-inch (6-mm)][3/8-inch (10-mm)]** radius. Repeat grooving of contraction joints after applying surface finishes. Eliminate grooving-tool marks on concrete surfaces.
 - a. Tolerance: Ensure that grooved joints are within **[3 inches (75 mm)]<Insert dimension>** either way from centers of dowels.
 2. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut **1/8-inch- (3-mm-)** wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before developing random contraction cracks.
 - a. Tolerance: Ensure that sawed joints are within **[3 inches (75 mm)]<Insert dimension>** in both directions from centers of dowels.
 3. Doweled Contraction Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.
- E. Edging: After initial floating, tool edges of paving, gutters, curbs, and joints in concrete with an edging tool to a **[1/4-inch (6-mm)][3/8-inch (10-mm)]** radius. Repeat tooling of edges after applying surface finishes. Eliminate edging-tool marks on concrete surfaces.

3.6 CONCRETE PLACEMENT

- A. Before placing concrete, inspect and complete formwork installation[, **steel reinforcement**,] and items to be embedded or cast-in.
- B. Remove snow, ice, or frost from subbase surface[**and steel reinforcement**] before placing concrete. Do not place concrete on frozen surfaces.
- C. Moisten subbase to provide a uniform dampened condition at time concrete is placed. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.
- D. Comply with **ACI 301 (ACI 301M)** requirements for measuring, mixing, transporting, and placing concrete.
- E. Do not add water to concrete during delivery or at Project site. Do not add water to fresh concrete after testing.
- F. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.
- G. Consolidate concrete according to **ACI 301 (ACI 301M)** by mechanical vibrating equipment supplemented by hand spading, rodding, or tamping.
1. Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from joint assemblies[, **reinforcement**,] or side forms. Use only square-faced shovels for hand spreading and consolidation. Consolidate with care to prevent dislocating [**reinforcement**][**dowels**][**and**] joint devices.

- H. Screed paving surface with a straightedge and strike off.
- I. Commence initial floating using bull floats or darbies to impart an open-textured and uniform surface plane before excess moisture or bleedwater appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.

3.7 FLOAT FINISHING

- A. General: Do not add water to concrete surfaces during finishing operations.
- B. Float Finish: Begin the second floating operation when bleedwater sheen has disappeared and concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats or by hand floating if area is small or inaccessible to power units. Finish surfaces to true planes. Cut down high spots and fill low spots. Refloat surface immediately to uniform granular texture.

3.8 INTEGRALLY COLORED CONCRETE FINISH

- A. Integrally Colored Concrete Finish: After final floating, apply the following finish:
 - 1. Burlap Finish: Drag a seamless strip of damp burlap across float-finished concrete, perpendicular to line of traffic, to provide a uniform, gritty texture.
 - 2. Medium-to-Fine-Textured Broom Finish: Draw a soft-bristle broom across float-finished concrete surface, perpendicular to line of traffic, to provide a uniform, fine-line texture.
 - 3. Medium-to-Coarse-Textured Broom Finish: Provide a coarse finish by striating float-finished concrete surface **1/16 to 1/8 inch (1.6 to 3 mm)** deep with a stiff-bristled broom, perpendicular to line of traffic.

3.9 STENCILING

- A. Cut stencils to slab width and lay on wet concrete. Overlap "mortar joint" on trailing edge of each section of stencil onto leading "mortar joint" of previous section.
- B. Trim stencils to fit slab and adjacent patterns.
- C. Slightly embed stencil into concrete by rolling with stencil roller.
- D. Apply pigmented mineral dry-shake hardener materials to concrete surfaces according to manufacturer's written instructions.
- E. Stencil Rolling:
 - 1. Apply **[pigmented powder release agent][liquid release agent]** according to manufacturer's written instructions prior to applying texture roller to surface of concrete.
 - 2. Perform rolling operation to produce required texture on concrete surface.
- F. Remove stencils when concrete has sufficiently cured to bear weight. Do not leave stencils in concrete overnight.
- G. Remove debris with mechanical blower prior to application of curing compound. If release agent is applied, delay removal of debris for 24 hours, then flood area with low-pressure water hose, wetting release agent, and follow by cleaning surface with pressure washer.

3.10 PIGMENTED MINERAL DRY-SHAKE HARDENER APPLICATION

- A. Pigmented Mineral Dry-Shake Hardener Finish: After initial floating, apply dry-shake materials to paving surfaces according to manufacturer's written instructions and as follows:
1. Uniformly apply dry-shake hardener at a rate of **[100 lb/100 sq. ft. (49 kg/10 sq. m)]**<Insert rate of application> unless greater amount is recommended by manufacturer to match paving color required.
 2. Uniformly distribute approximately two-thirds of dry-shake hardener over the concrete surface with mechanical spreader; allow hardener to absorb moisture and embed it by power floating. Follow power floating with a second application of pigmented mineral dry-shake hardener, uniformly distributing remainder of material at right angles to first application to ensure uniform color, and embed hardener by final power floating.
 3. After final power floating, apply the following finish:
 - a. Burlap Finish: Drag a seamless strip of damp burlap across float-finished concrete, perpendicular to line of traffic, to provide a uniform, gritty texture.
 - b. Medium-to-Fine-Textured Broom Finish: Draw a soft-bristle broom across float-finished concrete surface, perpendicular to line of traffic, to provide a uniform, fine-line texture.
 - c. Medium-to-Coarse-Textured Broom Finish: Provide a coarse finish by striating float-finished concrete surface **1/16 to 1/8 inch (1.6 to 3 mm)** deep with a stiff-bristled broom, perpendicular to line of traffic.
- B. Pigmented Powder Release Agent: Uniformly distribute onto dry-shake-hardened and still-plastic concrete at a rate of **3 to 4 lb/100 sq. ft. (1.5 to 2 kg/10 sq. m)**.
- C. Liquid Release Agent: Uniformly mist surface of dry-shake-hardened and still-plastic concrete at a rate of **5 gal/1000 sq. ft. (0.2 L/sq. m)**.

3.11 STAMPING

- A. Mat Stamping: After floating and while concrete is plastic, apply mat-stamped finish.
1. Pigmented Powder Release Agent: Uniformly distribute onto concrete at a rate of **3 to 4 lb/100 sq. ft. (1.5 to 2 kg/10 sq. m)**.
 2. Liquid Release Agent: Apply liquid release agent to the concrete surface and the stamp mat. Uniformly mist surface of concrete at a rate of **5 gal/1000 sq. ft. (0.2 L/sq. m)**.
 3. After application of release agent, accurately align and place stamp mats in sequence.
 4. Uniformly load mats and press into concrete to produce required imprint pattern and depth of imprint on concrete surface. Gently remove stamp mats. Hand stamp edges and surfaces unable to be imprinted by stamp mats.
 5. Remove residual release agent according to manufacturer's written instructions, but no fewer than three days after stamping concrete. High-pressure-wash surface and joint patterns, taking care not to damage stamped concrete. Control, collect, and legally dispose of runoff.
- B. Tool Stamping: After floating and while concrete is plastic, apply tool-stamped finish.
1. Cover surface with polyethylene film, stretch taut to remove wrinkles, lap sides and ends **3 inches (75 mm)**, and secure to edge forms. Lightly broom surface to remove air bubbles.
 2. Accurately align and place stamp tools in sequence and tamp into concrete to produce required imprint pattern and depth of imprint on concrete surface. Gently remove stamp tools. Hand stamp edges and surfaces unable to be imprinted by stamp tools.
 3. Carefully remove polyethylene film immediately after tool stamping.
- C. Roller Stamping: After floating and while concrete is plastic, apply roller-stamped finish.

1. Cover surface with polyethylene film, stretch taut to remove wrinkles, lap sides and ends **3 inches (75 mm)**, and secure to edge forms. Lightly broom surface to remove air bubbles.
2. Accurately align roller and perform rolling operation to produce required imprint pattern and depth of imprint on concrete surface. Hand stamp surfaces inaccessible to roller.
3. Carefully remove polyethylene film immediately after roller stamping.

3.12 CONCRETE PROTECTION AND CURING

- A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.
- B. Comply with ACI 306.1 for cold-weather protection.
- C. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching **0.2 lb/sq. ft. x h (1 kg/sq. m x h)** before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete but before float finishing.
- D. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.
- E. Curing Compound: Apply immediately after final finishing. Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating, and repair damage during curing period.
 1. Cure integrally colored concrete with a **[pigmented]** curing compound.
 2. Cure concrete finished with pigmented mineral dry-shake hardener with a **[pigmented]** curing compound.
- F. Curing and Sealing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Repeat process 24 hours later and apply a second coat. Maintain continuity of coating, and repair damage during curing period.
- G. Curing Paper: Cure with unwrinkled curing paper in pieces large enough to cover the entire width and edges of slab. Do not lap sheets. Fold curing paper down over paving edges and secure with continuous banks of earth to prevent displacement or billowing due to wind. Immediately repair holes or tears in paper.

3.13 STAINING

- A. Newly placed concrete paving shall be at least **[14][30]<Insert number>** days old before staining.
- B. Prepare surfaces according to manufacturer's written instructions and as follows:
 1. Clean concrete thoroughly by scraping, applying solvents or stripping agents, sweeping and pressure washing, or scrubbing with a rotary floor machine and detergents recommended by stain manufacturer. Rinse until water is clear and allow surface to dry.
 - a. Do not use acidic solutions to clean surfaces.
 2. Test surfaces with droplets of water. If water beads and does not penetrate surface, or penetrates only in some areas, profile surfaces by **[acid etching][grinding, sanding, or abrasive blasting]**.

- Retest and continue profiling surface until water droplets immediately darken and uniformly penetrate concrete surfaces.
 3. Apply acidic solution to dampened concrete surfaces, scrubbing with uncolored, acid-resistant nylon-bristle brushes until bubbling stops and concrete surface has texture of 120-grit sandpaper. Do not allow solution to dry on concrete surfaces. Rinse until water is clear. Control, collect, and legally dispose of runoff.
 4. Neutralize concrete surfaces and rinse until water is clear. Test surface for residue with clean white cloth. Test surface according to ASTM F710 to ensure pH is between **[7 and 8]<Insert values>**.
- C. Scoring: Score decorative jointing in paving surfaces **1/16 inch (1.6 mm)** deep with diamond blades to match pattern indicated. Rinse until water is clear. Score **[after][before]** staining.
1. Joint Width: **[3/8 inch (10 mm)]<Insert dimension>**.
- D. Allow paving surface to dry before applying stain. Verify readiness of paving to receive stain according to ASTM D4263 by tightly taping **18-by-18-inch (450-by-450-mm), 4-mil- (0.1-mm-)** thick polyethylene sheet to a representative area of paving surface. Apply stain only if no evidence of moisture has accumulated under sheet after 16 hours.
- E. Reactive Stain: Apply reactive stain to paving surfaces according to manufacturer's written instructions and as follows:
1. Apply stain by uncolored bristle brush, roller, or high-volume, low-pressure sprayer and immediately scrub into concrete surface with uncolored, acid-resistant nylon-bristle brushes in continuous, circular motion. Do not spread stain after fizzing stops. Allow to dry four hours and repeat application of stain in sufficient quantity to obtain color consistent with approved mockup.
 2. Remove stain residue after four hours by wet scrubbing with commercial-grade detergent recommended by stain manufacturer. Rinse until water is clear. Control, collect, and legally dispose of runoff.
- F. Penetrating Stain: Apply to paving surfaces according to manufacturer's written instructions and as follows:
1. Apply first coat of stain to dry, clean surfaces by airless sprayer or by high-volume, low-pressure sprayer.
 2. Allow to dry four hours and repeat application of stain in sufficient quantity to obtain color consistent with approved mockup.
 3. Rinse until water is clear. Control, collect, and legally dispose of runoff.
- 3.14 SEALER APPLICATION
- A. Clear Acrylic Sealer: Apply uniformly in two coats in continuous operations according to manufacturer's written instructions. Allow first coat to dry before applying second coat, at 90 degrees to the direction of the first coat, using same application methods and rates.
1. Begin sealing dry surface no sooner than **[14]<Insert number>** days after concrete placement.
 2. Allow stained concrete surfaces to dry before applying sealer.
 3. Thoroughly mix slip-resistance-enhancing additive into sealer before applying sealer according to manufacturer's written instructions. Stir sealer occasionally during application to maintain even distribution of additive.

3.15 PAVING TOLERANCES

- A. Comply with tolerances in **ACI 117 (ACI 117M)** and as follows:
1. Elevation: **3/4 inch (19 mm)**.
 2. Thickness: Plus **3/8 inch (10 mm)**, minus **1/4 inch (6 mm)**.
 3. Surface: Gap below **10-foot- (3-m-)** long, unleveled straightedge not to exceed **1/2 inch (13 mm)**.
 4. Lateral Alignment and Spacing of Dowels: **1 inch (25 mm)**.
 5. Vertical Alignment of Dowels: **1/4 inch (6 mm)**.
 6. Alignment of Dowel-Bar End Relative to Line Perpendicular to Paving Edge: **1/4 inch per 12 inches (6 mm per 300 mm)** of dowel.
 7. Joint Spacing: **3 inches (75 mm)**.
 8. Contraction Joint Depth: Plus **1/4 inch (6 mm)**, no minus.
 9. Joint Width: Plus **1/8 inch (3 mm)**, no minus.

3.16 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Testing Services: Testing of composite samples of fresh concrete obtained according to ASTM C172/C172M shall be performed according to the following requirements:
1. Testing Frequency: Obtain at least one composite sample for each **[100 cu. yd. (76 cu. m)][5000 sq. ft. (465 sq. m)]** or fraction thereof of each concrete mixture placed each day.
 - a. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
 2. Slump: ASTM C143/C143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture. Perform additional tests when concrete consistency appears to change.
 3. Air Content: ASTM C231/C231M, pressure method; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
 4. Concrete Temperature: ASTM C1064/C1064M; one test hourly when air temperature is **40 deg F (4.4 deg C)** and below and when it is **80 deg F (27 deg C)** and above, and one test for each composite sample.
 5. Compression Test Specimens: ASTM C31/C31M; cast and laboratory cure one set of three standard cylinder specimens for each composite sample.
 6. Compressive-Strength Tests: ASTM C39/C39M; test one specimen at seven days and two specimens at 28 days.
 - a. A compressive-strength test shall be the average compressive strength from two specimens obtained from same composite sample and tested at 28 days.
- C. Strength of each concrete mixture will be satisfactory if average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than **500 psi (3.4 MPa)**.
- D. Test results shall be reported in writing to Architect, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of

concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.

- E. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect but will not be used as sole basis for approval or rejection of concrete.
- F. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Architect.
- G. Decorative concrete paving will be considered defective if it does not pass tests and inspections.
- H. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
- I. Prepare test and inspection reports.

3.17 REPAIR AND PROTECTION

- A. Remove and replace decorative concrete paving that is broken or damaged or does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved by Architect.
- B. Detailing: Grind concrete "squeeze" left from tool placement. Color ground areas with slurry of color hardener mixed with water and bonding agent. Remove excess release agent with high-velocity blower.
- C. Protect decorative concrete paving from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.
- D. Maintain decorative concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep paving not more than two days before date scheduled for Substantial Completion inspections.

3.18 DECORATIVE CONCRETE PAVING SCHEDULE

- A. Patterned Decorative Concrete Paving :
 - 1. Locations: Install at [drives][parking lots][walks][patios][and][swimming pool decks]<Insert location>.
 - 2. Coloring Method: [Integrally colored][Pigmented mineral dry-shake hardener].
 - a. Color: [As indicated by manufacturer's designation][Match Architect's sample][As selected by Architect from manufacturer's full range]<Insert color>.
 - 3. Field Patterning Method: [Stamped][Stenciled].
 - a. Texture and Pattern: [Keystone installed at 45-degrees diagonal to main lines of building]<Insert requirement>.
 - b. Pigmented Mineral Dry-Shake Hardener: <Insert color>.
 - c. Release Agent: [Match pigmented mineral dry-shake hardener]<Insert color>.
 - 4. Border and Accent Strip Patterning Method: [Stamped][Stenciled].

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- a. Texture and Pattern: <Insert requirement>.
- b. Pigmented Mineral Dry-Shake Hardener: <Insert color>.
- c. Release Agent: [Match pigmented mineral dry-shake hardener]<Insert color>.

B. Stained Decorative Concrete Paving :

1. Locations: Install at [drives][parking lots][walks][patios][and][swimming pool decks]<Insert location>.
2. Staining Method: [Reactive][Penetrating] stain.
3. Color: [As indicated by manufacturer's designation][Match Architect's sample][As selected by Architect from manufacturer's full range]<Insert color>.

END OF SECTION 32 13 16 00



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Task	Specification	Specification Description
32 13 16 13	32 13 13 00	Concrete Paving
32 13 16 13	32 13 16 00	Decorative Concrete Paving
32 13 43 00	32 13 13 00	Concrete Paving



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SECTION 32 13 73 00 - CONCRETE PAVING JOINT SEALANTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cold-applied joint sealants.
2. Hot-applied joint sealants.
3. Cold-applied, fuel-resistant joint sealants.
4. Hot-applied, fuel-resistant joint sealants.
5. Joint-sealant backer materials.
6. Primers.

B. Related Requirements:

1. Section 079200 "Joint Sealants" for sealing nontraffic and traffic joints in locations not specified in this Section.

1.2 PREINSTALLATION MEETINGS

- A. Preinstallation Conference:** Conduct conference at **[Project site]<Insert location>**.

1.3 ACTION SUBMITTALS

A. Product Data:

1. Concrete pavement joint sealants.
2. Joint-sealant backer materials.

- B. Samples for Initial Selection:** Manufacturer's standard color sheets, showing full range of available colors for each type of joint sealant.

- C. Samples for Verification:** Actual sample of finished products for each kind and color of joint sealant required.

1. Size: Joint sealants in **1/2-inch- (13-mm-)** wide joints formed between two **6-inch- (150-mm-)** long strips of material matching the appearance of exposed surfaces adjacent to joint sealants.

D. Paving-Joint-Sealant Schedule: Include the following information:

1. Joint-sealant application, joint location, and designation.
2. Joint-sealant manufacturer and product name.
3. Joint-sealant formulation.
4. Joint-sealant color.

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1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Statements: For **[Installer][testing agency]**.

1.5 QUALITY ASSURANCE

- A. Qualifications:
 - 1. Installers: Entity that employs installers and supervisors who are trained and approved by manufacturer.

1.6 PRECONSTRUCTION TESTING

- A. Preconstruction Testing: Performed by a qualified testing agency.

1.7 FIELD CONDITIONS

- A. Do not proceed with installation of joint sealants under the following conditions:
 - 1. When ambient and substrate temperature conditions are outside limits permitted by joint-sealant manufacturer[**or are below 40 deg F (5 deg C)**].
 - 2. When joint substrates are wet.
 - 3. Where joint widths are less than those allowed by joint-sealant manufacturer for applications indicated.
 - 4. Where contaminants capable of interfering with adhesion have not yet been removed from joint substrates.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

- A. Obtain joint sealants from single manufacturer[**for each sealant type**].

2.2 JOINT SEALANTS, GENERAL

- A. Compatibility: Provide joint sealants, backer materials, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer, based on testing and field experience.

2.3 COLD-APPLIED JOINT SEALANTS

- A. Single-Component, Nonsag, Silicone Joint Sealant: ASTM D5893/D5893M, Type NS.
 - 1. Products: Subject to compliance with requirements, **[provide the following][provide one of the following][available products that may be incorporated into the Work include, but are not limited to, the following]**:

- a. Crafcro Inc.; RoadSaver Silicone.
 - b. Pecora Corporation; 301 NS.
 - c. The Dow Chemical Company; Dow Corning 888 Silicone Joint Sealant.
 - d. **<Insert manufacturer's name; product name or designation>.**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Crafcro Inc]**
 - b. **[Pecora Corporation]**
 - c. **[The Dow Chemical Company]**
 - d. **<Insert manufacturer's name>**
- B. Single-Component, Self-Leveling, Silicone Joint Sealant: ASTM D5893/D5893M, Type SL.
1. Products: Subject to compliance with requirements, **[provide the following][provide one of the following][available products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. Crafcro Inc.; RoadSaver Silicone SL.
 - b. Pecora Corporation; **[300 SL][322FC]**.
 - c. The Dow Chemical Company; Dow Corning 890-SL Silicone Joint Sealant.
 - d. **<Insert manufacturer's name; product name or designation>.**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Crafcro Inc]**
 - b. **[Pecora Corporation]**
 - c. **[The Dow Chemical Company]**
 - d. **<Insert manufacturer's name>**
- C. Multicomponent, Nonsag, Urethane, Elastomeric Joint Sealant: ASTM C920, Type M, Grade NS, Class 25, for Use T.
1. Products: Subject to compliance with requirements, **[provide the following][provide one of the following][available products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. W.R. Meadows, Inc; Pourthane NS.
 - b. **<Insert manufacturer's name; product name or designation>.**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[W. R. Meadows, Inc]**
 - b. **<Insert manufacturer's name>**
- D. Single Component, Pourable, Urethane, Elastomeric Joint Sealant: ASTM C920, Type S, Grade P, Class 25, for Use T.
1. Products: Subject to compliance with requirements, **[provide the following][provide one of the following][available products that may be incorporated into the Work include, but are not**

limited to, the following]:

- a. W.R. Meadows, Inc; Pourthane SL.
 - b. <Insert manufacturer's name; product name or designation>.
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [W. R. Meadows, Inc]
 - b. <Insert manufacturer's name>
- E. Multicomponent, Pourable, Urethane, Elastomeric Joint Sealant: ASTM C920, Type M, Grade P, Class 25, for Use T.
1. Products: Subject to compliance with requirements, [provide the following][provide one of the following][available products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. Pecora Corporation; [Dynatred][Dynatrol II-SG][Urexpan NR-200].
 - b. <Insert manufacturer's name; product name or designation>.
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Pecora Corporation]
 - b. <Insert manufacturer's name>

2.4 HOT-APPLIED JOINT SEALANTS

- A. Hot-Applied, Single-Component Joint Sealant, Type I: ASTM D6690.
1. Products: Subject to compliance with requirements, [provide the following][provide one of the following][available products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. Crafcro Inc.; [Asphalt Rubber Plus][Asphalt Rubber Plus Type 2][RoadSaver 203][RoadSaver 211][RoadSaver 515].
 - b. Right Pointe; JTS Asphalt Rubber Modified 043.
 - c. W.R. Meadows, Inc; [Sealtight 1190][Sealtight 164].
 - d. <Insert manufacturer's name; product name or designation>.
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Crafcro Inc]
 - b. [Right Pointe]
 - c. [W. R. Meadows, Inc]
 - d. <Insert manufacturer's name>
- B. Hot-Applied, Single-Component Joint Sealant, Type I or Type II: ASTM D6690.

1. Products: Subject to compliance with requirements, **[provide the following][provide one of the following][available products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. Crafcro Inc.; **[RoadSaver 201][RoadSaver 220][RoadSaver 221][RoadSaver 534]**.
 - b. Right Pointe; **[JTS 3405 Parking Lot Sealant 007][JTS 3405 Rubber 009]**.
 - c. **<Insert manufacturer's name; product name or designation>**.
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Crafcro Inc]**
 - b. **[Right Pointe]**
 - c. **<Insert manufacturer's name>**
- C. Hot-Applied, Single-Component Joint Sealant, Type I, II, or III: ASTM D6690.
1. Products: Subject to compliance with requirements, **[provide the following][provide one of the following][available products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. Crafcro Inc.; RoadSaver 222.
 - b. Right Pointe; **[JTS 3405 Regular 003][JTS 3405 Rubber 009]**.
 - c. W.R. Meadows, Inc; Sealtight 3405.
 - d. **<Insert manufacturer's name; product name or designation>**.
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Crafcro Inc]**
 - b. **[Right Pointe]**
 - c. **[W. R. Meadows, Inc]**
 - d. **<Insert manufacturer's name>**
- D. Hot-Applied, Single-Component Joint Sealant, Type IV: ASTM D6690.
1. Products: Subject to compliance with requirements, **[provide the following][provide one of the following][available products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. Crafcro Inc.; RoadSaver 231.
 - b. W.R. Meadows, Inc; Sealtight 3405M.
 - c. **<Insert manufacturer's name; product name or designation>**.
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Crafcro Inc]**
 - b. **[W. R. Meadows, Inc]**
 - c. **<Insert manufacturer's name>**

2.5 COLD-APPLIED, FUEL-RESISTANT JOINT SEALANTS

- A. Fuel-Resistant, Single-Component, Pourable, Modified-Urethane, Elastomeric Joint Sealant: ASTM C920, Type S, Grade P, Class 25, for Use T.
1. Products: Subject to compliance with requirements, **[provide the following][provide one of the following][available products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. BASF Corporation; MasterSeal CR 125 (Pre-2014: Sonomeric 1).
 - b. **<Insert manufacturer's name; product name or designation>**.
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **<Insert manufacturer's name>**
- B. Fuel-Resistant, Multicomponent, Pourable, Modified-Urethane, Elastomeric Joint Sealant: ASTM C920, Type M, Grade P, Class 12-1/2 or 25, for Use T.
1. Products: Subject to compliance with requirements, **[provide the following][provide one of the following][available products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. Pecora Corporation; **<Insert product name or designation>**.
 - b. W.R. Meadows, Inc; **<Insert product name or designation>**.
 - c. **<Insert manufacturer's name; product name or designation>**.
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Pecora Corporation]**
 - b. **[W. R. Meadows, Inc]**
 - c. **<Insert manufacturer's name>**

2.6 HOT-APPLIED, FUEL-RESISTANT JOINT SEALANTS

- A. Hot-Applied, Fuel-Resistant, Single-Component Joint Sealants, Type I or Type II: ASTM D7116.
1. Products: Subject to compliance with requirements, **[provide the following][provide one of the following][available products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. Crafcro Inc.; **[Superseal 1614A][Superseal 444/777]**.
 - b. **<Insert manufacturer's name; product name or designation>**.
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Crafcro Inc]**

b. <Insert manufacturer's name>

B. Hot-Applied, Fuel-Resistant, Single-Component Joint Sealants, Type III: ASTM D7116.

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

a. Crafcro Inc.; Superseal Low-Mod.

b. <Insert manufacturer's name; product name or designation>.

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

a. [Crafcro Inc]

b. <Insert manufacturer's name>

2.7 JOINT-SEALANT BACKER MATERIALS

A. Joint-Sealant Backer Materials: Nonstaining; compatible with joint substrates, sealants, primers, and other joint fillers; and approved for applications indicated by joint-sealant manufacturer, based on field experience and laboratory testing.

B. Round Backer Rods for Cold- and Hot-Applied Joint Sealants: ASTM D5249, Type 1, of diameter and density required to control sealant depth and prevent bottom-side adhesion of sealant.

C. Round Backer Rods for Cold-Applied Joint Sealants: ASTM D5249, Type 3, of diameter and density required to control joint-sealant depth and prevent bottom-side adhesion of sealant.

D. Backer Strips for Cold- and Hot-Applied Joint Sealants: ASTM D5249; Type 2; of thickness and width required to control joint-sealant depth, prevent bottom-side adhesion of sealant, and fill remainder of joint opening under sealant.

2.8 PRIMERS

A. Primers: Product recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine joints to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting joint-sealant performance.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

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3.2 PREPARATION

- A. Surface Cleaning of Joints: Before installing joint sealants, clean out joints immediately to comply with joint-sealant manufacturer's written instructions.
 - 1. Remove all foreign material from joint substrates that could interfere with adhesion of joint sealant, including dust, old joint sealants, oil, grease, waterproofing, water repellents, water, surface dirt, and frost.
- B. Joint Priming: Prime joint substrates where indicated or where recommended in writing by joint-sealant manufacturer, based on preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.

3.3 INSTALLATION OF JOINT SEALANTS

- A. Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated unless more stringent requirements apply.
- B. Joint-Sealant Installation Standard: Comply with recommendations in ASTM C1193 for use of joint sealants as applicable to materials, applications, and conditions.
- C. Install joint-sealant backers to support joint sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.
 - 1. Do not leave gaps between ends of joint-sealant backer materials.
 - 2. Do not stretch, twist, puncture, or tear joint-sealant backer materials.
 - 3. Remove absorbent joint-sealant backer materials that have become wet before sealant application and replace them with dry materials.
- D. Install joint sealants immediately following backer material installation, using proven techniques that comply with the following:
 - 1. Place joint sealants so they fully contact joint substrates.
 - 2. Completely fill recesses in each joint configuration.
 - 3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.
- E. Tooling of Nonsag Joint Sealants: Immediately after joint-sealant application and before skinning or curing begins, tool sealants in accordance with the following requirements to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint:
 - 1. Remove excess joint sealant from surfaces adjacent to joints.
 - 2. Use tooling agents that are approved in writing by joint-sealant manufacturer and that do not discolor sealants or adjacent surfaces.
- F. Provide joint configuration to comply with joint-sealant manufacturer's written instructions unless otherwise indicated.

3.4 CLEANING AND PROTECTION

- A. Clean off excess joint sealant as the Work progresses, by methods and with cleaning materials approved in writing by joint-sealant manufacturers.
- B. Protect joint sealants, during and after curing period, from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated joint sealants immediately and replace with joint sealant so installations in repaired areas are indistinguishable from the original work.

3.5 PAVING-JOINT-SEALANT SCHEDULE

- A. Joints within concrete paving[**PJS-#**]:
 - 1. Joint Location:
 - a. Expansion and isolation joints in concrete paving.
 - b. Contraction joints in concrete paving.
 - c. Other joints as indicated.
 - 2. Joint Sealant: [**Single-component, nonsag, silicone joint sealant**][**Single-component, self-leveling, silicone joint sealant**][**Multicomponent, nonsag, urethane, elastomeric joint sealant**][**Single component, pourable, urethane, elastomeric joint sealant**][**Multicomponent, pourable, urethane, elastomeric joint sealant**][**Hot-applied, single-component joint sealant**]**<Insert joint sealant>**.
 - 3. Joint-Sealant Color: [**Manufacturer's standard**]**<Insert color>**.
- B. Joints within concrete paving and between concrete and asphalt paving[**PJS-#**]:
 - 1. Joint Location:
 - a. Joints between concrete and asphalt paving.
 - b. Joints between concrete curbs and asphalt paving.
 - c. Other joints as indicated.
 - 2. Joint Sealant: [**Hot-applied, single-component joint sealant**]**<Insert joint sealant>**.
 - 3. Joint-Sealant Color: [**Manufacturer's standard**]**<Insert color>**.
- C. Fuel-resistant joints within concrete paving[**PJS-#**]:
 - 1. Joint Location:
 - a. Expansion and isolation joints in concrete paving.
 - b. Contraction joints in concrete paving.
 - c. Other joints as indicated.
 - 2. Joint Sealant: [**Fuel-resistant, single-component, pourable, modified-urethane, elastomeric joint sealant**][**Fuel-resistant, multicomponent, pourable, modified-urethane, elastomeric joint sealant**][**Hot-applied, fuel-resistant, single-component joint sealant**]**<Insert joint sealant>**.
 - 3. Joint-Sealant Color: [**Manufacturer's standard**]**<Insert color>**.



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END OF SECTION 32 13 73 00



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Task	Specification	Specification Description
32 13 73 13	32 13 73 00	Concrete Paving Joint Sealants
32 13 73 16	32 12 16 00	Asphalt Paving
32 13 73 16	32 13 73 00	Concrete Paving Joint Sealants
32 13 73 19	32 12 16 00	Asphalt Paving
32 13 73 19	32 13 73 00	Concrete Paving Joint Sealants



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SECTION 32 14 00 00 - UNIT PAVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Brick pavers.
2. Concrete pavers.
3. Asphalt-block pavers.
4. Stone pavers.
5. Curbs and edge restraints.

B. Related Requirements:

1. [Section 075113 "Built-up Asphalt Roofing"] [Section 075116 "Built-up Coal Tar Roofing"] [Section 075213 "Atactic-Polypropylene (APP) Modified Bituminous Membrane Roofing"] [Section 075216 "Styrene-Butadiene-Styrene (SBS) Modified Bituminous Membrane Roofing"] [Section 075316 "Chlorosulfonate-Polyethylene (CSPE) Roofing"] [Section 075323 "Ethylene-Propylene-Diene-Monomer (EPDM) Roofing"] [Section 075416 "Ketone Ethylene Ester (KEE) Roofing"] [Section 075419 "Polyvinyl-Chloride (PVC) Roofing"] [Section 075423 "Thermoplastic Polyolefin (TPO) Roofing"] [Section 075552.13 "Atactic-Polypropylene (APP) Modified Bituminous Protected Membrane Roofing"] [Section 075552.16 "Styrene-Butadiene-Styrene (SBS) Modified Bituminous Protected Membrane Roofing"] [Section 075556 "Fluid-Applied Protected Membrane Roofing"] for roof pavers.
2. Section 096313 "Brick Flooring" for brick flooring for interior applications.
3. Section 096340 "Stone Flooring" for dimension stone paving.
4. Section 321216 "Asphalt Paving" for asphalt base under unit pavers.
5. Section 321313 "Concrete Paving" [for concrete base under unit pavers] [and] [for cast-in-place concrete curbs and gutters serving as edge restraints for unit pavers].
6. Section 321443 "Porous Unit Paving" for unit paving using grid pavers or pavers with openings between them.

1.2 PREINSTALLATION MEETINGS

- ##### A. Preinstallation Conference: Conduct conference at [Project site] <Insert location>.

1.3 ACTION SUBMITTALS

A. Product Data:

1. For materials other than water and aggregates.
2. For the following:
 - a. Pavers.
 - b. Bituminous setting materials.
 - c. Mortar and grout materials.
 - d. Edge restraints.
 - e. Precast concrete curbs.

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f. Granite curbs.

B. Sustainable Design Submittals:

1. Product Certificates: For regional materials, indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project and cost for each regional material.
2. Environmental Product Declaration (EPD): For each product.
3. Product Certificates: For indigenous materials, indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project, means of transportation, and cost for each indigenous material.
4. Environmental Product Declaration: For each product.
5. Product Certificates: For regional materials, indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project, means of transportation, and cost for each regional material.
6. Environmental Product Declaration: For each product.
7. Environmental Product Declaration: For each product.
8. Third-Party Certifications: For each product.
9. Third-Party Certified Life Cycle Assessment: For each product.

C. Sieve Analyses: For aggregate setting-bed materials, according to ASTM C136.

D. Samples for Initial Selection: For each type of unit paver indicated[.][**and the following:**]

1. Joint materials involving color selection.
2. Exposed edge restraints involving color selection.
3. Precast concrete curbs.
4. Granite curbs.

E. Samples for Verification: For full-size units of each type of unit paver indicated.[**Assemble no fewer than five Samples of each type of unit on suitable backing and grout joints.**][**Include Samples of the following:**]

1. Joint materials.
2. Exposed edge restraints.
3. Precast concrete curbs.
4. Granite curbs.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Adhesion and Compatibility Test Reports: From latex-additive manufacturer for mortar and grout containing latex additives.

C. Material Certificates: For unit pavers. Include statements of material properties indicating compliance with requirements, including compliance with standards. Provide for each type and size of unit.

D. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for unit pavers, indicating compliance with requirements.

1. For solid interlocking paving units, include test data for freezing and thawing according to ASTM C67.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: A qualified unit paving installer. Installer's **[field supervisor][personnel assigned to the Work]** must have Concrete Paver Installer Certification from the Interlocking Concrete Pavement Institute (ICPI) with **[one of][both of]** the following designations:
 - 1. Residential Paver Technician Designation.
 - 2. Commercial Paver Technician Designation.
- B. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for materials and execution.
 - 1. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.6 PRECONSTRUCTION TESTING

- A. Preconstruction Adhesion and Compatibility Testing: Submit to latex-additive manufacturer, for testing as indicated below, Samples of flooring materials that will contact or affect mortar and grout that contain latex additives.
 - 1. Use manufacturer's standard test methods to determine whether mortar and grout materials will obtain optimal adhesion with, and will be nonstaining to, installed brick and other materials constituting brick flooring installation.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Store pavers on elevated platforms in a dry location. If units are not stored in an enclosed location, cover tops and sides of stacks with waterproof sheeting, securely tied.
- B. Store cementitious materials on elevated platforms, under cover, and in a dry location. Do not use cementitious materials that have become damp.
- C. Store aggregates where grading and other required characteristics can be maintained and contamination avoided.
- D. Store liquids in tightly closed containers protected from freezing.
- E. Store asphalt cement and other bituminous materials in tightly closed containers.

1.8 FIELD CONDITIONS

- A. Cold-Weather Protection: Do not use frozen materials or materials mixed or coated with ice or frost. Do not build on frozen subgrade or setting beds. Remove and replace unit paver work damaged by frost or freezing.
- B. Weather Limitations for Bituminous Setting Bed:
 - 1. Install bituminous setting bed only when ambient temperature is above **40 deg F (4 deg C)** and when base is dry.
 - 2. Apply asphalt adhesive only when ambient temperature is above **50 deg F (10 deg C)** and when temperature has not been below **35 deg F (2 deg C)** for 12 hours immediately before application.

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Do not apply when setting bed is wet or contains excess moisture.

C. Weather Limitations for Mortar and Grout:

1. Cold-Weather Requirements: Comply with cold-weather construction requirements contained in TMS 602/ACI 530.1/ASCE 6.
2. Hot-Weather Requirements: Comply with hot-weather construction requirements contained in TMS 602/ACI 530.1/ASCE 6. Provide artificial shade and windbreaks and use cooled materials as required. Do not apply mortar to substrates with temperatures of **100 deg F (38 deg C)** and higher.
 - a. When ambient temperature exceeds **100 deg F (38 deg C)**, or when wind velocity exceeds **8 mph (13 km/h)** and ambient temperature exceeds **90 deg F (32 deg C)**, set pavers within 1 minute of spreading setting-bed mortar.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

- A. Obtain each type of unit paver, joint material, and setting material from single source with resources to provide materials and products of consistent quality in appearance and physical properties.

2.2 BRICK PAVERS

- A. Regional Materials: Brick shall be manufactured within **500 miles (800 km)** of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within **500 miles (800 km)** of Project site.
- B. Regional Materials: Brick shall be manufactured within **500 miles (800 km)** of Project site.
- C. Regional Materials: Brick shall be manufactured within **100 miles (160 km)** of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within **100 miles (160 km)** of Project site.
- D. Indigenous Materials: Brick shall be manufactured within **500 miles (800 km)** of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within **500 miles (800 km)** of Project site. If materials are transported by rail or water, the distance transported by rail or water shall be multiplied by 0.25 to determine the distance to Project site.
- E. Regional Materials: Brick shall be manufactured within **500 miles (800 km)** of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within **500 miles (800 km)** of Project site. If materials are transported by rail or water, the distance transported by rail or water shall be multiplied by 0.25 to determine the distance to Project site.
- F. Brick Pavers, Light-Traffic Paving Brick: ASTM C902, Class SX[or Class MX], [Type I][Type II][Type III], Application [PS][PX][PA]. Provide brick without frogs or cores in surfaces exposed to view in the completed Work.
 1. Thickness: [1-1/4 inches (32 mm)][1-1/2 inches (38 mm)][1-5/8 inches (41 mm)][2-1/4 inches (57 mm)][2-5/8 inches (67 mm)][As indicated]<Insert dimension>.
 2. Face Size: [3-3/4 by 7-1/2 inches (95 by 190 mm)][3-5/8 by 7-5/8 inches (92 by 194 mm)][3-5/8

- by 11-5/8 inches (92 by 295 mm)][7-5/8 by 7-5/8 inches (194 by 194 mm)][4 by 8 inches (102 by 203 mm)][4 by 12 inches (102 by 305 mm)][8 by 8 inches (203 by 203 mm)][As indicated]<Insert dimensions>.
3. Color: [Dark red][Medium red][Full-range red][Dark brown][Medium brown][Full-range brown][Tan][Buff][Cream][As indicated by manufacturer's designations][Match Architect's sample][As selected by Architect from manufacturer's full range]<Insert color>.
- G. Brick Pavers, Heavy Vehicular Paving Brick: ASTM C1272, [Type F, Application PX][Type R, Application PS][Type R, Application PX][Type R, Application PA]. Provide brick without frogs or cores in surfaces exposed to view in the completed Work.
1. Thickness: [2-1/4 inches (57 mm)][2-5/8 inches (67 mm)][As indicated]<Insert dimension>.
 2. Face Size: [3-3/4 by 7-1/2 inches (95 by 190 mm)][3-5/8 by 7-5/8 inches (92 by 194 mm)][3-5/8 by 11-5/8 inches (92 by 295 mm)][7-5/8 by 7-5/8 inches (194 by 194 mm)][4 by 8 inches (102 by 203 mm)][4 by 12 inches (102 by 305 mm)][8 by 8 inches (203 by 203 mm)][As indicated]<Insert dimensions>.
 3. Color: [Dark red][Medium red][Full-range red][Dark brown][Medium brown][Full-range brown][Tan][Buff][Cream][As indicated by manufacturer's designations][Match Architect's sample][As selected by Architect from manufacturer's full range]<Insert color>.
- H. Efflorescence: Brick to be rated "not effloresced" when tested according to ASTM C67.
- I. Temporary Protective Coating: Precoat exposed surfaces of brick pavers with a continuous film of a temporary protective coating that is compatible with brick, mortar, and grout products and can be removed without damaging grout or brick. Do not coat unexposed brick surfaces; handle brick to prevent coated surfaces from contacting backs or edges of other units. If, despite these precautions, coating does contact bonding surfaces of brick, remove coating from bonding surfaces before setting brick.
- 2.3 CONCRETE PAVERS
- A. Regional Materials: Concrete pavers shall be manufactured within **500 miles (800 km)** of Project site from aggregates[**and cementitious materials**] that have been extracted, harvested, or recovered, as well as manufactured, within **500 miles (800 km)** of Project site.
 - B. Regional Materials: Concrete pavers shall be manufactured within **500 miles (800 km)** of Project site.
 - C. Regional Materials: Concrete pavers shall be manufactured within **100 miles (160 km)** of Project site from aggregates[**and cementitious materials**] that have been extracted, harvested, or recovered, as well as manufactured, within **100 miles (160 km)** of Project site.
 - D. Indigenous Materials: Concrete pavers shall be manufactured within **500 miles (800 km)** of Project site from aggregates[**and cementitious materials**] that have been extracted, harvested, or recovered, as well as manufactured, within **500 miles (800 km)** of Project site. If materials are transported by rail or water, the distance transported by rail or water shall be multiplied by 0.25 to determine the distance to Project site.
 - E. Regional Materials: Concrete pavers shall be manufactured within **500 miles (800 km)** of Project site from aggregates[**and cementitious materials**] that have been extracted, harvested, or recovered, as well as manufactured, within **500 miles (800 km)** of Project site. If materials are transported by rail or water, the distance transported by rail or water shall be multiplied by 0.25 to determine the distance to Project site.
 - F. Concrete Pavers, Solid Interlocking Paving Units: Complying with ASTM C936/C936M[**and resistant to freezing and thawing when tested according to ASTM C67**], made from normal-weight aggregates.

1. Thickness: [2-3/8 inches (60 mm)][3-1/8 inches (80 mm)]<Insert dimension>.
2. Face Size and Shape:
 - a. [3-7/8 inches (98 mm)][4-7/16 inches (113 mm)][8-7/8 inches (225 mm)][9 inches (229 mm)] square.
 - b. [3-7/8-by-7-7/8-inch (98-by-200-mm)][4-by-8-inch (102-by-203-mm)][4-7/16-by-8-7/8-inch (113-by-225-mm)] rectangle.
 - c. [5-1/2-inch (140-mm) octagon with attached 3-1/2-inch (89-mm) square][4-1/2-by-9-inch (114-by-229-mm) rectangle with saw-tooth edges][4-3/4-inch (121-mm) rectangular and trapezoidal units arranged in semicircular courses to produce fan-shaped pattern][As indicated]<Insert dimensions and shape>.
3. Color: [As indicated by manufacturer's designations][Match Architect's sample][As selected by Architect from manufacturer's full range]<Insert color>.

G. Concrete Pavers, Solid Paving Units, Normal-Weight Concrete: Solid paving units made from normal-weight concrete with a compressive strength not less than [5000 psi (34 MPa)][6000 psi (41 MPa)]<Insert value>, water absorption not more than 5 percent according to ASTM C140, and no breakage and not more than 1 percent mass loss when tested for freeze-thaw resistance according to ASTM C67.

1. Thickness: [1-5/8 inches (41 mm)][1-3/4 inches (45 mm)][2 inches (51 mm)][2-3/8 inches (60 mm)]<Insert dimension>.
2. Face Size and Shape:
 - a. [8-7/8 inches (225 mm)][9 inches (229 mm)][12 inches (305 mm)][18 inches (457 mm)][24 inches (610 mm)] square.
 - b. [9-by-18-inch (229-by-457-mm)][12-by-24-inch (305-by-610-mm)] rectangle.
 - c. [As indicated]<Insert dimensions and shape>.
3. Color: [As indicated by manufacturer's designations][Match Architect's sample][As selected by Architect from manufacturer's full range]<Insert color>.

H. Concrete Pavers, Solid Paving Units, Lightweight Concrete: Solid paving units complying with ASTM C1491, made from lightweight concrete.

1. Thickness: [1-5/8 inches (41 mm)][1-3/4 inches (45 mm)][2 inches (51 mm)]<Insert dimension>.
2. Face Size and Shape: [9 inches (229 mm) square][12 inches (305 mm) square][18 inches (457 mm) square][As indicated]<Insert dimensions and shape>.
3. Color: [As indicated by manufacturer's designations][Match Architect's sample][As selected by Architect from manufacturer's full range]<Insert color>.

2.4 ASPHALT-BLOCK PAVERS

A. Asphalt-Block Pavers: Solid units made from asphalt cement complying with ASTM D312, Type III; inorganic stone dust or cement filler; and coarse aggregate, consisting of clean, hard, unweathered stone crushed into angular particles varying in size up to 3/8 inch (9.5 mm).

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

- a. **[Hanover Architectural Products]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Hanover Architectural Products]**
 - b. **<Insert manufacturer's name>**
3. Thickness: **[1-1/4 inches (32 mm)][2 inches (51 mm)][3 inches (76 mm)]<Insert dimension>**.
4. Face Size: **[4 by 6 inches (102 by 152 mm)][6 by 6 inches (152 by 152 mm)][8 by 8 inches (203 by 203 mm)][5 by 12 inches (127 by 305 mm)][6 by 12 inches (152 by 305 mm)][8-inch-(203-mm-) wide hexagon]<Insert dimensions>**.
5. Dimensional Tolerances: Plus or minus 1/16 inch (1.6 mm).
6. Finish: **[Natural, smooth][Ground][Ground and sandblasted]**.
7. Color: **[As indicated by manufacturer's designations][Match Architect's sample][As selected by Architect from manufacturer's full range]<Insert color>**.

2.5 STONE PAVERS

- A. Regional Materials: Stone shall be fabricated within **500 miles (800 km)** of Project site from materials that have been extracted, harvested, or recovered within **500 miles (800 km)** of Project site.
- B. Regional Materials: Stone shall be fabricated within **500 miles (800 km)** of Project site.
- C. Regional Materials: Stone shall be fabricated within **100 miles (160 km)** of Project site from materials that have been extracted, harvested, or recovered within **100 miles (160 km)** of Project site.
- D. Indigenous Materials: Stone shall be fabricated within **500 miles (800 km)** of Project site from materials that have been extracted, harvested, or recovered within **500 miles (800 km)** of Project site. If materials are transported by rail or water, the distance transported by rail or water shall be multiplied by 0.25 to determine the distance to Project site.
- E. Regional Materials: Stone shall be fabricated within **500 miles (800 km)** of Project site from materials that have been extracted, harvested, or recovered within **500 miles (800 km)** of Project site. If materials are transported by rail or water, the distance transported by rail or water shall be multiplied by 0.25 to determine the distance to Project site.
- F. Granite Pavers: Rectangular paving slabs made from granite complying with ASTM C615/C615M.
 1. Color and Grain: **[Light gray][Dark gray][Buff][White][Black][Pink]<Insert color>** with **[medium][fine]** grain.
 2. Finish: **[Honed][Thermal][As indicated][Match Architect's sample]<Insert finish>**.
 3. Match Architect's samples for color, finish, and other stone characteristics relating to aesthetic effects.
 4. Thickness: Not less than **[3/4 inch (20 mm)][30 mm][1-1/4 inches (32 mm)][1-5/8 inches (40 mm)]** unless otherwise indicated.
 5. Face Size: **[9 inches (229 mm) square][12 inches (305 mm) square][18 inches (457 mm) square][9 by 18 inches (229 by 457 mm)][As indicated]<Insert dimensions>**.
- G. Limestone Pavers: Rectangular paving slabs made from limestone complying with ASTM C568/C568M.
 1. Classification: **[II Medium-Density][III High-Density]**.
 2. Stone Abrasion Resistance: Minimum value of **[10]<Insert value>**, based on testing according to

- ASTM C241/C241M or ASTM C1353.
 3. Indiana Oolitic Limestone Grade and Color: **[Select, buff][Select, gray][Standard, buff][Standard, gray][Rustic, buff][Rustic, gray][Variegated]**, according to grade and color classification established by ILI.
 4. Finish: **[Smooth][Chat sawed][Shot sawed][As indicated]<Insert finish>**.
 5. Match Architect's samples for color, finish, and other stone characteristics relating to aesthetic effects.
 6. Thickness: Not less than **[1 inch (25 mm)][1-1/4 inches (32 mm)][1-5/8 inches (40 mm)][2 inches (50 mm)]** unless otherwise indicated.
 7. Face Size: **[9 inches (229 mm) square][12 inches (305 mm) square][18 inches (457 mm) square][9 by 18 inches (229 by 457 mm)][As indicated]<Insert dimensions>**.
- H. Marble Pavers: Rectangular paving slabs made from marble complying with ASTM C503/C503M.
1. Stone Abrasion Resistance: Minimum value of **[10]<Insert value>**, based on testing according to ASTM C241/C241M or ASTM C1353.
 2. Description: Uniform, fine- to medium-grained, **[white]<Insert color>** stone with only slight veining.
 3. Finish: **[Honed][As indicated][Match Architect's sample]<Insert finish>**.
 4. Match Architect's samples for color, finish, and other stone characteristics relating to aesthetic effects.
 5. Thickness: Not less than **[3/4 inch (20 mm)][30 mm][1-1/4 inches (32 mm)]** unless otherwise indicated.
 6. Face Size: **[9 inches (229 mm) square][12 inches (305 mm) square][18 inches (457 mm) square][9 by 18 inches (229 by 457 mm)][As indicated]<Insert dimensions>**.
- I. Quartz-Based Stone Pavers: **[Rectangular paving slabs][Random polygonal flagstones]** made from quartz-based stone complying with ASTM C616/C616M, Classification **[I Sandstone][II Quartzitic Sandstone][III Quartzite]**.
1. Stone Abrasion Resistance: Minimum value of **[10]<Insert value>**, based on testing according to ASTM C241/C241M or ASTM C1353.
 2. Finish: **[Sand rubbed][Natural cleft][Thermal][As indicated][Match Architect's sample]<Insert finish>**.
 3. Match Architect's samples for color, finish, and other stone characteristics relating to aesthetic effects.
 4. Thickness: Not less than **[1 inch (25 mm)][1-1/4 inches (32 mm)][1-1/2 inches (38 mm)][1-5/8 inches (40 mm)][2 inches (50 mm)]** unless otherwise indicated.
 5. Face Size: **[9 inches (229 mm) square][12 inches (305 mm) square][18 inches (457 mm) square][9 by 18 inches (229 by 457 mm)][As indicated][Random]<Insert dimensions>**.
- J. Slate Pavers: **[Rectangular paving slabs][Random polygonal flagstones]** made from slate complying with ASTM C629/C629M, Classification I Exterior, with a fine, even grain **[and unfading color,]** from clear, sound stock.
1. Color: **[Black][Blue-black][Gray][Blue-gray][Green][Purple][Mottled purple and green][Red]**.
 2. Stone Abrasion Resistance: Minimum value of **[8]<Insert value>**, based on testing according to ASTM C241/C241M or ASTM C1353.
 3. Finish: **[Honed][Sand rubbed][Natural cleft][As indicated][Match Architect's sample]<Insert finish>**.
 4. Match Architect's samples for color, finish, and other stone characteristics relating to aesthetic effects.
 5. Thickness: Not less than **[1/2 inch (13 mm)][3/4 inch (20 mm)][1 inch (25 mm)]** unless otherwise indicated.
 6. Face Size: **[9 inches (229 mm) square][12 inches (305 mm) square][18 inches (457 mm)]**

square][9 by 18 inches (229 by 457 mm)][As indicated][Random]<Insert dimensions>.

- K. Travertine Pavers: Rectangular paving slabs made from travertine complying with ASTM C1527/C1527M, Classification I Exterior.
1. Stone Abrasion Resistance: Minimum value of **[10]<Insert value>**, based on testing according to ASTM C241/C241M or ASTM C1353.
 2. Cut: Vein cut.
 3. Filling: Fill pores on faces of stone with cementitious filler of color **[selected by Architect][matching Architect's sample]**.
 4. Finish: **[Honed][As indicated][Match Architect's sample]<Insert finish>**.
 5. Match Architect's samples for color, finish, and other stone characteristics relating to aesthetic effects.
 6. Thickness: Not less than **[3/4 inch (20 mm)][30 mm][1-1/4 inches (32 mm)]** unless otherwise indicated.
 7. Face Size: **[9 inches (229 mm) square][12 inches (305 mm) square][18 inches (457 mm) square][9 by 18 inches (229 by 457 mm)][As indicated]<Insert dimensions>**.
- L. Rough Granite Pavers: Rectangular **[tumbled]** paving stones, with split **[or thermal-finished]** faces and edges, made from granite complying with ASTM C615/C615M.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Buechel Stone Corp]**
 - b. **[Cold Spring Granite Company]**
 - c. **[Fletcher Granite Company]**
 - d. **[Granicor]**
 - e. **[Milestone Imports, Inc.]**
 - f. **[North Carolina Granite Corporation]**
 - g. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Buechel Stone Corp]**
 - b. **[Cold Spring Granite Company]**
 - c. **[Fletcher Granite Company]**
 - d. **[Granicor]**
 - e. **[Milestone Imports, Inc.]**
 - f. **[North Carolina Granite Corporation]**
 - g. **<Insert manufacturer's name>**
 3. Color and Grain: **[Light gray][Dark gray][Buff][White][Black][Pink]<Insert color>** with **[medium][fine]** grain.
 4. Thickness: **[1-1/4 inches (32 mm)][2 inches (51 mm)][3 inches (76 mm)][4 inches (102 mm)][4 inches (102 mm), plus or minus 1/2 inch (13 mm)]<Insert dimension>**.
 5. Face Size: **[4 by 4 inches (100 by 100 mm), plus or minus 1/2 inch (13 mm)][3 to 5 inches (75 to 125 mm) by 8 to 12 inches (200 to 300 mm)][As indicated]<Insert dimensions>**.

2.6 CURBS AND EDGE RESTRAINTS

- A. Plastic Edge Restraints: Manufacturer's standard triangular PVC extrusions **[1-3/4 inches (45 mm) high by 3-1/2 inches (89 mm) wide][3-1/8 inches (79 mm) high by 9-1/2 inches (241 mm) wide]** designed to serve as edge restraints for unit pavers; rigid type for straight edges and flexible type for curved edges; with pipe connectors and **3/8-inch (9.5-mm) diameter by 12-inch- (300-mm-) long steel spikes.**
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Brickstop Corporation]**
 - b. **[Dimex LLC]**
 - c. **[Oly-Ola Edgings, Inc.]**
 - d. **[Pave Tech; Probst, Inc.]**
 - e. **[Sure-loc Edging Corporation.]**
 - f. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Brickstop Corporation]**
 - b. **[Dimex LLC]**
 - c. **[Oly-Ola Edgings, Inc.]**
 - d. **[Pave Tech; Probst, Inc.]**
 - e. **[Sure-loc Edging Corporation.]**
 - f. **<Insert manufacturer's name>**
- B. Steel Edge Restraints: Manufacturer's standard painted steel edging **[3/16 inch (4.8 mm) thick by 4 inches (100 mm) high][1/4 inch (6.4 mm) thick by 5 inches (125 mm) high]** with loops pressed from or welded to face to receive stakes at **36 inches (900 mm) o.c.** and steel stakes **15 inches (380 mm) long** for each loop.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Border Concepts, Inc]**
 - b. **[COLMET]**
 - c. **[J. D. Russell Company (The)]**
 - d. **[Sure-loc Edging Corporation.]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Border Concepts, Inc]**
 - b. **[COLMET]**
 - c. **[J. D. Russell Company (The)]**
 - d. **[Sure-loc Edging Corporation.]**
 - e. **<Insert manufacturer's name>**

3. Color: **[As indicated by manufacturer's designations][Match Architect's sample][As selected by Architect from manufacturer's full range]<Insert color>.**
- C. Aluminum Edge Restraints: Manufacturer's standard **[straight, 1/8-inch- (3.2-mm-) thick by 4-inch- (100-mm-) high][straight, 3/16-inch- (4.8-mm-) thick by 4-inch- (100-mm-) high][L-shaped, 1/8-inch- (3.2-mm-) thick by 1-3/8-inch- (35-mm-) high][L-shaped, 3/16-inch- (4.8-mm-) thick by 2-1/4-inch- (57-mm-) high]** extruded-aluminum edging with loops pressed from face to receive stakes at **12 inches (300 mm)** o.c. and aluminum stakes **12 inches (300 mm)** long for each loop.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Brickstop Corporation]**
 - b. **[Curv-Rite, Inc]**
 - c. **[Permaloc Corporation]**
 - d. **[Sure-loc Edging Corporation.]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Brickstop Corporation]**
 - b. **[Curv-Rite, Inc]**
 - c. **[Permaloc Corporation]**
 - d. **[Sure-loc Edging Corporation.]**
 - e. **<Insert manufacturer's name>**
- D. Job-Built Concrete Edge Restraints: Comply with requirements in Section 033000 "Cast-in-Place Concrete" for normal-weight, air-entrained, ready-mixed concrete with minimum 28-day compressive strength of **3000 psi (20 MPa)**.
- E. Precast Concrete Curbs: Made from normal-weight concrete with a compressive strength not less than **[5000 psi (34 MPa)][6000 psi (41 MPa)]<Insert value>** and water absorption not more than 5 percent, in shapes and sizes indicated.
1. Regional Materials: Concrete curbs shall be manufactured within **500 miles (800 km)** of Project site from aggregates **[and cementitious materials]** that have been extracted, harvested, or recovered, as well as manufactured, within **500 miles (800 km)** of Project site.
 2. Regional Materials: Concrete curbs shall be manufactured within **500 miles (800 km)** of Project site.
 3. Regional Materials: Concrete curbs shall be manufactured within **100 miles (160 km)** of Project site from aggregates **[and cementitious materials]** that have been extracted, harvested, or recovered, as well as manufactured, within **100 miles (160 km)** of Project site.
 4. Indigenous Materials: Concrete curbs shall be manufactured within **500 miles (800 km)** of Project site from aggregates **[and cementitious materials]** that have been extracted, harvested, or recovered, as well as manufactured, within **500 miles (800 km)** of Project site. If materials are transported by rail or water, the distance transported by rail or water shall be multiplied by 0.25 to determine the distance to Project site.
 5. Regional Materials: Concrete curbs shall be manufactured within **500 miles (800 km)** of Project site from aggregates **[and cementitious materials]** that have been extracted, harvested, or recovered, as well as manufactured, within **500 miles (800 km)** of Project site. If materials are transported by rail or water, the distance transported by rail or water shall be multiplied by 0.25 to determine the distance to Project site.

6. Color and Texture: **[Match Architect's sample][As selected by Architect from manufacturer's full range]<Insert color and texture>**.
- F. Granite Curbs: Granite curbing, with face battered **1 inch per foot (1:12)**, produced in random lengths not less than **36 inches (900 mm)** from granite complying with ASTM C615/C615M.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Cold Spring Granite Company]**
 - b. **[Fletcher Granite Company]**
 - c. **[Granicor]**
 - d. **[New England Stone, Inc.]**
 - e. **[North Carolina Granite Corporation]**
 - f. **[Polycor Inc.]**
 - g. **[Swenson Granite Works; a Polycor Inc. company]**
 - h. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Cold Spring Granite Company]**
 - b. **[Fletcher Granite Company]**
 - c. **[Granicor]**
 - d. **[New England Stone, Inc.]**
 - e. **[North Carolina Granite Corporation]**
 - f. **[Polycor Inc.]**
 - g. **[Swenson Granite Works; a Polycor Inc. company]**
 - h. **<Insert manufacturer's name>**
 3. Regional Materials: Stone shall be fabricated within **500 miles (800 km)** of Project site from materials that have been extracted, harvested, or recovered within **500 miles (800 km)** of Project site.
 4. Regional Materials: Stone shall be fabricated within **500 miles (800 km)** of Project site.
 5. Regional Materials: Stone shall be fabricated within **100 miles (160 km)** of Project site from materials that have been extracted, harvested, or recovered within **100 miles (160 km)** of Project site.
 6. Indigenous Materials: Stone shall be fabricated within **500 miles (800 km)** of Project site from materials that have been extracted, harvested, or recovered within **500 miles (800 km)** of Project site. If materials are transported by rail or water, the distance transported by rail or water shall be multiplied by 0.25 to determine the distance to Project site.
 7. Regional Materials: Stone shall be fabricated within **500 miles (800 km)** of Project site from materials that have been extracted, harvested, or recovered within **500 miles (800 km)** of Project site. If materials are transported by rail or water, the distance transported by rail or water shall be multiplied by 0.25 to determine the distance to Project site.
 8. Granite Color and Grain: **[Light gray][Dark gray][Buff][White][Black][Pink]<Insert color>** with **[fine][medium][coarse]** grain.
 9. Top Width: **[4 inches (102 mm)][5 inches (127 mm)][6 inches (152 mm)]<Insert dimension>**.
 10. Face Height: **[4 inches (102 mm)][6 inches (152 mm)][8 inches (203 mm)]<Insert dimension>**.
 11. Total Height: **[12 inches (305 mm)][16 inches (406 mm)][18 inches (457 mm)]<Insert dimension>**.
 12. Top Finish: **[Sawed][Thermal][Bush hammered]**.

13. Face Finish: **[Split][Sawed][Thermal][Bush hammered]**.

G. **<Insert requirements>**.

2.7 ACCESSORIES

- A. Cork Joint Filler: Preformed strips complying with ASTM D1752, Type II.
- B. Compressible Foam Filler: Preformed strips complying with ASTM D1056, Grade 2A1.

2.8 AGGREGATE SETTING-BED MATERIALS

- A. Graded Aggregate for Subbase: Sound, crushed stone or gravel complying with **[ASTM D448 for Size No. 57][ASTM D2940/D2940M, subbase material][requirements in Section 312000 "Earth Moving" for subbase material]**.
- B. Graded Aggregate for Base: Sound, crushed stone or gravel complying with **[ASTM D448 for Size No. 8][ASTM D2940/D2940M, base material][requirements in Section 312000 "Earth Moving" for base course]**.
- C. Sand for Leveling Course: Sound, sharp, washed, natural sand or crushed stone complying with gradation requirements in ASTM C33/C33M for fine aggregate.
- D. Stone Screenings for Leveling Course: Sound stone screenings complying with ASTM D448 for Size No. 10.
- E. Sand for Joints: Fine, sharp, washed, natural sand or crushed stone with 100 percent passing **No. 16 (1.18-mm)** sieve and no more than 10 percent passing **No. 200 (0.075-mm)** sieve.
 - 1. Provide sand of color needed to produce required joint color.
- F. Separation Geotextile: Woven geotextile fabric, manufactured for separation applications; made from polyolefins or polyesters, with elongation less than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:
 - 1. Survivability: Class 2, AASHTO M 288.
 - 2. Apparent Opening Size: **No. 60 (0.250-mm)** sieve, maximum; ASTM D4751.
 - 3. Permittivity: 0.02 per second, minimum; ASTM D4491.
 - 4. UV Stability: 50 percent after 500 hours' exposure, ASTM D4355.
- G. Drainage Geotextile: Nonwoven needle-punched geotextile fabric, manufactured for subsurface drainage applications, made from polyolefins or polyesters; with elongation greater than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:
 - 1. Survivability: Class 2, AASHTO M 288.
 - 2. Apparent Opening Size: **No. 40 (0.425-mm)** sieve, maximum; ASTM D4751.
 - 3. Permittivity: 0.5 per second, minimum; ASTM D4491.
 - 4. UV Stability: 50 percent after 500 hours' exposure, ASTM D4355.
- H. Herbicide: Commercial chemical for weed control, registered with the EPA. Provide in granular, liquid, or wettable powder form.

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2.9 BITUMINOUS SETTING-BED MATERIALS

- A. Primer for Base: ASTM D2028/D2028M, cutback asphalt, grade as recommended by unit paver manufacturer.
- B. Fine Aggregate for Setting Bed: ASTM D1073, No. 2 or No. 3.
- C. Asphalt Cement: ASTM D3381/D3381M, Viscosity Grade AC-10 or Grade AC-20.
- D. Neoprene-Modified Asphalt Adhesive: Paving manufacturer's standard adhesive consisting of oxidized asphalt combined with 2 percent neoprene and 10 percent long-fibered mineral fibers containing no asbestos.
- E. Sand for Joints: Fine, sharp, washed, natural sand or crushed stone with 100 percent passing **No. 16 (1.18-mm)** sieve and no more than 10 percent passing **No. 200 (0.075-mm)** sieve.
 - 1. Provide sand of color needed to produce required joint color.

2.10 MORTAR SETTING-BED MATERIALS

- A. Regional Materials: Aggregate for mortar and grout[, **cement, and lime**] shall be manufactured within **500 miles (800 km)** of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within **500 miles (800 km)** of Project site.
- B. Regional Materials: Aggregate for mortar and grout[, **cement, and lime**] shall be manufactured within **500 miles (800 km)** of Project site.
- C. Regional Materials: Aggregate for mortar and grout[, **cement, and lime**] shall be manufactured within **100 miles (160 km)** of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within **100 miles (160 km)** of Project site.
- D. Indigenous Materials: Aggregate for mortar and grout[, **cement, and lime**] shall be manufactured within **500 miles (800 km)** of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within **500 miles (800 km)** of Project site. If materials are transported by rail or water, the distance transported by rail or water shall be multiplied by 0.25 to determine the distance to Project site.
- E. Regional Materials: Aggregate for mortar and grout[, **cement, and lime**] shall be manufactured within **500 miles (800 km)** of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within **500 miles (800 km)** of Project site. If materials are transported by rail or water, the distance transported by rail or water shall be multiplied by 0.25 to determine the distance to Project site.
- F. Portland Cement: ASTM C150/C150M, Type I or Type II.
- G. Hydrated Lime: ASTM C207, Type S.
- H. Sand: ASTM C144.
- I. Latex Additive: [**Manufacturer's standard**][**acrylic resin**][or][**styrene-butadiene-rubber**] water emulsion, serving as replacement for part or all of gaging water, of type specifically recommended by latex-additive manufacturer for use with field-mixed portland cement and aggregate mortar bed, and not containing a retarder.

- J. Thin-Set Mortar for Bond Coat: Latex-portland cement mortar complying with ANSI A118.4.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ARDEX Americas]**
 - b. **[Boiardi Products Corporation; a QEP company]**
 - c. **[Bostik; Arkema]**
 - d. **[C-Cure]**
 - e. **[Custom Building Products]**
 - f. **[H.B. Fuller Construction Products Inc. / TEC]**
 - g. **[Jamo Inc]**
 - h. **[Laticrete International, Inc.]**
 - i. **[MAPEI Corporation]**
 - j. **[Parex, a Sika brand]**
 - k. **[ProSpec; H.B. Fuller Construction Products Inc.]**
 - l. **[Sakrete; CRH Americas, Oldcastle APG]**
 - m. **[Southern Grouts & Mortars, Inc]**
 - n. **[Summitville Tiles, Inc.]**
 - o. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ARDEX Americas]**
 - b. **[Boiardi Products Corporation; a QEP company]**
 - c. **[Bostik; Arkema]**
 - d. **[C-Cure]**
 - e. **[Custom Building Products]**
 - f. **[H.B. Fuller Construction Products Inc. / TEC]**
 - g. **[Jamo Inc]**
 - h. **[Laticrete International, Inc.]**
 - i. **[MAPEI Corporation]**
 - j. **[Parex, a Sika brand]**
 - k. **[ProSpec; H.B. Fuller Construction Products Inc.]**
 - l. **[Sakrete; CRH Americas, Oldcastle APG]**
 - m. **[Southern Grouts & Mortars, Inc]**
 - n. **[Summitville Tiles, Inc.]**
 - o. **<Insert manufacturer's name>**
 3. Provide prepackaged, dry-mortar mix containing dry, redispersible, vinyl acetate or acrylic additive to which only water must be added at Project site.
 4. Provide prepackaged, dry-mortar mix combined with **[acrylic resin][or][styrene-butadiene-rubber]** liquid-latex additive at Project site.
 5. Provide product that is approved by manufacturer for application thickness of **[5/8 inch (16 mm)]<Insert value>**.
- K. Water: Potable.
- L. Reinforcing Wire Fabric: Galvanized, welded wire fabric, **2 by 2 inches (50.8 by 50.8 mm)** by **0.062 inch (1.57 mm)** in diameter; comply with ASTM A1064/A1064M except for minimum wire size.

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2.11 GROUT MATERIALS

- A. Regional Materials: Aggregate for mortar and grout[, **cement, and lime**] shall be manufactured within **500 miles (800 km)** of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within **500 miles (800 km)** of Project site.
- B. Regional Materials: Aggregate for mortar and grout[, **cement, and lime**] shall be manufactured within **500 miles (800 km)** of Project site.
- C. Regional Materials: Aggregate for mortar and grout[, **cement, and lime**] shall be manufactured within **100 miles (160 km)** of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within **100 miles (160 km)** of Project site.
- D. Indigenous Materials: Aggregate for mortar and grout[, **cement, and lime**] shall be manufactured within **500 miles (800 km)** of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within **500 miles (800 km)** of Project site. If materials are transported by rail or water, the distance transported by rail or water shall be multiplied by 0.25 to determine the distance to Project site.
- E. Regional Materials: Aggregate for mortar and grout[, **cement, and lime**] shall be manufactured within **500 miles (800 km)** of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within **500 miles (800 km)** of Project site. If materials are transported by rail or water, the distance transported by rail or water shall be multiplied by 0.25 to determine the distance to Project site.
- F. Sand-Portland Cement Grout: ANSI A108.10, made of white or gray cement and white or colored aggregate as required to produce color indicated.
 - 1. Colored Mortar Pigments for Grout: Natural and synthetic iron and chromium oxides, compounded for use in mortar and grout mixes. Use only pigments that have proved, through testing and experience, to be satisfactory for use in portland cement grout.
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Davis Colors]**
 - 2) **[Lanxess Corporation]**
 - 3) **[Solomon Colors Inc.]**
 - 4) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Davis Colors]**
 - 2) **[Lanxess Corporation]**
 - 3) **[Solomon Colors Inc.]**
 - 4) **<Insert manufacturer's name>**
- G. Standard Cement Grout: ANSI A118.6, sanded.
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering**

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

- a. [Boiardi Products Corporation; a QEP company]
- b. [Bostik; Arkema]
- c. [C-Cure]
- d. [Custom Building Products]
- e. [H.B. Fuller Construction Products Inc. / TEC]
- f. [Jamo Inc]
- g. [Laticrete International, Inc.]
- h. [MAPEI Corporation]
- i. [Parex, a Sika brand]
- j. [ProSpec; H.B. Fuller Construction Products Inc.]
- k. [Sakrete; CRH Americas, Oldcastle APG]
- l. [Southern Grouts & Mortars, Inc]
- m. [Summitville Tiles, Inc.]
- n. <Insert manufacturer's name>

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

- a. [Boiardi Products Corporation; a QEP company]
- b. [Bostik; Arkema]
- c. [C-Cure]
- d. [Custom Building Products]
- e. [H.B. Fuller Construction Products Inc. / TEC]
- f. [Jamo Inc]
- g. [Laticrete International, Inc.]
- h. [MAPEI Corporation]
- i. [Parex, a Sika brand]
- j. [ProSpec; H.B. Fuller Construction Products Inc.]
- k. [Sakrete; CRH Americas, Oldcastle APG]
- l. [Southern Grouts & Mortars, Inc]
- m. [Summitville Tiles, Inc.]
- n. <Insert manufacturer's name>

H. High-Performance Cement Grout: ANSI A118.7, sanded.

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

- a. [ARDEX Americas]
- b. [Boiardi Products Corporation; a QEP company]
- c. [Bostik; Arkema]
- d. [C-Cure]
- e. [Custom Building Products]
- f. [H.B. Fuller Construction Products Inc. / TEC]
- g. [Jamo Inc]
- h. [Laticrete International, Inc.]
- i. [MAPEI Corporation]
- j. [Sakrete; CRH Americas, Oldcastle APG]
- k. [Southern Grouts & Mortars, Inc]
- l. [Summitville Tiles, Inc.]

- m. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [ARDEX Americas]
 - b. [Boiardi Products Corporation; a QEP company]
 - c. [Bostik; Arkema]
 - d. [C-Cure]
 - e. [Custom Building Products]
 - f. [H.B. Fuller Construction Products Inc. / TEC]
 - g. [Jamo Inc]
 - h. [Laticrete International, Inc.]
 - i. [MAPEI Corporation]
 - j. [Sakrete; CRH Americas, Oldcastle APG]
 - k. [Southern Grouts & Mortars, Inc]
 - l. [Summitville Tiles, Inc.]
 - m. <Insert manufacturer's name>
- 3. Polymer Type:
 - a. Ethylene vinyl acetate or acrylic additive, in dry, redispersible form, prepackaged with other dry ingredients.
 - b. [Acrylic resin][or][styrene-butadiene rubber] in liquid-latex form for addition to prepackaged dry-grout mix.
- I. Grout Colors: [As indicated by manufacturer's designations][Match Architect's samples][As selected by Architect from manufacturer's full range]<Insert color>.
- J. Water: Potable.

2.12 BITUMINOUS SETTING-BED MIX

- A. Mix bituminous setting-bed materials at an asphalt plant in approximate proportion, by weight, of 7 percent asphalt cement to 93 percent fine aggregate unless otherwise indicated. Heat mixture to **300 deg F (149 deg C)**.

2.13 MORTAR AND GROUT MIXES

- A. General: Comply with referenced standards and with manufacturers' written instructions for mix proportions, mixing equipment, mixer speeds, mixing containers, mixing times, and other procedures needed to produce setting-bed and joint materials of uniform quality and with optimal performance characteristics. Discard mortars and grout if they have reached their initial set before being used.
- B. Mortar-Bed Bond Coat: Mix neat cement and [latex additive][water] to a creamy consistency.
- C. Portland Cement-Lime Setting-Bed Mortar: Type M complying with ASTM C270, Proportion Specification.
- D. Latex-Modified, Portland Cement Setting-Bed Mortar: Proportion and mix portland cement, sand, and latex additive for setting bed to comply with written instructions of latex-additive manufacturer and as necessary to produce stiff mixture with a moist surface when bed is ready to receive pavers.

- E. Latex-Modified, Portland Cement Bond Coat: Proportion and mix portland cement, aggregate, and liquid latex for bond coat to comply with written instructions of liquid-latex manufacturer.
- F. Thinset Mortar Bond Coat: Proportion and mix according to manufacturer's written instructions.
- G. Job-Mixed Portland Cement Grout: Proportion and mix job-mixed portland cement and aggregate grout to match setting-bed mortar except omit hydrated lime and use enough water to produce a pourable mixture.
 - 1. Pigmented Grout: Select and proportion pigments with other ingredients to produce color required. Do not exceed pigment-to-cement ratio of 1 to 10, by weight.
 - 2. Colored-Aggregate Grout: Produce color required by combining colored aggregates with portland cement of selected color.
- H. Packaged Grout: Proportion and mix according to grout manufacturer's written instructions.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine surfaces indicated to receive unit paving, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Where unit paving is to be installed over waterproofing, examine waterproofing installation, with waterproofing Installer present, for protection from paving operations, including areas where waterproofing system is turned up or flashed against vertical surfaces.
- C. Proceed with installation only after unsatisfactory conditions have been corrected[**and waterproofing protection is in place**].

3.2 PREPARATION

- A. Remove substances from concrete substrates that could impair mortar bond, including curing and sealing compounds, form oil, and laitance.
- B. Sweep concrete substrates to remove dirt, dust, debris, and loose particles.
- C. Proof-roll prepared subgrade according to requirements in Section 312000 "Earth Moving" to identify soft pockets and areas of excess yielding. Proceed with unit paver installation only after deficient subgrades have been corrected and are ready to receive [**subbase**][**and**][**base**] course for unit pavers.

3.3 INSTALLATION, GENERAL

- A. Do not use unit pavers with chips, cracks, voids, discolorations, or other defects that might be visible or cause staining in finished work.
- B. Mix pavers from several pallets or cubes, as they are placed, to produce uniform blend of colors and textures.
- C. Cut unit pavers with motor-driven masonry saw equipment to provide clean, sharp, unchipped edges. Cut units to provide pattern indicated and to fit adjoining work neatly. Use full units without cutting where

possible. Hammer cutting is not acceptable.

1. For concrete pavers, a block splitter may be used.
- D. Handle protective-coated brick pavers to prevent coated surfaces from contacting backs or edges of other units. If, despite these precautions, coating does contact bonding surfaces of brick, remove coating from bonding surfaces before setting brick.
- E. Joint Pattern: **[Running bond][Herringbone][Basket weave][Grid][As indicated][Match and continue existing unit paver joint pattern]**.
- F. Pavers over Waterproofing: Exercise care in placing pavers and setting materials over waterproofing so protection materials are not displaced and waterproofing is not punctured or otherwise damaged. Carefully replace protection materials that become displaced and arrange for repair of damaged waterproofing before covering with paving.
 1. Provide joint filler at waterproofing that is turned up on vertical surfaces[**unless otherwise indicated; where unfilled joints are indicated, provide temporary filler or protection until paver installation is complete**].
- G. Tolerances:
 1. Do not exceed **1/32-inch (0.8-mm) unit-to-unit offset from flush (lippage) or 1/8 inch in 10 feet (3 mm in 3 m) from level, or indicated slope, for finished surface of paving.**
 2. Do not exceed[**1/16-inch (1.6-mm) unit-to-unit offset from flush (lippage) nor 1/8 inch in 24 inches (3 mm in 600 mm) and**] **1/4 inch in 10 feet (6 mm in 3 m) from level, or indicated slope, for finished surface of paving.**
- H. Expansion and Control Joints:
 1. Provide for sealant-filled joints at locations and of widths indicated. Provide compressible foam filler as backing for sealant-filled joints[**unless otherwise indicated; where unfilled joints are indicated, provide temporary filler until paver installation is complete**]. Install joint filler before setting pavers. Sealant materials and installation are specified in Section 079200 "Joint Sealants."
 2. Provide cork joint filler at locations and of widths indicated. Install joint filler before setting pavers. Make top of joint filler flush with top of pavers.
- I. Provide edge restraints as indicated. Install edge restraints before placing unit pavers.
 1. Install edge restraints to comply with manufacturer's written instructions. Install stakes at intervals required to hold edge restraints in place during and after unit paver installation.
 2. For metal edge restraints with top edge exposed, drive stakes at least **1 inch (25 mm)** below top edge.
 3. Install job-built concrete edge restraints to comply with requirements in Section 033000 "Cast-in-Place Concrete."
 4. Where pavers set in mortar bed are indicated as edge restraints for pavers set in aggregate setting bed, install pavers set in mortar and allow mortar to cure before placing aggregate setting bed and remainder of pavers. Cut off mortar bed at a steep angle so it will not interfere with aggregate setting bed.
 5. Where pavers embedded in concrete are indicated as edge restraints for pavers set in aggregate setting bed, install pavers embedded in concrete and allow concrete to cure before placing aggregate setting bed and remainder of pavers. Hold top of concrete below aggregate setting bed.

- J. Provide steps made of pavers as indicated. Install paver steps before installing adjacent pavers.
 - 1. Where pavers set in mortar bed are indicated for steps constructed adjacent to pavers set in aggregate setting bed, install steps and allow mortar to cure before placing aggregate setting bed and remainder of pavers. Cut off mortar bed at a steep angle so it will not interfere with aggregate setting bed.

3.4 AGGREGATE SETTING-BED APPLICATIONS

- A. Compact soil subgrade uniformly to at least **[95]<Insert number>** percent of **[ASTM D698][ASTM D1557]** laboratory density.
- B. Proof-roll prepared subgrade to identify soft pockets and areas of excess yielding. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Architect, and replace with compacted backfill or fill as directed.
- C. Place separation geotextile over prepared subgrade, overlapping ends and edges at least **12 inches (300 mm)**.
- D. Place aggregate[**subbase and**] base, compact by tamping with plate vibrator, and screed to depth indicated.
- E. Place aggregate[**subbase and**] base, compact to 100 percent of ASTM D1557 maximum laboratory density, and screed to depth indicated.
- F. Place drainage geotextile over compacted base course, overlapping ends and edges at least **12 inches (300 mm)**.
- G. Place leveling course and screed to a thickness of **1 to 1-1/2 inches (25 to 38 mm)**, taking care that moisture content remains constant and density is loose and uniform until pavers are set and compacted.
- H. Treat leveling course with herbicide to inhibit growth of grass and weeds.
- I. Set pavers with a minimum joint width of **1/16 inch (1.5 mm)** and a maximum of **1/8 inch (3 mm)**, being careful not to disturb leveling base. If pavers have spacer bars, place pavers hand tight against spacer bars. Use string lines to keep straight lines. Fill gaps between units that exceed **[3/8 inch (10 mm)]<Insert dimension>** with pieces cut to fit from full-size unit pavers.
 - 1. When installation is performed with mechanical equipment, use only unit pavers with spacer bars on sides of each unit.
- J. Vibrate pavers into leveling course with a low-amplitude plate vibrator capable of a **3500- to 5000-lbf (16- to 22-kN)** compaction force at 80 to 90 Hz. Use vibrator with neoprene mat on face of plate or other means as needed to prevent cracking and chipping of pavers. Perform at least three passes across paving with vibrator.
 - 1. Compact pavers when there is sufficient surface to accommodate operation of vibrator, leaving at least **36 inches (900 mm)** of uncompacted pavers adjacent to temporary edges.
 - 2. Before ending each day's work, compact installed concrete pavers except for **36-inch (900-mm)** width of uncompacted pavers adjacent to temporary edges (laying faces).
 - 3. As work progresses to perimeter of installation, compact installed pavers that are adjacent to permanent edges unless they are within **36 inches (90 mm)** of laying face.
 - 4. Before ending each day's work and when rain interrupts work, cover pavers that have not been compacted and cover leveling course on which pavers have not been placed with nonstaining plastic sheets to protect them from rain.

- K. Spread dry sand and fill joints immediately after vibrating pavers into leveling course. Vibrate pavers and add sand until joints are completely filled, then remove excess sand. Leave a slight surplus of sand on the surface for joint filling.
- L. Do not allow traffic on installed pavers until sand has been vibrated into joints.
- M. Repeat joint-filling process 30 days later.

3.5 BITUMINOUS SETTING-BED APPLICATIONS

- A. Apply primer to concrete slab or binder course immediately before placing setting bed.
- B. Prepare for setting-bed placement by locating **3/4-inch- (19-mm-)** deep control bars approximately **11 feet (3.3 m)** apart and parallel to one another, to serve as guides for striking board. Adjust bars to subgrades required for accurate setting of paving units to finished grades indicated.
- C. Place bituminous setting bed where indicated, in panels, by spreading bituminous material between control bars. Spread mix at a minimum temperature of **250 deg F (121 deg C)**. Strike setting bed smooth, firm, even, and not less than **3/4 inch (19 mm)** thick. Add fresh bituminous material to low, porous spots after each pass of striking board. After each panel is completed, advance first control bar to next position in readiness for striking adjacent panels. Carefully fill depressions that remain after removing depth-control bars.
 - 1. Roll setting bed with power roller to a nominal depth of **3/4 inch (19 mm)**. Adjust thickness as necessary to allow accurate setting of unit pavers to finished grades indicated. Complete rolling before mix temperature cools to **185 deg F (85 deg C)**.
- D. Apply neoprene-modified asphalt adhesive to cold setting bed by squeegeeing or troweling to a uniform thickness of **1/16 inch (1.6 mm)**. Proceed with setting of paving units only after adhesive is tacky and surface is dry to touch.
- E. Place pavers carefully by hand in straight courses, maintaining accurate alignment and uniform top surface. Protect newly laid pavers with plywood panels on which workers can stand. Advance protective panels as work progresses, but maintain protection in areas subject to continued movement of materials and equipment to avoid creating depressions or disrupting alignment of pavers. If additional leveling of paving is required, and before treating joints, roll paving with power roller after sufficient heat has built up in the surface from several days of hot weather.
- F. Joint Treatment: Place unit pavers with hand-tight joints. Fill joints by sweeping sand over paved surface until joints are filled. Remove excess sand after joints are filled.

3.6 MORTAR SETTING-BED APPLICATIONS

- A. Saturate concrete subbase with clean water several hours before placing setting bed. Remove surface water about one hour before placing setting bed.
- B. Apply mortar-bed bond coat over surface of concrete subbase about 15 minutes before placing mortar bed. Do not exceed **1/16-inch (1.6-mm)** thickness for bond coat. Limit area of bond coat to avoid its drying out before placing setting bed.
- C. Apply mortar bed over bond coat; spread and screed mortar bed to uniform thickness at subgrade elevations required for accurate setting of pavers to finished grades indicated.

- D. Place reinforcing wire over concrete subbase, lapped at joints by at least one full mesh and supported so mesh becomes embedded in the middle of mortar bed. Hold edges back from vertical surfaces approximately **1/2 inch (13 mm)**.
- E. Place mortar bed with reinforcing wire fully embedded in middle of mortar bed. Spread and screed mortar bed to uniform thickness at subgrade elevations required for accurate setting of pavers to finished grades indicated.
- F. Mix and place only that amount of mortar bed that can be covered with pavers before initial set. Before placing pavers, cut back, bevel edge, and remove and discard setting-bed material that has reached initial set.
- G. Wet brick pavers before laying if the initial rate of absorption exceeds **30 g/30 sq. in. (30 g/194 sq. cm)** per minute when tested according to ASTM C67. Allow units to absorb water so they are damp but not wet at time of laying.
- H. Place pavers before initial set of cement occurs. Immediately before placing pavers on mortar bed, apply uniform **1/16-inch- (1.5-mm-)** thick bond coat to mortar bed or to back of each paver with a flat trowel.
- I. Tamp or beat pavers with a wooden block or rubber mallet to obtain full contact with setting bed and to bring finished surfaces within indicated tolerances. Set each paver in a single operation before initial set of mortar; do not return to areas already set or disturb pavers for purposes of realigning finished surfaces or adjusting joints.
- J. Spaced Joint Widths: Provide **[3/8-inch (10-mm)][1/2-inch (13-mm)][3/4-inch (19-mm)]** nominal joint width with variations not exceeding plus or minus **[1/16 inch (1.5 mm)][1/8 inch (3 mm)][3/16 inch (4.5 mm)]**.
- K. Grouted Joints: Grout paver joints complying with ANSI A108.10.
- L. Grout joints as soon as possible after initial set of setting bed.
 - 1. Force grout into joints, taking care not to smear grout on adjoining surfaces.
 - 2. Clean pavers as grouting progresses by dry brushing or rubbing with dry burlap to remove smears before tooling joints.
 - 3. Tool exposed joints slightly concave when thumbprint hard, using a jointer larger than joint thickness unless otherwise indicated.
 - 4. If tooling squeezes grout from joints, remove excess grout and smears by dry brushing or rubbing with dry burlap and tool joints again to produce a uniform appearance.
- M. Cure grout by maintaining in a damp condition for seven days unless otherwise recommended by grout or liquid-latex manufacturer.

3.7 REPAIRING, POINTING, AND CLEANING

- A. Remove and replace unit pavers that are loose, chipped, broken, stained, or otherwise damaged or that do not match adjoining units. Provide new units to match adjoining units and install in same manner as original units, with same joint treatment and with no evidence of replacement.
- B. Pointing: During tooling of joints, enlarge voids or holes and completely fill with grout. Point joints at sealant joints to provide a neat, uniform appearance, properly prepared for sealant application.
- C. Cleaning: Remove excess grout from exposed paver surfaces; wash and scrub clean.



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1. Remove temporary protective coating as recommended by coating manufacturer and as acceptable to paver and grout manufacturers.
2. Do not allow protective coating to enter floor drains. Trap, collect, and remove coating material.

END OF SECTION 32 14 00 00



32 - Exterior Improvements

Task	Specification	Specification Description
32 14 09 00	32 14 00 00	Unit Paving
32 14 09 00	32 93 00 00	Plants
32 14 11 00	32 13 13 00	Concrete Paving
32 14 11 00	32 14 00 00	Unit Paving
32 14 13 00	32 14 00 00	Unit Paving
32 14 13 16	32 13 13 00	Concrete Paving
32 14 13 16	32 14 00 00	Unit Paving
32 14 13 19	32 13 13 00	Concrete Paving
32 14 13 19	32 14 00 00	Unit Paving



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SECTION 32 14 16 00 - VITRIFIED BRICK PAVEMENT REPLACEMENT

1.1 GENERAL

A. General

1. Limits of Brick Pavement Replacement shall be as per the detail entitled "Payment Limits for Surface Restoration" shown in the plans, plus one foot on each side. Alternate individual bricks may have to be removed in order to maintain staggered joint pattern along the edge of the undisturbed brick pavement.

1.2 PRODUCT

A. Preparation

1. Base shall be provided and shaped to match level, kind and thickness (4" min.) of adjoining base. The base material shall be compacted to meet the density standards. 4" 2500 PSI concrete base may be used for irregular patches and where compaction is otherwise impractical. Concrete shall be properly placed, consolidated and cured. One inch of sand, or good grade dirt, free from clay, loam or other foreign matter shall be used for cushion to hold the bricks in place. The sand shall be shaped to a true surface parallel to required finished pavement surface.

B. Materials

1. Existing bricks shall be cleaned, stored, and secured by the Contractor.

1.3 EXECUTION

A. Reinstallation of Bricks

1. The bricks shall be installed in rows, better face upward, sorted by size with joints staggered, then rolled daily with a static tandem wheel roller. Additional bricks, if required, will be supplied by the Owner. City Personnel shall inspect work daily. After inspection, the bricks shall be sprayed with a solution of lime and water, using 26 lbs. of lime to 55 gallons of water. Asphalt steep 7330 or equal shall be used for joint filler. The steep shall be heated until fluid and poured over bricks and removed when cool with square pointed shovels dipped in lime water. Removed asphalt may be reused. If adjoining bricks are grouted, new filler shall be grout (8:1, builders sand: cement).

B. Acceptance

1. Upon completion of the work, and before acceptance and final payment, the Contractor shall remove all false work, equipment, rubbish, surplus, and discarded materials. The Contractor shall restore in an acceptable manner all property, both public and private, damaged during the prosecution of the work. The Contractor shall leave the roadway in a neat and presentable condition each day.

END OF SECTION 32 14 16 00



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Task	Specification	Specification Description
32 14 16 00	32 13 13 00	Concrete Paving
32 14 16 00	32 14 00 00	Unit Paving
32 14 33 00	32 14 00 00	Unit Paving



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SECTION 32 14 33 13 - POROUS UNIT PAVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Concrete Unit Pavers:
2. Concrete Unit Pavers:
 - a. Concrete grid pavers.
 - b. Solid concrete pavers for porous paving.
3. Curbs and edge restraints.

B. Related Requirements:

1. Section 312000 "Earth Moving" for excavation and compacted subgrade.
2. Section 321313 "Concrete Paving" for cast-in-place concrete curbs that serve as edge restraints for porous paving.
3. Section 321400 "Unit Paving" for nonporous unit paving, **[edge restraints][precast concrete curbs][and][granite curbs]**.
4. Section 329300 "Plants" for planting ground cover in porous paving.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at **[Project site]<Insert location>**.

1. **<Insert requirements>**.

1.3 ACTION SUBMITTALS

A. Product Data:

1. For materials other than aggregates.
2. For the following:
 - a. Pavers.
 - b. Edge restraints.
 - c. Precast concrete curbs.
 - d. Granite curbs.
 - e. Geotextiles.

B. Sustainable Design Submittals:

1. Product Certificates: For regional materials, indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project and cost for each regional material.
2. Environmental Product Declaration (EPD): For each product.

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3. Product Certificates: For indigenous materials, indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project, means of transportation, and cost for each indigenous material.
4. Environmental Product Declaration: For each product.
5. Product Certificates: For regional materials, indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project, means of transportation, and cost for each regional material.
6. Environmental Product Declaration: For each product.
7. Environmental Product Declaration: For each product.
8. Third-Party Certifications: For each product.
9. Third-Party Certified Life Cycle Assessment: For each product.

C. Sieve Analyses: For aggregate materials, according to ASTM C136.

D. Samples:

1. Full-size units of each type of unit paver indicated.
2. Exposed edge restraints.
3. Precast concrete curbs.
4. Granite curbs.
5. Aggregate fill.
6. Aggregate setting bed materials.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.
- B. Material Certificates: For unit pavers. Include statements of material properties indicating compliance with requirements, including compliance with standards. Provide for each type and size of unit.
- C. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for unit pavers, indicating compliance with requirements.
 1. For grid paving units, include durability test data based on testing according to proven field performance requirements of ASTM C1319 performed on units subjected to three years' exposure to same general type of environment, temperature range, and traffic volume as Project.
 2. For solid interlocking paving units, include test data for freezing and thawing according to ASTM C67.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: A qualified porous unit paving installer. Installer's **[field supervisor][personnel assigned to the Work]** shall have Concrete Paver Installer Certification from the Interlocking Concrete Pavement Institute (ICPI) with PICP (Permeable Interlocking Concrete Pavement) Specialist Designation.
- B. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for materials and execution.
 1. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Store pavers on elevated platforms in a dry location. If units are not stored in an enclosed location, cover tops and sides of stacks with waterproof sheeting, securely tied.
- B. Store aggregates where grading and other required characteristics can be maintained and contamination can be avoided.

PART 2 - PRODUCTS

2.1 CONCRETE UNIT PAVERS

- A. Regional Materials: Concrete pavers shall be manufactured within **500 miles (800 km)** of Project site from aggregates[**and cementitious materials**] that have been extracted, harvested, or recovered, as well as manufactured, within **500 miles (800 km)** of Project site.
- B. Regional Materials: Concrete pavers shall be manufactured within **500 miles (800 km)** of Project site.
- C. Regional Materials: Concrete pavers shall be manufactured within **100 miles (160 km)** of Project site from aggregates[**and cementitious materials**] that have been extracted, harvested, or recovered, as well as manufactured, within **100 miles (160 km)** of Project site.
- D. Indigenous Materials: Concrete pavers shall be manufactured within **500 miles (800 km)** of Project site from aggregates[**and cementitious materials**] that have been extracted, harvested, or recovered, as well as manufactured, within **500 miles (800 km)** of Project site. If materials are transported by rail or water, the distance transported by rail or water shall be multiplied by 0.25 to determine the distance to Project site.
- E. Regional Materials: Concrete pavers shall be manufactured within **500 miles (800 km)** of Project site from aggregates[**and cementitious materials**] that have been extracted, harvested, or recovered, as well as manufactured, within **500 miles (800 km)** of Project site. If materials are transported by rail or water, the distance transported by rail or water shall be multiplied by 0.25 to determine the distance to Project site.
- F. Source Limitations: Obtain each type of paver from single source that has resources to provide materials and products of consistent quality in appearance and physical properties.
- G. Concrete Grid Pavers: Grid paving units complying with ASTM C1319, made from normal-weight aggregates.
 - 1. Thickness: [3-1/8 inches (80 mm)][3-1/2 inches (90 mm)][4 inches (100 mm)]<Insert dimension>.
 - 2. Face Size and Shape: [As indicated]<Insert size and shape>.
 - 3. Opening Percentage: <Insert number>percent.
 - 4. Color: [As indicated by manufacturer's designations][Match Architect's sample][As selected by Architect from manufacturer's full range]<Insert color>.
- H. Solid Concrete Pavers for Porous Paving: Solid interlocking paving units of shapes that provide openings between units, complying with ASTM C936/C936M[, **resistant to freezing and thawing when tested according to ASTM C67**], and made from normal-weight aggregates.
 - 1. Thickness: [2-3/8 inches (60 mm)][3-1/8 inches (80 mm)][3-1/2 inches (90 mm)][4 inches (100 mm)]<Insert dimension>.
 - 2. Face Size and Shape: [As indicated]<Insert size and shape>.

3. Opening Percentage: <Insert number>percent.
4. Color: [As indicated by manufacturer's designations][Match Architect's sample][As selected by Architect from manufacturer's full range]<Insert color>.

2.2 CURBS AND EDGE RESTRAINTS

- A. Plastic Edge Restraints: Triangular PVC extrusions, [1-3/4 inches (45 mm) high by 3-1/2 inches (90 mm) wide][3-1/8 inches (80 mm) high by 9-1/2 inches (240 mm) wide], designed to serve as edge restraints for unit pavers; rigid type for straight edges and flexible type for curved edges, with pipe connectors and 3/8-inch- (9.5-mm-) diameter by 12-inch- (300-mm-) long steel spikes.
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Brickstop Corporation]
 - b. [Cambridge Pavers, Inc.]
 - c. [Dimex LLC]
 - d. [Oly-Ola Edgings, Inc.]
 - e. [Pave Tech; Probst, Inc.]
 - f. [Sure-loc Edging Corporation.]
 - g. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Brickstop Corporation]
 - b. [Cambridge Pavers, Inc.]
 - c. [Dimex LLC]
 - d. [Oly-Ola Edgings, Inc.]
 - e. [Pave Tech; Probst, Inc.]
 - f. [Sure-loc Edging Corporation.]
 - g. <Insert manufacturer's name>
- B. Steel Edge Restraints: Painted steel edging, [3/16 inch (4.8 mm) thick by 4 inches (100 mm) high][1/4 inch (6.4 mm) thick by 5 inches (125 mm) high], with loops pressed from or welded to face to receive stakes at 36 inches (900 mm) o.c., and with steel stakes 15 inches (380 mm) long for each loop.
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Border Concepts, Inc]
 - b. [COLMET]
 - c. [J. D. Russell Company (The)]
 - d. [Sure-loc Edging Corporation.]
 - e. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the

following:

- a. **[Border Concepts, Inc]**
 - b. **[COLMET]**
 - c. **[J. D. Russell Company (The)]**
 - d. **[Sure-loc Edging Corporation.]**
 - e. **<Insert manufacturer's name>**
3. Color: **[As indicated by manufacturer's designations][Match Architect's sample][As selected by Architect from manufacturer's full range]<Insert color>**.
- C. Aluminum Edge Restraints: **[Straight, 1/8 inch (3.2 mm) thick by 4 inches (100 mm) high][Straight, 3/16 inch (4.8 mm) thick by 4 inches (100 mm) high][L-shaped, 1/8 inch (3.2 mm) thick by 1-3/8 inches (35 mm) high][L-shaped, 3/16 inch (4.8 mm) thick by 2-1/4 inches (57 mm) high]** extruded-aluminum edging, with loops pressed from face to receive stakes at **12 inches (300 mm)** o.c., and with aluminum stakes **12 inches (300 mm)** long for each loop.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Brickstop Corporation]**
 - b. **[Curv-Rite, Inc]**
 - c. **[Permaloc Corporation]**
 - d. **[Sure-loc Edging Corporation.]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Brickstop Corporation]**
 - b. **[Curv-Rite, Inc]**
 - c. **[Permaloc Corporation]**
 - d. **[Sure-loc Edging Corporation.]**
 - e. **<Insert manufacturer's name>**
- D. Precast Concrete Curbs: Made from normal-weight concrete with a compressive strength not less than **[5000 psi (35 MPa)][6000 psi (41 MPa)]<Insert compressive strength>** and water absorption not more than 5 percent, in shapes and sizes indicated.
1. Regional Materials: Concrete curbs shall be manufactured within **500 miles (800 km)** of Project site from aggregates **[and cementitious materials]** that have been extracted, harvested, or recovered, as well as manufactured, within **500 miles (800 km)** of Project site.
 2. Regional Materials: Concrete curbs shall be manufactured within **500 miles (800 km)** of Project site.
 3. Regional Materials: Concrete curbs shall be manufactured within **100 miles (160 km)** of Project site from aggregates **[and cementitious materials]** that have been extracted, harvested, or recovered, as well as manufactured, within **100 miles (160 km)** of Project site.
 4. Indigenous Materials: Concrete curbs shall be manufactured within **500 miles (800 km)** of Project site from aggregates **[and cementitious materials]** that have been extracted, harvested, or recovered, as well as manufactured, within **500 miles (800 km)** of Project site. If materials are transported by rail or water, the distance transported by rail or water shall be multiplied by 0.25 to determine the distance to Project site.
 5. Regional Materials: Concrete curbs shall be manufactured within **500 miles (800 km)** of Project

site from aggregates[**and cementitious materials**] that have been extracted, harvested, or recovered, as well as manufactured, within **500 miles (800 km)** of Project site. If materials are transported by rail or water, the distance transported by rail or water shall be multiplied by 0.25 to determine the distance to Project site.

6. Color and Texture: **[Match Architect's sample][Match pavers][As selected by Architect from manufacturer's full range]<Insert color and texture>**.

- E. Granite Curbs: Granite curbing, with face battered **1 inch per foot (1:12)**, produced in random lengths not less than **36 inches (900 mm)** from granite complying with ASTM C615/C615M.

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

- a. **[Cold Spring Granite Company]**
- b. **[Fletcher Granite Company]**
- c. **[Granitor]**
- d. **[North Carolina Granite Corporation]**
- e. **[Polycor Inc.]**
- f. **[Swenson Granite Works; a Polycor Inc. company]**
- g. **<Insert manufacturer's name>**

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

- a. **[Cold Spring Granite Company]**
- b. **[Fletcher Granite Company]**
- c. **[Granitor]**
- d. **[North Carolina Granite Corporation]**
- e. **[Polycor Inc.]**
- f. **[Swenson Granite Works; a Polycor Inc. company]**
- g. **<Insert manufacturer's name>**

3. Regional Materials: Stone shall be fabricated within **500 miles (800 km)** of Project site from materials that have been extracted, harvested, or recovered within **500 miles (800 km)** of Project site.
4. Regional Materials: Stone shall be fabricated within **500 miles (800 km)** of Project site.
5. Regional Materials: Stone shall be fabricated within **100 miles (160 km)** of Project site from materials that have been extracted, harvested, or recovered within **100 miles (160 km)** of Project site.
6. Indigenous Materials: Stone shall be fabricated within **500 miles (800 km)** of Project site from materials that have been extracted, harvested, or recovered within **500 miles (800 km)** of Project site. If materials are transported by rail or water, the distance transported by rail or water shall be multiplied by 0.25 to determine the distance to Project site.
7. Regional Materials: Stone shall be fabricated within **500 miles (800 km)** of Project site from materials that have been extracted, harvested, or recovered within **500 miles (800 km)** of Project site. If materials are transported by rail or water, the distance transported by rail or water shall be multiplied by 0.25 to determine the distance to Project site.
8. Granite Color and Grain:
 - a. **[Light gray][Dark gray][Buff][White][Black][Pink]<Insert color>** with **[fine][medium][coarse]** grain.
 - b. Match Architect's sample.

9. Top Width: [4 inches (100 mm)][5 inches (125 mm)][6 inches (150 mm)]<Insert width>.
10. Face Height: [4 inches (100 mm)][6 inches (150 mm)][8 inches (200 mm)]<Insert height>.
11. Total Height: [12 inches (300 mm)][16 inches (400 mm)][18 inches (450 mm)]<Insert height>.
12. Top Finish: [Sawn][Thermal][Bushhammered]<Insert finish>.
13. Face Finish: [Split][Sawn][Thermal][Bushhammered]<Insert finish>.

F. <Insert requirements>.

2.3 AGGREGATE SETTING-BED MATERIALS

- A. Regional Materials: Aggregate[**and soil**] shall be extracted, harvested, or recovered, as well as manufactured, within **500 miles (800 km)** of Project site.
- B. Regional Materials: Aggregate[**and soil**] shall be manufactured within **500 miles (800 km)** of Project site.
- C. Regional Materials: Aggregate[**and soil**] shall be extracted, harvested, or recovered, as well as manufactured, within **100 miles (160 km)** of Project site.
- D. Indigenous Materials: Aggregate[**and soil**] shall be extracted, harvested, or recovered, as well as manufactured, within **500 miles (800 km)** of Project site. If materials are transported by rail or water, the distance transported by rail or water shall be multiplied by 0.25 to determine the distance to Project site.
- E. Regional Materials: Aggregate[**and soil**] shall be extracted, harvested, or recovered, as well as manufactured, within **500 miles (800 km)** of Project site. If materials are transported by rail or water, the distance transported by rail or water shall be multiplied by 0.25 to determine the distance to Project site.
- F. Graded Aggregate for Subbase: Sound crushed stone or gravel complying with [ASTM D448 for Size No. 57][ASTM D448 for Size No. 5][ASTM D2940/D2940M, subbase material][requirements in Section 312000 "Earth Moving" for subbase material].
- G. Graded Aggregate for Base Course: Sound crushed stone or gravel complying with [ASTM D448 for Size No. 8][ASTM D448 for Size No. 57][ASTM D2940/D2940M, base-course material][requirements in Section 312000 "Earth Moving" for base-course material].
- H. Sand for Leveling Course: Sound, sharp, washed, natural sand or crushed stone complying with gradation requirements in ASTM C33/C33M for fine aggregate.
- I. Soil Mix for Leveling Course: Sound, sharp, washed, natural sand or crushed stone complying with gradation requirements in ASTM C33/C33M for fine aggregate blended with planting soil according to [Section 329113 "Soil Preparation."][Section 329115 "Soil Preparation (Performance Specification)."] Use blend consisting of [1/2 sand and 1/2 planting soil mix][2/3 sand and 1/3 planting soil mix]<Insert proportions>.
- J. Graded Aggregate for Leveling Course: Sound crushed stone or gravel complying with ASTM D448 for Size No. [8][9].
- K. Separation Geotextile: Woven geotextile fabric, manufactured for separation applications; made from polyolefins or polyesters, with elongation less than 50 percent; complying with AASHTO M 288 and the following, measured according to test methods referenced:
 1. Survivability: Class 2; AASHTO M 288.
 2. Apparent Opening Size: **No. 60 (0.250-mm)** sieve, maximum; ASTM D4751.
 3. Permittivity: 0.02 per second, minimum; ASTM D4491.
 4. UV Stability: 50 percent after 500 hours' exposure; ASTM D4355.

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- L. Drainage Geotextile: Nonwoven needle-punched geotextile, manufactured for subsurface drainage applications, made from polyolefins or polyesters; with elongation greater than 50 percent; complying with AASHTO M 288 and the following, measured according to test methods referenced:
 - 1. Survivability: Class 2; AASHTO M 288.
 - 2. Apparent Opening Size: **No. 40 (0.425-mm)** sieve, maximum; ASTM D4751.
 - 3. Permittivity: 0.5 per second, minimum; ASTM D4491.
 - 4. UV Stability: 50 percent after 500 hours' exposure; ASTM D4355.

2.4 FILL MATERIALS

- A. Soil Fill for Porous Paving: Planting soil according to **[Section 329113 "Soil Preparation."][Section 329115 "Soil Preparation (Performance Specification)."]**
- B. Aggregate Fill for Porous Paving: Graded, sound, crushed stone or gravel complying with ASTM D448 for Size No. **[8][9]**.
 - 1. Color: **[As indicated][Match Architect's sample]**.
- C. Grass Seed: Comply with requirements in Section 329200 "Turf and Grasses."

PART 3 - EXECUTION

3.1 PREPARATION

- A. Proof-roll prepared subgrade according to requirements in Section 312000 "Earth Moving" to identify soft pockets and areas of excess yielding. Proceed with porous paver installation only after deficient subgrades have been corrected and are ready to receive **[subbase and]**base course for porous paving.

3.2 INSTALLATION, GENERAL

- A. Do not use unit pavers with chips, cracks, voids, discolorations, and other defects that might be structurally unsound or visible in finished work.
- B. Mix pavers from several pallets or cubes, as they are placed, to produce uniform blend of colors and textures.
- C. Cut unit pavers with motor-driven masonry saw equipment **[or a block splitter]** to provide clean, sharp, unchipped edges. Cut units to provide pattern indicated and to fit adjoining work neatly. Use full units without cutting where possible. Hammer cutting is not acceptable.
- D. Tolerances:
 - 1. Variation in Plane between Adjacent Units (Lipping): Do not exceed **1/16-inch (1.5-mm)** unit-to-unit offset from flush.
 - 2. Variation from Level or Indicated Slope: Do not exceed **1/8 inch in 24 inches (3 mm in 600 mm)** and **1/4 inch in 10 feet (6 mm in 3 m)** or a maximum of **1/2 inch (13 mm)**.
- E. Provide edge restraints as indicated. Install edge restraints before placing unit pavers.

1. Install edge restraints to comply with manufacturer's written instructions. Install stakes at intervals required to hold edge restraints in place during and after porous paver installation.
 2. For metal edge restraints with top edge exposed, drive stakes at least **1 inch (25 mm)** below top edge.
- F. Provide curbs as indicated. Install curbs before placing unit pavers.
1. Install **[precast concrete][granite]** curbs on a bedding of compacted base-course material over compacted subgrade. Install curbs before placing base course for pavers. Set curbs at elevations indicated, accurately aligned, and place and compact base-course material behind curbs as indicated.
 2. Install precast concrete curbs on aggregate base course after placing and compacting base course for pavers. Set curbs with top edge **1 inch (25 mm)** below top of pavers. Anchor curbs with metal stakes driven through holes in curbs into base-course material.
 3. Install precast concrete curbs on aggregate-base course after placing and compacting base course for pavers. Set curbs with top surface **[1/2 inch (13 mm)][2 inches (50 mm)][4 inches (100 mm)]** above top of pavers. Anchor curbs with metal stakes driven behind curbs into base-course material.

3.3 INSTALLATION OF SETTING-BED

- A. Compact subgrade uniformly to at least **[95]<Insert number>** percent of **[ASTM D698][ASTM D1557]** laboratory density.
- B. Proof-roll prepared subgrade to identify soft pockets and areas of excess yielding. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Architect, and replace with compacted backfill or fill as directed.
- C. Place **[separation][drainage]** geotextile over prepared subgrade, overlapping ends and edges at least **12 inches (300 mm)**.
- D. Place aggregate **[subbase][and][base]**, compact by tamping with plate vibrator, and screed to depth indicated.
- E. Place aggregate **[subbase][and][base]**, compact to **[100]<Insert number>** percent of ASTM D1557 maximum laboratory density, and screed to depth indicated.
- F. Place drainage geotextile over compacted subbase, overlapping ends and edges at least **12 inches (300 mm)**.
- G. Place drainage geotextile over compacted base course, overlapping ends and edges at least **12 inches (300 mm)**.
- H. Place leveling course, and screed to a thickness of **[1 to 1-1/2 inches (25 to 38 mm)][2 to 2-1/2 inches (50 to 64 mm)][3 inches (76 mm)]<Insert dimension>**, taking care that moisture content remains constant and density is loose and constant until pavers are set and compacted.

3.4 INSTALLATION OF PAVERS

- A. Set unit pavers on leveling course, being careful not to disturb leveling base. If pavers have lugs or spacer bars to control spacing, place pavers hand tight against lugs or spacer bars. If pavers do not have lugs or spacer bars, place pavers with a **1/16-inch- (1.6-mm-)** minimum and **1/8-inch- (3.2-mm-)** maximum joint width. Use string lines to keep straight lines. Fill gaps between units that exceed **[3/8 inch (10 mm)]<Insert dimension>** with pieces cut to fit from full-size pavers.

1. When installation is performed with mechanical equipment, use only unit pavers with lugs or spacer bars on sides of each unit.
- B. Compact pavers into leveling course with a low-amplitude plate vibrator capable of a **3500- to 5000-lbf (16- to 22-kN)** compaction force at 80 to 90 Hz. Use vibrator with neoprene mat on face of plate or other means as needed to prevent cracking and chipping of pavers. Perform at least three passes across paving with vibrator.
 1. Compact pavers when there is sufficient surface to accommodate operation of vibrator, leaving at least **36 inches (900 mm)** of uncompacted pavers adjacent to temporary edges.
 2. Before ending each day's work, compact installed concrete pavers except for **36-inch (900-mm)** width of uncompacted pavers adjacent to temporary edges (laying faces).
 3. As work progresses to perimeter of installation, compact installed pavers that are adjacent to permanent edges unless they are within **36 inches (90 mm)** of laying face.
 4. Before ending each day's work and when rain interrupts work, cover pavers that have not been compacted and leveling course on which pavers have not been placed with nonstaining plastic sheets to protect them from rain.
- C. Place soil fill as follows, immediately after vibrating pavers into leveling course. Spread and screed soil fill level with tops of pavers. Vibrate pavers and add soil fill until porous paving is filled to about **3/4 inch (19 mm)** from top surface; remove excess soil fill if any.
 1. Before ending each day's work, place soil fill in installed porous paving except for **42-inch (1067-mm)** width of unfilled paving adjacent to temporary edges (laying faces).
 2. As work progresses to perimeter of installation, place soil fill in installed paving that is adjacent to permanent edges unless it is within **42 inches (1067 mm)** of laying face.
 3. Before ending each day's work and when rain interrupts work, cover paving that has not been filled with nonstaining plastic sheets to protect it from rain.
- D. After filling pavers with soil, sow seed according to Section 329200 "Turf and Grasses," except sow seed at half the rate specified for seeding lawns. Sweep seed from surfaces of pavers into voids and water with fine spray.
 1. Within 24 hours after sowing seed, spread an additional **3/16 inch (4.8 mm)** of uncompacted soil fill over seed and soak with water.
- E. Place graded aggregate fill immediately after vibrating pavers into leveling course. Spread and screed aggregate fill level with tops of pavers.
 1. Before ending each day's work, place aggregate fill in installed porous paving except for **42-inch (1067-mm)** width of unfilled paving adjacent to temporary edges (laying faces).
 2. As work progresses to perimeter of installation, place aggregate fill in installed paving that is adjacent to permanent edges unless it is within **42 inches (1067 mm)** of laying face.
 3. Before ending each day's work and when rain interrupts work, cover paving that has not been filled with nonstaining plastic sheets to protect it from rain.
- F. As work progresses, remove and replace pavers that are loose, chipped, broken, stained, or otherwise damaged or that do not match adjoining units. Provide new units to match adjoining units and install in same manner as original units, with same joint treatment and with no evidence of replacement.

3.5 MAINTENANCE AND PROTECTION

- A. Water newly planted grass and keep moist until grass is established. Maintain grass that is planted in paving to comply with requirements in Section 329200 "Turf and Grasses."



- B. Erect barricades and warning signs as required to protect newly planted areas from traffic. Maintain barricades for [60]<Insert number> days after planting.

END OF SECTION 32 14 33 13



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Task	Specification	Specification Description
32 14 33 13	32 14 00 00	Unit Paving
32 14 40 00	32 13 13 00	Concrete Paving
32 14 40 00	32 14 00 00	Unit Paving
32 16 13 13	32 13 13 00	Concrete Paving
32 16 13 14	32 13 13 00	Concrete Paving
32 16 13 16	32 13 13 00	Concrete Paving
32 16 13 19	32 13 13 00	Concrete Paving
32 16 13 23	32 13 13 00	Concrete Paving
32 16 13 33	32 13 13 00	Concrete Paving
32 16 13 43	32 13 13 00	Concrete Paving
32 16 13 43	32 14 33 13	Porous Unit Paving
32 16 23 00	32 13 13 00	Concrete Paving
32 16 23 00	32 14 00 00	Unit Paving



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SECTION 32 17 13 00 - PARKING BUMPERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
1. Precast concrete wheel stops.
 2. Resilient wheel stops.
 3. Resilient-shell, concrete-filled wheel stops.

1.2 ACTION SUBMITTALS

- A. Product Data:
1. Precast concrete wheel stops.
 2. Resilient wheel stops.
 3. Resilient-shell, concrete-filled wheel stops
- B. Sustainable Design Submittals:
1. Product Data: For recycled content, indicating postconsumer and preconsumer recycled content and cost.
- C. Samples for Initial Selection: For each type of exposed finish requiring color selection.
- D. Samples for Verification: For wheel stops, **[6 inches (150 mm) long]**<Insert dimension>, showing color and cross section; with mounting hardware.

PART 2 - PRODUCTS

2.1 PARKING BUMPERS

- A. Precast Concrete Wheel Stops: Precast, steel-reinforced, air-entrained concrete; **[4000-psi (27.6-MPa)]**<Insert value> minimum compressive strength; **[manufacturer's standard height and width]****[4-1/2 inches (115 mm) high by 9 inches (225 mm) wide]**<Insert dimensions> by **[72 inches (1800 mm)]**<Insert dimension> long. Provide chamfered corners[, **transverse drainage slots on underside,**] and a minimum of **[two][three]** factory-formed or -drilled vertical holes through wheel stop for anchoring to substrate.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American Eagle Precast, LLC]**
 - b. **[American Precast Concrete Inc.]**
 - c. **[Bush Concrete Products, Inc.]**

- d. [Cast-Crete USA, Inc.]
- e. [Dura-Crete, Inc.]
- f. [Granite Precasting and Concrete, Inc.]
- g. [Oldcastle Infrastructure Inc.; CRH Americas]
- h. [Steps Plus, Inc.]
- i. <Insert manufacturer's name>

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

- a. [American Eagle Precast, LLC]
- b. [American Precast Concrete Inc.]
- c. [Bush Concrete Products, Inc.]
- d. [Cast-Crete USA, Inc.]
- e. [Dura-Crete, Inc.]
- f. [Granite Precasting and Concrete, Inc.]
- g. [Oldcastle Infrastructure Inc.; CRH Americas]
- h. [Steps Plus, Inc.]
- i. <Insert manufacturer's name>

- 3. Source Limitations: Obtain wheel stops from single source from single manufacturer.
- 4. Surface Appearance: Smooth, free of pockets, sand streaks, honeycombs, and other obvious defects. Corners shall be uniform, straight, and sharp.
- 5. Surface Sealer: [Manufacturer's standard salt-resistant, clear sealer]<Insert requirement>, applied at precasting location.
- 6. Mounting Hardware: Galvanized-steel [spike or dowel, 1/2-inch (13-mm) diameter, 14-inch (350-mm) minimum length][lag screw, shield, and washers; 1/2-inch (13-mm) diameter, 8-inch (203-mm) minimum length][hardware as standard with wheel-stop manufacturer].

- B. Resilient Wheel Stops: Solid, integrally colored [rubber][or][plastic]; UV stabilized; [manufacturer's standard height and width][4 inches (100 mm) high by 6 inches (150 mm) wide]<Insert dimensions> by [72 inches (1800 mm)]<Insert dimension> long. Provide chamfered corners and a minimum of [two][three][four] factory-formed or -drilled vertical holes through wheel stop for anchoring to substrate.

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

- a. [Checkers; Justrite Safety Group]
- b. [GNR Technologies Inc.]
- c. [Plastic Safety Systems, Inc.]
- d. [Plasticade]
- e. [RoadKare; a RubberForm company]
- f. <Insert manufacturer's name>

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

- a. [Checkers; Justrite Safety Group]
- b. [GNR Technologies Inc.]
- c. [Plastic Safety Systems, Inc.]

- d. **[Plasticade]**
 - e. **[RoadKare; a RubberForm company]**
 - f. **<Insert manufacturer's name>**
3. Source Limitations: Obtain wheel stops from single source from single manufacturer.
 4. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than **[95]<Insert value>** percent.
 5. Color: **[Black][Yellow][Gray][Green][Blue]<Insert color>**.
 6. Embedded Markings: Molded-in, **[blue][white][yellow]** reflective markings, permanently inset in exposed surface.
 7. Mounting Hardware: Galvanized-steel **[spike or dowel, 1/2-inch (13-mm) minimum diameter, 14-inch (350-mm) minimum length][lag screw, shield, and washers; 1/2-inch (13-mm) diameter, 8-inch (203-mm) minimum length][hardware as standard with wheel-stop manufacturer]**.
 8. Adhesive: Polyurethane or epoxy, as recommended in writing by wheel-stop manufacturer for adhesion to substrate.
- C. Resilient-Shell, Concrete-Filled Wheel Stops: Integrally colored HDPE polymer; UV-stabilized resilient shell; filled with precast, steel-reinforced concrete; **[4000-psi (27.6-MPa)]<Insert value>** minimum compressive strength; **[manufacturer's standard height and width][5 inches (125 mm) high by 6 inches (150 mm) wide]<Insert dimensions>** by **[72 inches (1800 mm)]<Insert dimension>** long. Provide chamfered corners and a minimum of **[two][three]** factory-formed or -drilled vertical holes through wheel stop for anchoring to substrate.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Century Group Inc.]**
 - b. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Century Group Inc.]**
 - b. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain wheel stops from single source from single manufacturer.
 4. Color: **[Yellow][Blue]<Insert color>**.
 5. Surface Appearance: Smooth and uniform, with straight and sharp corners.
 6. Mounting Hardware: Galvanized-steel **[spike or dowel, 1/2-inch (13-mm) minimum diameter, 14-inch (350-mm) minimum length][hardware as standard with wheel-stop manufacturer]**.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that pavement is in suitable condition to begin installation in accordance with manufacturer's written instructions.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.



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3.2 INSTALLATION

- A. Install wheel stops in accordance with manufacturer's written instructions unless otherwise indicated.
- B. Install wheel stops in bed of adhesive before anchoring to substrate.
- C. Securely anchor wheel stops to substrate with hardware in each preformed vertical hole in wheel stop as recommended in writing by manufacturer. Recess head of hardware beneath top of wheel stop.

END OF SECTION 32 17 13 00



32 - Exterior Improvements

Task	Specification	Specification Description
32 17 13 16	32 17 13 00	Parking Bumpers
32 17 13 19	32 17 13 00	Parking Bumpers
32 17 13 23	11 12 00 00	Parking Control Equipment
32 17 13 23	13 34 23 16	Fabricated Control Booths
32 17 13 23	32 17 13 00	Parking Bumpers
32 17 13 26	11 12 00 00	Parking Control Equipment
32 17 13 26	13 34 23 16	Fabricated Control Booths
32 17 13 26	32 17 13 00	Parking Bumpers



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SECTION 32 17 16 00 - MANUFACTURED TRAFFIC-CALMING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Speed bumps.
2. Speed humps.
3. Speed cushions.

1.2 ACTION SUBMITTALS

A. Product Data:

1. Speed bumps.
2. Speed humps.
3. Speed cushions.

B. Sustainable Design Submittals:

C. Samples for Initial Selection: For each type of exposed finish requiring color selection.

D. Samples for Verification: Manufactured traffic-calming devices, **[6 inches long]**<Insert dimension>, showing color and cross section; with fasteners.

PART 2 - PRODUCTS

2.1 SPEED BUMPS

A. Speed Bumps: Solid, integrally colored, preformed **[recycled rubber]****[or]****[polyurethane]**; UV stabilized. Provide factory-formed or -drilled vertical holes for anchoring to substrate.

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

- a. **[Barco Products Company]**
- b. **[Checkers; Justrite Safety Group]**
- c. **[Pawling Corporation]**
- d. **[Plasticade]**
- e. **[RoadKare; a RubberForm company]**
- f. **[RubberForm Recycled Products, LLC]**
- g. **[Traffic Logix]**
- h. **<Insert manufacturer's name>**

2. Source Limitations: Obtain speed bumps from single source from single manufacturer.

3. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than **[95]<Insert value>** percent.
4. Size: **[2 inches high by 10 inches wide by 72 inches long]<Insert dimensions>**; with tapered, square, or rounded ends.
5. Color: **[Black][Yellow]<Insert color>**.
6. Embedded Markings: Molded-in, **[blue][white][yellow]** reflective markings, permanently inset in exposed surface.
7. Mounting Hardware: Galvanized-steel **[spike or dowel, 1/2-inch diameter, 10-inch minimum length][lag screw, shield, and washers; 1/2-inch diameter, 8-inch minimum length][hardware as standard with speed bump manufacturer]**.
8. Adhesive: **[As recommended in writing by speed bump manufacturer]<Insert requirement>** to permanently adhere speed bump to substrate.

2.2 SPEED HUMPS

- A. Speed Humps: Solid, integrally colored, preformed recycled rubber; UV stabilized. Provide factory-formed or -drilled vertical holes for anchoring to substrate.
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Barco Products Company]**
 - b. **[Checkers; Justrite Safety Group]**
 - c. **[Plasticade]**
 - d. **[RoadKare; a RubberForm company]**
 - e. **[RubberForm Recycled Products, LLC]**
 - f. **[Traffic Logix]**
 - g. **<Insert manufacturer's name>**
 2. Source Limitations: Obtain speed humps from single source from single manufacturer.
 3. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than **[95]<Insert value>** percent.
 4. Size: Modular assembly **[3 inches high by 12 feet in overall width][4 inches high by 14 feet in overall width]<Insert dimensions>**, with overall length as dimensioned on Drawings; and with tapered, square, or rounded ends.
 5. Surface Profile: **[Circular][Sinusoidal][Trapezoidal]**.
 6. Color: **[Black][Yellow]<Insert color>**.
 7. Embedded Markings: Molded-in, **[blue][white][yellow]** reflective markings, permanently inset in exposed surface.
 8. Mounting Hardware: Galvanized-steel **[spike or dowel, 1/2-inch diameter, 10-inch minimum length][lag screw, shield, and washers; 1/2-inch diameter, 8-inch minimum length][hardware as standard with speed hump manufacturer]**.
 9. Adhesive: **[As recommended in writing by speed hump manufacturer]<Insert requirement>** to permanently adhere speed hump to substrate.

2.3 SPEED CUSHIONS

- A. Speed Cushions: Solid, integrally colored, preformed recycled rubber; UV stabilized. Provide factory-formed or -drilled vertical holes for anchoring to substrate.
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the**

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

- a. [Barco Products Company]
 - b. [RoadKare; a RubberForm company]
 - c. [RubberForm Recycled Products, LLC]
 - d. [Traffic Logix]
 - e. <Insert manufacturer's name>
2. Source Limitations: Obtain speed cushions from single source from single manufacturer.
 3. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than [95]<Insert value> percent.
 4. Size: Modular assembly [3 inches high by 12 feet in overall width][4 inches high by 14 feet in overall width]<Insert dimensions>, with overall length as dimensioned on Drawings; and with tapered, square, or rounded ends.
 5. Color: [Black][Yellow]<Insert color>.
 6. Embedded Markings: Molded-in, [blue][white][yellow] reflective markings, permanently inset in exposed surface.
 7. Mounting Hardware: Galvanized-steel [spike or dowel, 1/2-inch diameter, 10-inch minimum length][lag screw, shield, and washers; 1/2-inch diameter, 8-inch minimum length][hardware as standard with speed cushion manufacturer].
 8. Adhesive: [As recommended in writing by speed cushion manufacturer]<Insert requirement> to permanently adhere speed cushions to substrate.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install manufactured traffic-calming devices according to manufacturer's written instructions unless otherwise indicated.
- B. Install devices in bed of adhesive before anchoring.
- C. Securely anchor devices to substrate with hardware spaced as recommended in writing by manufacturer for heavy traffic. Recess head of hardware beneath top surface of device.

END OF SECTION 32 17 16 00



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Task	Specification	Specification Description
32 17 16 00	32 12 16 00	Asphalt Paving



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SECTION 32 17 23 00 - PAVEMENT MARKINGS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Painted markings applied to asphalt paving.
2. Painted markings applied to concrete surfaces.

B. Related Requirements:

1. Section 071800 "Traffic Coatings" for painting whole areas of building floors and pavements with coatings having an integral wearing surface.
2. Section 099113 "Exterior Painting" for painting exterior concrete surfaces other than pavement markings.
3. Section 099123 "Interior Painting" for painting interior concrete surfaces other than pavement markings.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at **[Project site]<Insert location>**.

1. Review methods and procedures related to marking asphalt paving or concrete surfaces including, but not limited to, the following:
 - a. Asphalt-paving or concrete-surface aging period before application of pavement markings.
 - b. Review requirements for protecting pavement markings, including restriction of traffic during installation period.

1.3 ACTION SUBMITTALS

A. Product Data: Include technical data and tested physical and performance properties.

1. Pavement-marking paint, alkyd.
2. Pavement-marking paint, solvent-borne.
3. Pavement-marking paint, acrylic.
4. Pavement-marking paint, latex.
5. Glass beads.

B. Shop Drawings:

1. Indicate pavement markings, colors, lane separations, defined parking spaces, and dimensions to adjacent work.
2. Indicate, with international symbol of accessibility, spaces allocated for people with disabilities.

C. Samples: For each exposed product and for each color and texture specified; on rigid backing, **8 inches (200 mm)** square.

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1.4 QUALITY ASSURANCE

- A. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of **<Insert applicable standards>** of **<Insert name of state or local DOT>** for pavement-marking work.
1. Measurement and payment provisions and safety program submittals included in standard specifications do not apply to this Section.

1.5 FIELD CONDITIONS

- A. Environmental Limitations: Proceed with pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature of **[40 deg F (4.4 deg C) for alkyd materials][55 deg F (12.8 deg C) for water-based materials]**, and not exceeding **95 deg F (35 deg C)**.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Accessibility Standard: Comply with applicable provisions in **[the USDOJ's "2010 ADA Standards for Accessible Design"] [the ABA standards of the Federal agency having jurisdiction] [and] [ICC A117.1] <Insert requirement>**.

2.2 PAVEMENT-MARKING PAINT

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Aexcel Corporation]**
 2. **[Colorado Paint Company II, LLC; SWARCO America, Inc.]**
 3. **[Columbia Paint & Coatings, Inc.; a subsidiary of Sherwin-Williams Company (The)]**
 4. **[Conco Paints]**
 5. **[Diamond Vogel Paint Company]**
 6. **[Dunn-Edwards Corporation (a Nippon Paint Holdings Co. Ltd. company)]**
 7. **[Ennis-Flint, Inc.]**
 8. **[Farrell-Calhoun]**
 9. **[Florida Paints]**
 10. **[General Paint]**
 11. **[Insl-X Products; Benjamin Moore & Co.]**
 12. **[McCormick Paints]**
 13. **[PPG Paints; PPG Industries, Inc.]**
 14. **[Rodda Paint Co.]**
 15. **[Rust-Oleum Corporation; a subsidiary of RPM International, Inc.]**
 16. **[Sherwin-Williams Company (The)]**
 17. **[The Dow Chemical Company]**
 18. **[Transpo Industries, Inc.]**
 19. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. [Aexcel Corporation]
 2. [Colorado Paint Company II, LLC; SWARCO America, Inc.]
 3. [Columbia Paint & Coatings, Inc.; a subsidiary of Sherwin-Williams Company (The)]
 4. [Conco Paints]
 5. [Diamond Vogel Paint Company]
 6. [Dunn-Edwards Corporation (a Nippon Paint Holdings Co. Ltd. company)]
 7. [Ennis-Flint, Inc.]
 8. [Farrell-Calhoun]
 9. [Florida Paints]
 10. [General Paint]
 11. [Insl-X Products; Benjamin Moore & Co.]
 12. [McCormick Paints]
 13. [PPG Paints; PPG Industries, Inc.]
 14. [Rodda Paint Co.]
 15. [Rust-Oleum Corporation; a subsidiary of RPM International, Inc.]
 16. [Sherwin-Williams Company (The)]
 17. [The Dow Chemical Company]
 18. [Transpo Industries, Inc.]
 19. <Insert manufacturer's name>
- C. Source Limitations: Obtain pavement-marking paints from single source from single manufacturer.
- D. Pavement-Marking Paint, Alkyd: Alkyd-resin type, lead and chromate free, ready mixed, complying with AASHTO M 248, [Type N][Type F][Type S]; colors complying with FS TT-P-1952F.
1. Color: [White][Yellow][Blue][As indicated]<Insert color>.
- E. Pavement-Marking Paint, Solvent-Borne: MPI #32, solvent-borne traffic-marking paint.
1. Color: [White][Yellow][Blue][As indicated]<Insert color>.
- F. Pavement-Marking Paint, Acrylic: Acrylic, waterborne emulsion, lead and chromate free, ready mixed, complying with FS TT-P-1952F, Type II, with drying time of less than [three][45] minutes.
1. Color: [White][Yellow][Blue][As indicated]<Insert color>.
- G. Pavement-Marking Paint, Latex: MPI #97, latex traffic-marking paint.
1. Color: [White][Yellow][Blue][As indicated]<Insert color>.
- H. Glass Beads: AASHTO M 247, Type 1 or FS TT-B-1325D, Type 1[, made of 100 percent recycled glass].
1. Roundness: Minimum [75][80] percent true spheres by weight.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that pavement-marking substrate is dry and in suitable condition to begin pavement marking in accordance with manufacturer's written instructions.
- B. Proceed with pavement marking only after unsatisfactory conditions have been corrected.



3.2 PAVEMENT MARKING

- A. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Architect.
- B. Allow asphalt paving or concrete surfaces to age for a minimum of [30][90]<Insert number> days before starting pavement marking.
- C. Sweep and clean surface to eliminate loose material and dust.
- D. Apply paint with mechanical equipment to produce pavement markings, of dimensions indicated, with uniform, straight edges. Apply at manufacturer's recommended rates to provide a minimum wet film thickness of [15 mils (0.4 mm)]<Insert dimension>.
 - 1. Apply graphic symbols and lettering with paint-resistant, die-cut stencils, firmly secured to asphalt paving or concrete surface. Mask an extended area beyond edges of each stencil to prevent paint application beyond stencil. Apply paint so that it cannot run beneath stencil.
 - 2. Broadcast glass beads uniformly into wet markings at a rate of 6 lb/gal. (0.72 kg/L).

3.3 PROTECTING AND CLEANING

- A. Protect pavement markings from damage and wear during remainder of construction period.
- B. Clean spillage and soiling from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

END OF SECTION 32 17 23 00



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Task	Specification	Specification Description
32 17 23 13	07 18 00 00	Traffic Coatings
32 17 23 13	32 12 16 00	Asphalt Paving
32 17 23 13	32 13 13 00	Concrete Paving
32 17 23 13	32 17 23 00	Pavement Markings
32 17 23 23	07 18 00 00	Traffic Coatings
32 17 23 23	32 12 16 00	Asphalt Paving
32 17 23 23	32 13 13 00	Concrete Paving
32 17 23 23	32 17 23 00	Pavement Markings
32 17 23 33	07 18 00 00	Traffic Coatings
32 17 23 33	32 12 16 00	Asphalt Paving
32 17 23 33	32 13 13 00	Concrete Paving
32 17 23 33	32 17 23 00	Pavement Markings



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SECTION 32 17 26 00 - TACTILE WARNING SURFACING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cast-in-place detectable warning tiles.
2. Surface-applied detectable warning tiles.
3. Detectable warning mats.
4. Cast-in-place detectable warning metal tiles.
5. Surface-applied detectable warning metal tiles.
6. Detectable warning unit pavers.

B. Related Requirements:

1. Section 321313 "Concrete Paving" for concrete walkways serving as substrates for tactile warning surfacing.
2. Section 321400 "Unit Paving" for unit paving installations incorporating detectable warning unit pavers specified in this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

1. Product Data: For recycled content, indicating postconsumer and preconsumer recycled content and cost.
2. Product Certificates: For regional materials, indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project and cost for each regional material.
3. Environmental Product Declaration (EPD): For each product.
4. Product Certificates: For indigenous materials, indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project, means of transportation, and cost for each indigenous material.
5. Environmental Product Declaration: For each product.
6. Product Certificates: For regional materials, indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project, means of transportation, and cost for each regional material.
7. Environmental Product Declaration: For each product.
8. Environmental Product Declaration: For each product.
9. Third-Party Certifications: For each product.
10. Third-Party Certified Life Cycle Assessment: For each product.

C. Samples for Initial Selection: For each type of exposed finish requiring color selection.

D. Samples for Verification: For each type of tactile warning surface, in manufacturer's standard sizes unless otherwise indicated, showing edge condition, truncated-dome pattern, texture, color, and cross section; with fasteners and anchors.

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1.3 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For tactile warning surfacing, to include in maintenance manuals.

1.4 QUALITY ASSURANCE

- A. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for materials and execution.
 - 1. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.5 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at **[Project site]<Insert location>**.

1.6 PROJECT CONDITIONS

- A. Cold-Weather Protection: Do not use frozen materials or materials mixed or coated with ice or frost. Do not build on frozen subgrade or setting beds. Remove and replace unit paver work damaged by frost or freezing.
- B. Weather Limitations for Adhesive Application:
 - 1. Apply adhesive only when ambient temperature is above **50 deg F (10 deg C)** and when temperature has not been below **35 deg F (2 deg C)** for 12 hours immediately before application. Do not apply when substrate is wet or contains excess moisture.
- C. Weather Limitations for Mortar and Grout:
 - 1. Cold-Weather Requirements: Comply with cold-weather construction requirements contained in ACI 530.1/ASCE 6/TMS 602.
 - 2. Hot-Weather Requirements: Comply with hot-weather construction requirements contained in ACI 530.1/ASCE 6/TMS 602. Provide artificial shade and windbreaks, and use cooled materials as required. Do not apply mortar to substrates with temperatures of **100 deg F (38 deg C)** and higher.
 - a. When ambient temperature exceeds **100 deg F (38 deg C)**, or when wind velocity exceeds **8 mph (13 km/h)** and ambient temperature exceeds **90 deg F (32 deg C)**, set unit pavers within 1 minute of spreading setting-bed mortar.

1.7 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of tactile warning surfaces that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Deterioration of finishes beyond normal weathering and wear.
 - b. Separation or delamination of materials and components.

2. Warranty Period: **[Five]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 TACTILE WARNING SURFACING, GENERAL

- A. Accessibility Requirements: Comply with applicable provisions in **[the U.S. Architectural & Transportation Barriers Compliance Board's ADA-ABA Accessibility Guidelines for Buildings and Facilities][and][ICC A117.1]** for tactile warning surfaces.
 1. For tactile warning surfaces composed of multiple units, provide units that when installed provide consistent side-to-side and end-to-end dome spacing that complies with requirements.
- B. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than **<Insert value>** percent.
- C. Regional Materials: Products shall be manufactured within **500 miles (800 km)** of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within **500 miles (800 km)** of Project site.
- D. Regional Materials: Products shall be manufactured within **500 miles (800 km)** of Project site.
- E. Regional Materials: Products shall be manufactured within **100 miles (160 km)** of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within **100 miles (160 km)** of Project site.
- F. Indigenous Materials: Products shall be manufactured within **500 miles (800 km)** of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within **500 miles (800 km)** of Project site. If materials are transported by rail or water, the distance transported by rail or water shall be multiplied by 0.25 to determine the distance to Project site.
- G. Regional Materials: Products shall be manufactured within **500 miles (800 km)** of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within **500 miles (800 km)** of Project site. If materials are transported by rail or water, the distance transported by rail or water shall be multiplied by 0.25 to determine the distance to Project site.
- H. Source Limitations: Obtain each type of tactile warning surfacing[, **joint material**][, **setting material**][, **anchor**][, and][**fastener**] from single source with resources to provide materials and products of consistent quality in appearance and physical properties.

2.2 DETECTABLE WARNING TILES

- A. Cast-in-Place Detectable Warning Tiles: Accessible truncated-dome detectable warning tiles[**with replaceable surface**] configured for setting flush in new concrete walkway surfaces, with slip-resistant surface treatment on domes and field of tile.
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ACO Polymer Products, Inc.]**

- b. [ADA Solutions, a division of SureWerx USA]
 - c. [Arcis Corp.]
 - d. [Armor-Tile]
 - e. [Armorcast Products Company; brand of Hubbell Utility Solutions; Hubbell Incorporated]
 - f. [Detectable Warning Systems, Inc.]
 - g. [Detectile Corp.]
 - h. [Ecoglo, Inc.]
 - i. [Mingo Products, Inc.]
 - j. [StrongGo Industries, LLC]
 - k. [Transpo Industries, Inc.]
 - l. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [ACO Polymer Products, Inc.]
 - b. [ADA Solutions, a division of SureWerx USA]
 - c. [Arcis Corp.]
 - d. [Armor-Tile]
 - e. [Armorcast Products Company; brand of Hubbell Utility Solutions; Hubbell Incorporated]
 - f. [Detectable Warning Systems, Inc.]
 - g. [Detectile Corp.]
 - h. [Ecoglo, Inc.]
 - i. [Mingo Products, Inc.]
 - j. [StrongGo Industries, LLC]
 - k. [Transpo Industries, Inc.]
 - l. <Insert manufacturer's name>
3. Material: [Cast-fiber-reinforced polymer concrete tile][Molded glass- and carbon-fiber-reinforced polyester].
4. Color: [Safety yellow][Red brick][Black][Gray][As selected by Architect from manufacturer's full line].
5. Shapes and Sizes:
 - a. Rectangular panel, [12 by 12 inches (305 by 305 mm)][24 by 24 inches (610 by 610 mm)][24 by 36 inches (610 by 914 mm)][24 by 48 inches (610 by 1219 mm)][24 by 60 inches (610 by 1524 mm)][36 by 48 inches (914 by 1219 mm)][36 by 60 inches (914 by 1524 mm)]<Insert dimensions>.
 - b. Radius panel, nominal 24 inches (610 mm) deep by [6-foot (1829-mm)][8-foot (2438-mm)][10-foot (3048-mm)][12-foot (3658-mm)][15-foot (4572-mm)]<Insert dimension> outside radius.
6. Dome Spacing and Configuration: [1.67-inch (42.4-mm) spacing][2.35-inch (59.7-mm) spacing][Manufacturer's standard compliant spacing]<Insert spacing>, in [square][diamond][manufacturer's standard] pattern.
7. Mounting:
 - a. Permanently embedded detectable warning tile wet-set into freshly poured concrete.
 - b. Detectable warning tile set into formed recess in concrete and adhered with [mortar][adhesive].
 - c. Replaceable detectable warning tile wet-set into freshly poured concrete and surface-fastened to permanently embedded anchors.

- B. Surface-Applied Detectable Warning Tiles: Accessible truncated-dome detectable warning concrete tiles configured for surface application on existing concrete walkway surfaces, with slip-resistant surface treatment on domes, field of tile, and beveled outside edges.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ADA Solutions, a division of SureWerx USA]**
 - b. **[Arcis Corp.]**
 - c. **[Armor-Tile]**
 - d. **[Armorcast Products Company; brand of Hubbell Utility Solutions; Hubbell Incorporated]**
 - e. **[Detectable Warning Systems, Inc.]**
 - f. **[Ecoglo, Inc.]**
 - g. **[Transpo Industries, Inc.]**
 - h. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ADA Solutions, a division of SureWerx USA]**
 - b. **[Arcis Corp.]**
 - c. **[Armor-Tile]**
 - d. **[Armorcast Products Company; brand of Hubbell Utility Solutions; Hubbell Incorporated]**
 - e. **[Detectable Warning Systems, Inc.]**
 - f. **[Ecoglo, Inc.]**
 - g. **[Transpo Industries, Inc.]**
 - h. **<Insert manufacturer's name>**
 3. Material: **[Cast-fiber-reinforced polymer concrete tile][Molded glass- and carbon-fiber-reinforced polyester]**.
 4. Color: **[Safety yellow][Red brick][Black][Gray][As selected by Architect from manufacturer's full line]**.
 5. Shapes and Sizes:
 - a. Rectangular panel, **[12 by 12 inches (305 by 305 mm)][24 by 24 inches (610 by 610 mm)][24 by 36 inches (610 by 914 mm)][24 by 48 inches (610 by 1219 mm)][24 by 60 inches (610 by 1524 mm)][36 by 48 inches (914 by 1219 mm)][36 by 60 inches (914 by 1524 mm)]<Insert dimensions>**.
 - b. Radius panel, nominal 24 inches (610 mm) deep by **[6-foot (1829-mm)][8-foot (2438-mm)][10-foot (3048-mm)][12-foot (3658-mm)][15-foot (4572-mm)]<Insert dimension>** outside radius.
 6. Dome Spacing and Configuration: **[1.67-inch (42.4-mm) spacing][2.35-inch (59.7-mm) spacing][Manufacturer's standard compliant spacing]<Insert spacing>**, in **[square][diamond][manufacturer's standard]** pattern.
 7. Mounting: Adhered **[and fastened]** to existing concrete walkway.
- C. Cast-in-Place Detectable Warning Metal Tiles: Accessible truncated-dome detectable warning metal tiles **[with replaceable surface]** configured for setting flush in new concrete walkway surfaces, with slip-resistant surface treatment on domes and field of tile.

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[ADA Solutions, a division of SureWerx USA]**
 - b. **[Advantage Tactile Systems]**
 - c. **[EJ Group, Inc.]**
 - d. **[Neenah Foundry Company]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[ADA Solutions, a division of SureWerx USA]**
 - b. **[Advantage Tactile Systems]**
 - c. **[EJ Group, Inc.]**
 - d. **[Neenah Foundry Company]**
 - e. **<Insert manufacturer's name>**
3. Material:
 - a. Stainless-Steel Plate and Sheet: ASTM A240/A240M or ASTM A666, **[Type 304][Type 316L]**.
 - 1) Finish and Color:
 - a) Manufacturer's standard powder coat, **[safety yellow][red brick][black][gray][color as selected by Architect from manufacturer's full line]**.
 - b) Mill finish.
 - b. Cast Iron: Gray iron, ASTM A48/A48M, CL 35.
4. Shapes and Sizes:
 - a. Rectangular panel, **[12 by 12 inches (305 by 305 mm)][18 by 24 inches (457 by 610 mm)][24 by 24 inches (610 by 610 mm)][24 by 36 inches (610 by 914 mm)][24 by 48 inches (610 by 1219 mm)][24 by 60 inches (610 by 1524 mm)][36 by 48 inches (914 by 1219 mm)][36 by 60 inches (914 by 1524 mm)]<Insert dimensions>**.
 - b. Radius panel, nominal **24 inches (610 mm)** deep by **[6-foot (1829-mm)outside radius][8-foot (2438-mm)outside radius][10-foot (3048-mm)outside radius][12-foot (3658-mm)outside radius][15-foot (4572-mm) outside radius][17.5-foot (5334-mm)outside radius][outside radius indicated on Drawings]<Insert dimension>**.
5. Dome Spacing and Configuration: **[1.67-inch (42.4-mm) spacing][2.35-inch (59.7-mm) spacing][Manufacturer's standard compliant spacing]<Insert spacing>**, in **[square][diamond][manufacturer's standard]** pattern.
6. Mounting:
 - a. Permanently embedded detectable warning tile wet-set into freshly poured concrete.
 - b. Permanently embedded detectable warning tile set into formed recess in concrete and adhered with **[mortar][adhesive]**.
 - c. Replaceable embedded detectable warning tile fastened to permanently installed anchors.

- D. Surface-Applied Detectable Warning Metal Tiles: Accessible truncated-dome detectable warning metal tiles or plates configured for fastening to surface of existing concrete walkway surfaces, with slip-resistant surface treatment on domes, field of tile, and beveled outside edges.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Advantage Tactile Systems]**
 - b. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Advantage Tactile Systems]**
 - b. **<Insert manufacturer's name>**
 3. Material: Stainless-Steel Plate and Sheet: ASTM A240/A240M or ASTM A666, **[Type 304][Type 316L]**.
 4. Finish and Color:
 - a. Manufacturer's standard powder coat, **[safety yellow][red brick][black][gray][color as selected by Architect from manufacturer's full line]**.
 - b. Mill finish.
 5. Shapes and Sizes:
 - a. Rectangular panel, **[24 by 24 inches (610 by 610 mm)][24 by 36 inches (610 by 914 mm)][24 by 48 inches (610 by 1219 mm)][24 by 60 inches (610 by 1524 mm)]<Insert dimensions>**.
 6. Dome Spacing and Configuration: **[1.67-inch (42.4-mm) spacing][2.35-inch (59.7-mm) spacing][Manufacturer's standard compliant spacing]<Insert spacing>**, in **[square][diamond][manufacturer's standard]** pattern.
 7. Mounting:
 - a. Replaceable surface-applied detectable warning tile fastened with permanently installed anchors to existing concrete walkway.
 - b. Permanently fixed detectable warning tile adhered **[and fastened]** to existing concrete walkway.

2.3 DETECTABLE WARNING MATS

- A. Surface-Applied Detectable Warning Mats: Accessible truncated-dome detectable warning resilient mats, UV resistant, manufactured for adhering to existing concrete walkway surfaces, with slip-resistant surface treatment on domes, field of mat, and beveled outside edges.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Detectable Warning Systems, Inc.]**

- b. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Detectable Warning Systems, Inc.]
 - b. <Insert manufacturer's name>
- 3. Material: Modified rubber compound, UV resistant.
- 4. Color: [As indicated by manufacturer's designations][Match Architect's sample][As selected by Architect from manufacturer's full range]<Insert color>.
- 5. Shapes and Sizes:
 - a. Rectangular panel, [24 by 36 inches (610 by 914 mm)][24 by 48 inches (610 by 1219 mm)][24 by 60 inches (610 by 1524 mm)]<Insert dimensions>.
- 6. Dome Spacing and Configuration: [1.67-inch (42.4-mm) spacing][2.35-inch (59.7-mm) spacing][Manufacturer's standard compliant spacing]<Insert spacing>, in [square][diamond][manufacturer's standard] pattern.
- 7. Mounting: Adhered to pavement surface with adhesive[and fastened with fasteners].

2.4 DETECTABLE WARNING UNIT PAVERS

- A. Detectable Warning Concrete Unit Pavers: Solid paving units, made from normal-weight concrete with a compressive strength of not less than **5000 psi (34 MPa)** <Insert value>, water absorption of not more than 5 percent according to ASTM C140, and no breakage and not more than 1 percent mass loss when tested for freeze-thaw resistance according to ASTM C67, with accessible detectable warning truncated domes on exposed surface of units.
 - 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Advanced Surfaces Inc.]
 - b. [Armor-Tile]
 - c. [ECG, Inc.; a division of Elizabeth City Glass Co.]
 - d. [Hanover Architectural Products]
 - e. [Tile Tech Pavers]
 - f. <Insert manufacturer's name>
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Advanced Surfaces Inc.]
 - b. [Armor-Tile]
 - c. [ECG, Inc.; a division of Elizabeth City Glass Co.]
 - d. [Hanover Architectural Products]
 - e. [Tile Tech Pavers]
 - f. <Insert manufacturer's name>
 - 3. Shapes and Sizes:

- a. Thickness: [2 inches (51 mm)][2-1/2 inches (63 mm)]<Insert dimension> at field of tile.
 - b. Face Size: Nominal [12 by 12 inches (305 by 305 mm)][24 by 24 inches (610 by 610 mm)]<Insert dimensions>.
4. Dome Spacing and Configuration: [1.67-inch (42.4-mm) spacing][2.35-inch (59.7-mm) spacing][Manufacturer's standard compliant spacing]<Insert spacing>, in [square][diamond][manufacturer's standard] pattern.
5. Color: [As indicated by manufacturer's designations][Match Architect's sample][As selected by Architect from manufacturer's full range]<Insert color>.
- B. Setting Bed: Comply with requirements in Section 321400 "Unit Paving."
- C. Aggregate Setting Bed:
 1. Graded Aggregate for Base: Sound, crushed stone or gravel complying with ASTM D448 for Size No. 8.
 2. Sand for Leveling Course: Sound, sharp, washed, natural sand or crushed stone complying with gradation requirements in ASTM C33/C33M for fine aggregate.
 3. Sand for Joints: Fine, sharp, washed, natural sand or crushed stone with 100 percent passing No. 16 (1.18-mm) sieve and no more than 10 percent passing No. 200 (0.075-mm) sieve.
- D. Mortar Setting Bed:
 1. Portland Cement: ASTM C150/C150M, Type I or Type II.
 2. Sand: ASTM C33/C33M.
 3. Latex Additive: Manufacturer's standard water emulsion, serving as replacement for part or all of gaging water, of type specifically recommended by latex-additive manufacturer for use with field-mixed portland cement and aggregate mortar bed, and not containing a retarder.
 4. Thinset Mortar: Latex-modified portland cement mortar complying with ANSI A118.4.
 5. Water: Potable.

2.5 ACCESSORIES

- A. Fasteners and Anchors: Manufacturer's standard as required for secure anchorage of tactile warning surfaces, noncorrosive and compatible with each material joined, and complying with the following:
 1. Furnish [Type 304][Type 316] stainless-steel fasteners for exterior use.
 2. Fastener Heads: For nonstructural connections, use flathead or oval countersunk screws and bolts with tamper-resistant heads, colored to match tile.
- B. Adhesive: As recommended by manufacturer for adhering tactile warning surfacing unit to pavement.
- C. Sealant: As recommended by manufacturer for sealing perimeter of tactile warning surfacing unit.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that pavement is in suitable condition to begin installation according to manufacturer's written instructions. Verify that installation of tactile warning surfacing will comply with accessibility requirements upon completion.

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

3.2 INSTALLATION OF TACTILE WARNING SURFACING

- A. General: Prepare substrate and install tactile warning surfacing according to manufacturer's written instructions unless otherwise indicated.
- B. Place tactile warning surfacing units in dimensions and orientation indicated. Comply with location requirements of AASHTO MP 12.

3.3 INSTALLATION OF DETECTABLE WARNING TILES

A. Cast-in-Place Detectable Warning Tiles:

1. Concrete Paving Installation: Comply with installation requirements in Section 321313 "Concrete Paving." Mix, place, and finish concrete to conditions complying with detectable warning tile manufacturer's written requirements for satisfactory embedment of tile.
2. Set each detectable warning tile accurately and firmly in place and completely seat tile back and embedments in wet concrete by tamping or vibrating. If necessary, temporarily apply weight to tiles to ensure full contact with concrete.
3. Set surface of tile flush with surrounding concrete and adjacent tiles, with variations between tiles and between concrete and tiles not exceeding plus or minus **1/8 inch (3 mm)** from flush.
4. Protect exposed surfaces of installed tiles from contact with wet concrete. Complete finishing of concrete paving surrounding tiles. Remove concrete from tile surfaces.
5. Clean tiles using methods recommended in writing by manufacturer.

B. Removable Cast-in-Place Detectable Warning Tiles:

1. Concrete Paving Installation: Comply with installation requirements in Section 321313 "Concrete Paving." Mix, place, and finish concrete to conditions complying with detectable warning tile manufacturer's written requirements for satisfactory embedment of removable tile.
2. Set each detectable warning tile accurately and firmly in place with embedding anchors and fasteners attached, and firmly seat tile back in wet concrete by tamping or vibrating. If necessary, temporarily apply weight to tiles to ensure full contact with concrete.
3. Set surface of tile flush with surrounding concrete and adjacent tiles, with variations between tiles and between concrete and tiles not exceeding plus or minus **1/8 inch (3 mm)** from flush.
4. Protect exposed surfaces of installed tiles from contact with wet concrete. Complete finishing of concrete paving surrounding tiles. Remove concrete from tile surfaces.
5. Clean tiles using methods recommended in writing by manufacturer.

C. Surface-Applied Detectable Warning Tiles:

1. Lay out detectable warning tiles as indicated and mark concrete pavement.
2. Prepare existing paving surface by grinding and cleaning as recommended by manufacturer.
 - a. Cut perimeter kerf in existing concrete pavement to receive metal tile flange.
3. Apply adhesive to back of tiles in amounts and pattern recommended by manufacturer, and set tiles in place. Firmly seat tiles in adhesive bed, eliminating air pockets and establishing full adhesion to pavement. If necessary, temporarily apply weight to tiles to ensure full contact with concrete.
4. Install anchor devices through face of tiles and into pavement using anchors located as recommended by manufacturer. Set heads of anchors flush with top surface of mat.

5. Mask perimeter of tiles and adjacent concrete, and apply sealant in continuous bead around perimeter of tile installation.
6. Remove masking, adhesive, excess sealant, and soil from exposed surfaces of detectable warning tiles and surrounding concrete pavement using cleaning agents recommended in writing by manufacturer.
7. Protect installed tiles from traffic until adhesive has set.

3.4 INSTALLATION OF DETECTABLE WARNING MATS

- A. Lay out detectable warning mats as indicated and mark concrete pavement at edges of mats.
- B. Prepare existing paving surface by grinding and cleaning as recommended by manufacturer.
- C. Apply adhesive to back of mat in amounts and pattern recommended by manufacturer, and set mat in place. Firmly seat mat in adhesive bed, eliminating air pockets and establishing full adhesion to pavement. If necessary, temporarily apply weight to mat to ensure full contact with adhesive.
- D. Install anchor devices through face of mat and into pavement using anchors located as recommended by manufacturer. Set heads of anchors flush with mat surface.
- E. Mask mat perimeter and adjacent concrete, and apply sealant in continuous bead around perimeter of mat.
- F. Remove masking, adhesive, excess sealant, and soil from exposed surfaces of detectable warning mat and surrounding concrete pavement using cleaning agents recommended in writing by manufacturer.
- G. Protect installed mat from traffic until adhesive has set.

3.5 INSTALLATION OF DETECTABLE WARNING UNIT PAVERS

- A. Unit Paver Installation, General:
 1. Setting-Bed and Unit Paver Installation: Comply with installation requirements in Section 321400 "Unit Paving."
 2. Mix unit pavers from several pallets or cubes, as they are placed, to produce uniform blend of colors and textures.
 3. Cut unit pavers with motor-driven masonry saw equipment to provide pattern indicated and to fit adjoining work neatly. Use full units without cutting where possible.
 4. Tolerances: Do not exceed **1/4 inch in 10 feet (6 mm in 3 m)** from level, or indicated slope, for finished surface of paving.
- B. Aggregate Setting-Bed Applications:
 1. Place aggregate base, compact by tamping with plate vibrator, and screed to depth indicated.
 2. Place leveling course and screed to a thickness of **1 to 1-1/2 inches (25 to 38 mm)**, taking care that moisture content remains constant and density is loose and uniform until unit pavers are set and compacted.
 3. Treat leveling course with herbicide to inhibit growth of grass and weeds.
 4. Set unit pavers with a minimum joint width of **1/16 inch (1.5 mm)** and a maximum of **1/8 inch (3 mm)**, being careful not to disturb leveling base. If pavers have spacer bars, place pavers hand tight against spacer bars. Use string lines to keep straight lines.
 5. Vibrate pavers into leveling course with a low-amplitude plate vibrator capable of a **3500- to 5000-lbf (16- to 22-kN)** compaction force at 80 to 90 Hz.
 6. Spread dry sand and fill joints immediately after vibrating pavers into leveling course. Vibrate

pavers and add sand until joints are completely filled, then remove excess sand. Leave a slight surplus of sand on the surface for joint filling.

C. Mortar Setting-Bed Applications:

1. Saturate concrete subbase with clean water several hours before placing setting bed. Remove surface water about one hour before placing setting bed.
2. Apply mortar-bed bond coat over surface of concrete subbase about 15 minutes before placing mortar bed. Limit area of bond coat to avoid its drying out before placing setting bed. Do not exceed **1/16-inch (1.6-mm)** thickness for bond coat.
3. Apply mortar bed over bond coat; spread and screed mortar bed to uniform thickness at subgrade elevations required for accurate setting of pavers to finished grades indicated.
4. Mix and place only that amount of mortar bed that can be covered with pavers before initial set. Before placing pavers, cut back, bevel edge, and remove and discard setting-bed material that has reached initial set.
5. Place pavers before initial set of cement occurs. Immediately before placing pavers on mortar bed, apply uniform **1/16-inch- (1.5-mm-)** thick bond coat to mortar bed or to back of each paver with a flat trowel.
6. Tamp or beat pavers with a wooden block or rubber mallet to obtain full contact with setting bed and to bring finished surfaces within indicated tolerances. Set each paver in a single operation before initial set of mortar; do not return to areas already set or disturb pavers for purposes of realigning finished surfaces or adjusting joints.
7. Spaced Joint Widths: Provide [**3/8-inch (10-mm)**][**1/2-inch (13-mm)**] nominal joint width with variations not exceeding plus or minus [**1/16 inch (1.5 mm)**][**1/8 inch (3 mm)**].
8. Grouted Joints: Grout paver joints complying with ANSI A108.10. Grout joints as soon as possible after initial set of setting bed.
 - a. Force grout into joints, taking care not to smear grout on adjoining surfaces.
 - b. Tool exposed joints slightly concave when thumbprint hard.
 - c. Cure grout by maintaining in a damp condition for seven days unless otherwise recommended by grout or liquid-latex manufacturer.
9. Remove excess grout from exposed paver surfaces; wash and scrub clean.
10. Protect installation from traffic until grout has set.

3.6 CLEANING AND PROTECTION

- A. Remove and replace tactile warning surfacing that is broken or damaged or does not comply with requirements in this Section. Remove in complete sections from joint to joint unless otherwise approved by Architect. Replace using tactile warning surfacing installation methods acceptable to Architect.
- B. Protect tactile warning surfacing from damage and maintain free of stains, discoloration, dirt, and other foreign material.

END OF SECTION 32 17 26 00

SECTION 32 18 16 13 - PLAYGROUND PROTECTIVE SURFACING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Unitary, seamless surfacing.
2. Unitary, tile surfacing.
3. Organic loose-fill surfacing.
4. Inorganic loose-fill surfacing.

1.2 DEFINITIONS

- A. Definitions in ASTM F2223 apply to Work of this Section.
- B. Critical Height: Standard measure of shock attenuation according to ASTM F2223; same as "critical fall height" in ASTM F1292. According to ASTM F1292, this approximates "the maximum fall height from which a life-threatening head injury would not be expected to occur."
- C. SBR: Styrene-butadiene rubber.
- D. Unitary Surfacing: A protective surfacing of one or more material components bound together to form a continuous surface; same as "unitary system" in ASTM F2223.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Sustainable Design Submittals:
1. Product Data: For recycled content, indicating postconsumer and preconsumer recycled content and cost.
- C. Shop Drawings: For each type of protective surfacing.
1. Include plans, sections, placement[**and penetration**] details, and attachment to substrates.
 2. Include accessories and edge terminations.
 3. Include **[patterns made by varying colors of surfacing][and][details of graphics]**.
 4. Include fall heights and use zones for equipment and structures specified in Section 116800 "Play Field Equipment and Structures," coordinated with the critical heights for protective surfacing.
- D. Samples for Initial Selection: For each type of exposed finish.
1. Include Samples of accessories involving color selection.
- E. Samples for Verification: For each type of protective surfacing and exposed finish.
1. Include Samples of accessories to verify color and finish selection.

32 - Exterior Improvements

2. Unitary, Seamless Surfacing: Minimum **6 by 6 inches (150 by 150 mm)**.
3. Unitary, Tile Surfacing: Minimum **6 by 6 inches (150 by 150 mm)**.
4. Loose-Fill Surfacing: Minimum **1 quart (0.95 L)**.
5. Edging: **6 inches (150 mm)** long by full width and cross section.
6. Stabilizing Mats: Minimum **12 by 12 inches (300 by 300 mm)**.
7. Drainage/Separation Geotextile: Minimum **12 by 12 inches (300 by 300 mm)**.
8. Drainage Panel: Minimum **6 by 6 inches (150 by 150 mm)**.
9. Weed-Control Barrier: Minimum **12 by 12 inches (300 by 300 mm)**.

- F. Product Schedule: For protective surfacing. [**Use same designations indicated on Drawings.**]

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For [**Installer**] [**and**] [**testing agency**].
- B. Material Certificates: For each type of loose-fill surfacing.
- C. Product Certificates: For each type of unitary surfacing product.
- D. Field quality-control reports.
- E. Sample Warranty: For manufacturer's special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For playground protective surfacing to include in maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials, [**from the same product run,**] that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Unitary Tile Units: Full-size units equal to [**1**] < **Insert number** > percent of amount installed, but no fewer than [**3**] < **Insert number** > units.
 2. Loose Fill: Amount equal to [**1**] < **Insert number** > percent of amount installed, but no fewer than [**3**] < **Insert number** > units
 3. Edging Units: [**3**] < **Insert number** > full-size units.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.
- B. Mockups: Build mockups to verify selections made under Sample submittals and to set quality standards for materials and execution.
 1. Build mockups for protective surfacing including accessories.
 - a. Size: [**48 inches (1200 mm) by 48 inches (1200 mm)**] < **Insert dimension(s)** > .

2. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
3. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.8 WARRANTY

- A. Special Warranty: Manufacturer and Installer agree to repair or replace components of protective surfacing that fail in materials or workmanship within specified warranty period.
 1. Failures include, but are not limited to, the following:
 - a. Reduction in impact attenuation as measured by reduction of critical fall height.
 - b. Deterioration of protective surfacing and other materials beyond normal weathering.
 - c. **<Insert failure modes>**.
 2. Warranty Period: **[Two][Three][Five][10][15]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

- A. Obtain protective surfacing materials[, **including loose-fill accessories,**] from single source from single manufacturer.
 1. Provide geosynthetic accessories of each type from source recommended by manufacturer of protective surfacing materials.

2.2 PERFORMANCE REQUIREMENTS

- A. Impact Attenuation: Critical fall height tested according to ASTM F1292.
- B. Accessibility Standard: Minimum surfacing performance according to ASTM F1951.

2.3 UNITARY, SINGLE-DENSITY, SEAMLESS SURFACING

- A. Description: Manufacturer's standard, site-mixed and applied, single-layer material in thickness as required, tested for impact attenuation according to ASTM F1292[**and for accessibility according to ASTM F1951**].
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 1. **[Child Safe Products, Inc.]**
 2. **[GameTime; a PlayCore Company]**
 3. **[Hanover Specialties, Inc.]**
 4. **[No Fault LLC]**
 5. **[Playsafe Surfacing LLC]**

6. <Insert manufacturer's name>

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

1. [Child Safe Products, Inc.]
2. [GameTime; a PlayCore Company]
3. [Hanover Specialties, Inc.]
4. [No Fault LLC]
5. [Playsafe Surfacing LLC]
6. <Insert manufacturer's name>

D. Leveling and Patching Material: Portland cement-based grout or epoxy- or polyurethane-based formulation suitable for exterior use and approved by protective surfacing manufacturer.

2.4 UNITARY, DUAL-DENSITY, SEAMLESS SURFACING

A. Description: Manufacturer's standard, site-mixed and applied, two-layer material with wearing layer over cushioning layer, with combined, overall thickness as required, tested for impact attenuation according to ASTM F1292[**and for accessibility according to ASTM F1951**].

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

1. [Child Safe Products, Inc.]
2. [Fibar Group LLC (The)]
3. [GameTime; a PlayCore Company]
4. [Hanover Specialties, Inc.]
5. [Landscape Structures Inc.]
6. [No Fault LLC]
7. [Playsafe Surfacing LLC]
8. [SpectraTurf, Inc]
9. [Surface America, Inc.]
10. <Insert manufacturer's name>

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

1. [Child Safe Products, Inc.]
2. [Fibar Group LLC (The)]
3. [GameTime; a PlayCore Company]
4. [Hanover Specialties, Inc.]
5. [Landscape Structures Inc.]
6. [No Fault LLC]
7. [Playsafe Surfacing LLC]
8. [SpectraTurf, Inc]
9. [Surface America, Inc.]
10. <Insert manufacturer's name>

D. Leveling and Patching Material: Portland cement-based grout or epoxy- or polyurethane-based formulation suitable for exterior use and approved by protective surfacing manufacturer.

2.5 UNITARY, TILE SURFACING

- A. Description: Manufacturer's standard blend of **[recycled]** SBR, EPDM rubber, or PVC particles forming an integral wearing and cushioning material, with overall thickness as required, tested for impact attenuation according to ASTM F1292 **[and for accessibility according to ASTM F1951]**.
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[BCI Burke Company, LLC]**
 2. **[Ecore International]**
 3. **[GameTime; a PlayCore Company]**
 4. **[Little Tikes Company U.S. (The); PlayPower Inc.]**
 5. **[No Fault LLC]**
 6. **[OTS Company, Inc.]**
 7. **[SpectraTurf, Inc]**
 8. **[Surface America, Inc.]**
 9. **<Insert manufacturer's name>**
- C. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[BCI Burke Company, LLC]**
 2. **[Ecore International]**
 3. **[GameTime; a PlayCore Company]**
 4. **[Little Tikes Company U.S. (The); PlayPower Inc.]**
 5. **[No Fault LLC]**
 6. **[OTS Company, Inc.]**
 7. **[SpectraTurf, Inc]**
 8. **[Surface America, Inc.]**
 9. **<Insert manufacturer's name>**
- D. Leveling and Patching Material: Portland cement-based grout or epoxy- or polyurethane-based formulation suitable for exterior use and approved by protective surfacing manufacturer.

2.6 UNITARY, DUAL-DENSITY, TILE SURFACING

- A. Description: Manufacturer's standard **[EPDM]** colored wearing layer bonded to **[recycled]** rubber cushioning layer, tested for impact attenuation according to ASTM F1292 **[and for accessibility according to ASTM F1951]**.
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[Ecore International]**
 2. **[GameTime; a PlayCore Company]**
 3. **[Landscape Structures Inc.]**
 4. **[OTS Company, Inc.]**
 5. **[Playworld Systems, Inc.]**
 6. **[SpectraTurf, Inc]**
 7. **[Surface America, Inc.]**
 8. **<Insert manufacturer's name>**

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

1. **[Ecore International]**
2. **[GameTime; a PlayCore Company]**
3. **[Landscape Structures Inc.]**
4. **[OTS Company, Inc.]**
5. **[Playworld Systems, Inc.]**
6. **[SpectraTurf, Inc]**
7. **[Surface America, Inc.]**
8. **<Insert manufacturer's name>**

- D. Leveling and Patching Material: Portland cement-based grout or epoxy- or polyurethane-based formulation suitable for exterior use and approved by protective surfacing manufacturer.

2.7 ORGANIC LOOSE-FILL SURFACING

- A. Engineered Wood Fiber: ASTM F2075; containing no bark, leaves, twigs, or foreign or toxic materials[; **tested for accessibility according to ASTM F1951**].

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

- a. **[Fibar Group LLC (The)]**
- b. **[GameTime; a PlayCore Company]**
- c. **[Sof'Solutions Inc.]**
- d. **[Supreme Forest Products, Inc.]**
- e. **[Zeager Bros., Inc.]**
- f. **<Insert manufacturer's name>**

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

- a. **[Fibar Group LLC (The)]**
- b. **[GameTime; a PlayCore Company]**
- c. **[Sof'Solutions Inc.]**
- d. **[Supreme Forest Products, Inc.]**
- e. **[Zeager Bros., Inc.]**
- f. **<Insert manufacturer's name>**

3. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than **[95]<Insert value>** percent.
4. Critical Height: **[4 feet (1.2 m)][5 feet (1.5 m)][7 feet (2.1 m)][10 feet (3 m)][As indicated on Drawings]<Insert dimension>**.
5. Uncompressed Material Depth: Not less than **[as required for critical height indicated][6 inches (150 mm)][9 inches (229 mm)][as indicated on Drawings]<Insert dimension>**.

- B. Wood Chips: Random-sized wood chips suitable for mulching trees and shrubs, free of metal scrap and other impurities that can cause injuries; **complying with the testing and performance requirements for hazardous metals and tramp metal according to ASTM F2075**].

- C. Double-Shredded Bark Mulch: Random-sized bark, shredded twice, suitable for mulching trees and shrubs, free of metal scrap and other impurities that can cause injuries; **complying with the testing and performance requirements for hazardous metals and tramp metal according to ASTM F2075**].

2.8 INORGANIC LOOSE-FILL SURFACING

- A. Shredded Rubber: Rubber particles, free from steel wires, rubber dust, and other foreign substances, tested for impact attenuation according to ASTM F1292[**and for accessibility according to ASTM F1951**].
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[GameTime; a PlayCore Company]**
 - b. **[IMC Outdoor Living. A Division of Liberty Tire Recycling]**
 - c. **[Little Tikes Company U.S. (The); PlayPower Inc.]**
 - d. **[No Fault LLC]**
 - e. **[Playsafe Surfacing LLC]**
 - f. **[Sof'Solutions Inc.]**
 - g. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[GameTime; a PlayCore Company]**
 - b. **[IMC Outdoor Living. A Division of Liberty Tire Recycling]**
 - c. **[Little Tikes Company U.S. (The); PlayPower Inc.]**
 - d. **[No Fault LLC]**
 - e. **[Playsafe Surfacing LLC]**
 - f. **[Sof'Solutions Inc.]**
 - g. **<Insert manufacturer's name>**
 3. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than **[95]<Insert value>** percent.
 4. Critical Height: **[4 feet (1.2 m)][5 feet (1.5 m)][7 feet (2.1 m)][10 feet (3 m)][As indicated on Drawings]<Insert dimension>**.
 5. Uncompressed Material Depth: Not less than **[as required for critical height indicated][6 inches (150 mm)][9 inches (229 mm)][as indicated on Drawings]<Insert dimension>**.
 6. Color(s): **[As indicated by manufacturer's designations][Match Architect's sample][As selected by Architect from manufacturer's full range]<Insert color>**.
- B. Inorganic Aggregate Materials: Clean, washed, and free of loam, clay, organic matter, debris, and other foreign substances.
1. Fine Sand: Complying with ASTM C136 for the following sieve analysis test results:
 - a. Sieve Sizes and Percent Passing through Screen: No. 16 passing 100 percent, No. 30 passing 98 percent, No. 50 passing 62 percent, No. 100 passing 17 percent, and No. 200 passing zero to 1 percent.
 2. Coarse Sand: Complying with ASTM C136 for the following sieve analysis test results:

- a. Sieve Sizes and Percent Passing through Screen: No. 4 passing 98 percent, No. 8 passing 73 percent, No. 16 passing 4 percent, No. 30 passing 1 percent, and No. 50 passing zero to 1 percent.
3. Fine Gravel: Rounded, hard, durable stone, free of sand, with particle size less than **3/8 inch (9.5 mm)** in diameter; complying with ASTM C136 for the following sieve analysis test results:
 - a. Sieve Sizes and Percent Passing through Screen: **3/8 inch (9.5 mm)** passing 100 percent, No. 3-1/2 passing 93 percent, No. 4 passing 65 percent, No. 8 passing 8 percent, No. 16 passing 5 percent, and No. 30 passing 4 percent.
4. Medium Gravel: Rounded, hard, durable, riverbed gravel or tumbled stone, free of sand, with particle size less than **1/2 inch (13 mm)** in diameter; complying with ASTM C136 for the following sieve analysis test results:
 - a. Sieve Sizes and Percent Passing through Screen: **1/2 inch (13 mm)** passing 100 percent, **3/8 inch (9.5 mm)** passing 80 percent, **5/16 inch (8 mm)** passing 20 percent, No. 4 passing 8 percent, and No. 16 passing 3 percent.
5. Critical Height: **[4 feet (1.2 m)][5 feet (1.5 m)][As indicated on Drawings]<Insert dimension>**.
6. Uncompressed Material Depth: Not less than **[as required for critical height indicated][9 inches (229 mm)][as indicated on Drawings]<Insert dimension>**.

2.9 LOOSE-FILL ACCESSORIES

- A. Edging: Anchored-in-place, weather-resistant containment barrier designed to minimize sharp edges, protrusions, and tripping hazards; formed by interconnected, modular units.
 1. Polyethylene Units: UV-light-stabilized[, **100 percent recycled**] polyethylene, not less than **[1/4-inch (6-mm)]<Insert dimension>** wall thickness; made into smooth-surfaced **[straight][and][curved]** units with radiused exposed edges and integral, molded-in color; in manufacturer's standard sizes.
 - a. Color: **[As indicated by manufacturer's designations][Match Architect's sample][As selected by Architect from manufacturer's full range]<Insert color>**.
 2. Metal Units: Steel fabricated with radiused exposed edges and finished with PVC coating, **[straight][right-angled corner][and][curved]** units, in manufacturer's standard sizes.
 - a. Color: **[As indicated by manufacturer's designations][Match Architect's sample][As selected by Architect from manufacturer's full range]<Insert color>**.
 3. Rubber Units: Compression molded from **[100 percent recycled]** SBR, in manufacturer's standard sizes.
 - a. Color: **[As indicated by manufacturer's designations][Match Architect's sample][As selected by Architect from manufacturer's full range]<Insert color>**.
 4. Anchor Stakes: Manufacturer's standard, of corrosion-resistant-coated metal or noncorrodible material, designed to be nonprotruding when installed, for connecting units and securing in-place.
- B. Stabilizing Mats: Water-permeable PVC or rubber mats tested for impact attenuation according to ASTM F1292[, **with anchoring system designed to anchor mat securely to subgrade through loose fill**],

and rated for use in the following locations:

1. Under and in Front of Slide Exits: **[At finished grade of protective surfacing][Below surface of protective surfacing][As indicated on Drawings].**
2. Under and Around Swings: **[At finished grade of protective surfacing][Below surface of protective surfacing][As indicated on Drawings].**
3. Around Transfer Stations at Accessible Perimeter: At finished grade of protective surfacing.
4. At high-traffic areas and playground equipment where indicated on Drawings.
5. Size: **[Manufacturer's standard size as recommended in writing][36 by 36 inches (914 by 914 mm)][40 by 40 inches (1016 by 1016 mm)][48 by 48 inches (1200 by 1200 mm)]<Insert dimensions>.**
6. Color(s): **[As indicated by manufacturer's designations][Match Architect's sample][As selected by Architect from manufacturer's full range]<Insert colors>.**

2.10 GEOSYNTHETIC ACCESSORIES

- A. Drainage/Separation Geotextiles: Comply with Section 312000 "Earth Moving."
- B. Drainage/Separation Geotextile: Nonwoven, needle-punched geotextile, manufactured for drainage applications and made from polyolefins or polyesters; with the following minimum properties:
 1. Weight: **[4 oz./sq. yd. (136 g/sq. m)]<Insert value>**; ASTM D5261.
 2. Water Flow Rate: **[100 gpm/sq. ft. (68 L/s per sq. m)][150 gpm/sq. ft. (102 L/s per sq. m)]<Insert value>** according to ASTM D4491.
- C. Drainage Panel: Prefabricated, composite drainage panels made with drainage core and filter fabric.
 1. Drainage Core: Three-dimensional, nonbiodegradable, molded-plastic-sheet material designed to effectively drain water under maximum fill pressures.
 2. Fabric: Nonwoven, needle-punched geotextile, specifically manufactured as a filter geotextile and made from polyolefins or polyesters; with the following minimum properties:
 - a. Weight: **[4 oz./sq. yd. (136 g/sq. m)]<Insert value>** according to ASTM D5261.
 - b. Water Flow Rate: **[100 gpm/sq. ft. (68 L/s per sq. m)][150 gpm/sq. ft. (102 L/s per sq. m)]<Insert value>** according to ASTM D4491.
 3. Minimum Flow Rate: **[9 gpm/foot (1.9 L/s per m)]<Insert value>** according to ASTM D4491.
- D. Weed-Control Barrier: Composite fabric geotextile consisting of woven, needle-punched polypropylene substrate bonded to a nonwoven polypropylene fabric, weighing not less than **4.8 oz./sq. yd. (160 g/sq. m).**

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for subgrade elevations, slope, and drainage and for other conditions affecting performance of the Work.
 1. Verify that substrates are sound and without high spots, ridges, holes, and depressions.
- B. Hard-Surface Substrates: Verify that substrates are satisfactory for unitary, protective surfacing

installation and that substrate surfaces are dry, cured, and uniformly **[level][sloped to drain]** within recommended tolerances according to protective surfacing manufacturer's written requirements for cross-section profile.

1. Asphalt Substrates: Verify that substrates are dry, sufficiently cured to bond with adhesive, and free from surface defects, dust, dirt, loose particles, grease, oil, and other contaminants incompatible with protective surfacing or that may interfere with adhesive bond.
2. Concrete Substrates: Verify that substrates are dry and free from surface defects, laitance, glaze, efflorescence, curing compounds, form-release agents, hardeners, dust, dirt, loose particles, grease, oil, and other contaminants incompatible with protective surfacing or that may interfere with adhesive bond. Determine adhesion, dryness, and acidity characteristics by performing procedures recommended in writing by protective surfacing manufacturer.

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

3.2 PREPARATION

- A. Prepare substrates to receive surfacing products according to protective surfacing manufacturer's written instructions.
- B. Hard-Surface Substrates: Clean surface free of laitance, efflorescence, curing compounds, and other contaminants incompatible with protective surfacing.
 1. Repair: Fill holes and depressions in unsatisfactory surfaces with leveling and patching material.
 2. Treatment: Mechanically abrade or otherwise prepare concrete substrates according to protective surfacing manufacturer's written instructions to achieve adequate roughness.
 3. Terminal Edges: Saw cut **[concrete][asphalt]** for terminal edges of protective surfacing.
 4. Treat control joints and other nonmoving substrate cracks to prevent telegraphing through protective surfacing.

3.3 INSTALLATION OF GEOSYNTHETIC ACCESSORIES

- A. Install geosynthetic accessories before edging and according to playground surface system manufacturer's and geosynthetic manufacturer's written instructions and in a manner that cannot become a tripping hazard.
 1. Drainage/Separation Geotextile: Completely cover area beneath protective surfacing, overlapping geotextile sides and edges a minimum of **[4 inches (100 mm)][8 inches (200 mm)]<Insert dimension>** with **[manufacturer's standard treatment for][overlapping loosely laid][adhesively bonded or taped]** seams.
 2. Drainage Panels: Completely cover area beneath protective surfacing, abutting the drainage cores and overlapping seams with geotextile fabric facing with **[manufacturer's standard treatment][overlapping loosely laid][adhesively bonded or taped]** seams.
 3. Weed-Control Barrier: Completely cover area beneath loose-fill installation, overlapping barrier edges a minimum of **[4 inches (100 mm)][8 inches (200 mm)]<Insert dimension>** with **[manufacturer's standard treatment for][overlapping loosely laid][adhesively bonded or taped]** seams.

3.4 INSTALLATION OF SEAMLESS SURFACING

- A. Mix and apply components of seamless surfacing according to manufacturer's written instructions to produce uniform, monolithic, and impact-attenuating protective surfacing of required overall thickness.

1. Substrate Primer: Apply over prepared substrate at manufacturer's standard spreading rate for type of substrate.
2. Poured Cushioning Layer: Spread evenly over primed substrate to form a uniform layer applied at manufacturer's standard spreading rate in one continuous operation, with a minimum of cold joints.
3. Intercoat Primer: Over cured cushioning layer, apply primer at manufacturer's standard spreading rate.
4. Wearing Layer: Spread over primed base course to form a uniform layer applied at manufacturer's standard spreading rate in one continuous operation and, except where color changes, with **[no][a minimum of]** cold joints. Finish surface to produce manufacturer's standard wearing-surface texture.
 - a. Design: Where **[colored pattern][graphic design]** is required, place colored, design material as soon as previously placed material is sufficiently cured, using primer or adhesive if required by manufacturer's written instructions.
5. Lacquer Topcoat: Spray or roller applied at manufacturer's standard coating rate in one continuous operation.
6. Edge Treatment: **[Flush][Extended surface course][Saw-cut base and vertical pour][As indicated on Drawings]**. Fully adhere edges to substrate with full coverage of substrate. Maintain fully cushioned thickness required to comply with performance requirements.

3.5 INSTALLATION OF TILE SURFACING

- A. Apply components of tile surfacing according to manufacturer's written instructions to produce a uniform wearing surface with no unaligned units, raised edges (lipping), or other surface imperfections.
- B. Lay out units from center marks established between principal perimeter edges, discounting minor offsets, so units at opposite sides of installation are of equal width. Adjust as necessary to avoid using cut widths that equal less than one-half of a unit. **[Allow for edging.]**
 1. Alignment Axis and Pattern:
 - a. Lay units along axis and in grid pattern indicated on Drawings.
 - b. Lay units **[square][at a 45-degree angle]** with playground equipment axis. Lay units in straight-line grid pattern with joints aligned.
 - c. Lay units **[square][at a 45-degree angle]** with playground equipment axis. Lay units in half-unit, offset grid pattern with staggered joints.
- C. Cut and fit units around playground equipment supports and vertical surfaces. Do not create voids greater than **3/8 inch (9.5 mm)** wide.
 1. Do not stretch units during installation.
- D. Adhesively Applied Units: Adhere units to substrates using a full spread of adhesive applied to substrate or to unit **[and to each other]**.
- E. Mechanically Fastened Units: Anchor to substrates.
- F. Mechanically Attached Units: Attach all four sides of units **[, including edging and corner units,]** to each other using number of fasteners per side as recommended in writing by protective surfacing manufacturer.
 1. Free lay sheet of attached units on substrate.
 2. Adhesively apply perimeter units. Adhere not less than one course of perimeter units **[and**

edging and corner units] to substrates using a full spread of adhesive applied to substrate or to unit[**and to each other**].

- G. Edging: Maintain fully cushioned thickness required to comply with performance requirements.
- H. Filler/Sealant: Mask area surrounding cutouts around playground equipment supports and other obstructions. Apply a full bead of filler/sealant, filling cutouts immediately after laying tile around cutout.

3.6 INSTALLATION OF LOOSE-FILL SURFACING

- A. Apply components of loose-fill surfacing according to manufacturer's written instructions to produce a uniform surface.
- B. Edging: Place and permanently secure edging in place, and attach units to each other.
- C. Loose Fill: Place loose-fill materials to required depth after installation of playground equipment support posts and foundations.[**Include manufacturer's recommended amount of additional material to offset natural compaction over time.**][**Include manufacturer's recommended amount of additional material to offset mechanical compaction.**]
- D. Stabilizing Mats: Coordinate installation of mats and mat anchoring system with placing[**and compacting**] loose fill.
- E. Grading: Uniformly grade loose fill to an even surface free from irregularities.
- F. Compaction: After initial grading, mechanically compact loose fill before finish grading.
- G. Finish Grading: Hand rake to a uniformly smooth finished surface and to required elevations.

3.7 FIELD QUALITY CONTROL

- A. Testing Agency: [**Owner will engage**][**Engage**] a qualified testing agency to perform tests.
- B. Perform the following tests[**with the assistance of a factory-authorized service representative**]:
 - 1. Perform "Installed Surface Performance Test" according to ASTM F1292 for each protective surfacing type and thickness in each playground area.
 - 2. Perform installed-surface-performance tests at no less than one series of tests for each [**1000 sq. ft. (100 sq. m)**]**<Insert dimension>** of each type and thickness of in-place protective surfacing or part thereof.
- C. Playground protective surfacing will be considered defective if it does not pass tests.
- D. Prepare test reports.

3.8 PROTECTION

- A. Prevent traffic over [**seamless**][**tile**] surfacing for not less than 48 hours after installation.

END OF SECTION 32 18 16 13

SECTION 32 18 23 13 - SYNTHETIC GRASS SURFACING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Synthetic grass surfacing.

B. Related Requirements:

1. Section 312000 "Earth Moving" for preparation, compaction, and grading of granular base.

1.2 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at **[Project site]<Insert location>**.

1.3 ACTION SUBMITTALS

A. Product Data:

1. Synthetic grass surfacing.

B. Shop Drawings: For synthetic grass surfacing.

1. Include sections and details.
2. Show locations of seams and method of seaming.
3. Show layout of game lines, numbers, and letters. Indicate application method of each line and marking.
4. Show location and layout of team logo/graphics.

C. Samples: For each type of synthetic grass surfacing indicated.

1. Turf Fabric: **[12 inches (300 mm)]<Insert dimension>** square.
2. Game Line Turf Fabric: **[12 inches (300 mm)]<Insert dimension>** long by actual width.
3. Infill Material: **[4 oz. (100 g)]<Insert quantity>** of each type.
4. Shock-Attenuation Pad: **[12 inches (300 mm)]<Insert dimension>** square.
5. Seam Sample: **[24 inches (600 mm)]<Insert dimension>** square with seam centered in sample.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For **[Installer][testing agency]**.

B. Product Test Reports: For each synthetic grass surfacing assembly.

C. Field quality-control reports.

D. Sample Warranties: For special warranties.

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1.5 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For synthetic grass surfacing, including maintenance cleaning instructions, to include in maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Turf Fabric: Minimum of **[300 sq. ft. (28 sq. m)]<Insert quantity>** for each type indicated.
 - 2. Infill: Minimum of **[two]<Insert number>** bags of each type.
 - 3. Seaming Tape and Adhesive: One roll of seaming tape and one gallon of adhesive.
 - 4. One new set of maintenance tools, of type recommended by synthetic grass surfacing manufacturer for installation.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Store materials in location and manner to allow installation of synthetic grass surfacing without excess disturbance of granular base.

1.9 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace synthetic grass surfacing that fails in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Deterioration and excessive wear.
 - b. Deterioration from UV light.
 - c. Excessive loss of shock attenuation.
 - d. Seam separation, including game lines and markings.
 - 2. Warranty Period: **[8][12]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Turf Fabric: Turf fabric tested in accordance with the following methods, with additional test method conditions for each method in accordance with ASTM F1551.
 - 1. Tuft Bind: Not less than **[8 lbf (36 N)][10 lbf (45 N)]<Insert value>** in accordance with ASTM

- D1335.
2. Breaking Strength: Minimum [200 lbf (890 N)][250 lbf (1112 N)]<Insert value> in warp direction and minimum [200 lbf (890 N)][250 lbf (1112 N)]<Insert value> perpendicular to warp direction, in accordance with ASTM D5034.
- B. Synthetic Turf Playing Surfaces: Assembly tested in accordance with the following methods, with additional test method conditions for each method in accordance with ASTM F1551.
1. Shock Attenuation: No greater than <Insert value> G(max) at time of installation in accordance with ASTM F355.
 2. Abrasiveness Index: <Insert value> in accordance with ASTM F1015.
 3. Athletic Shoe Traction Index: Determined in accordance with ASTM F2333 for [football][soccer]<Insert shoe type> shoe, as follows:
 - a. Rotational: [Mean][Range] of <Insert value(s)>.
 - b. Translational: [Mean][Range] of <Insert value(s)>.
- C. Permeability: <Insert inches/h (mm/h)> of rainfall capacity in accordance with ASTM F2898 or EN 15330-1.
- D. Durability: Minimum of <Insert number> wear cycles in accordance with EN 15306 (Lisport test).

2.2 SYNTHETIC GRASS SURFACING

- A. Synthetic Grass Surfacing for Field Sports: Complete surfacing system, consisting of synthetic yarns bound to water-permeable backing and infill indicated, suitable for [football][soccer][multipurpose sport][field hockey][baseball]<Insert sport> playing fields.
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [A-Turf Inc.; an Ecore company]
 - b. [Act Global]
 - c. [AstroTurf; a SportGroup company]
 - d. [Challenger Turf, Inc.]
 - e. [Desso Sports Systems North America]
 - f. [Domo Sports Grass]
 - g. [FieldTurf, a Tarkett Sports Company]
 - h. [ForeverLawn]
 - i. [Mondo]
 - j. [Shaw Sports Turf Division of Berkshire Hathaway]
 - k. [Sporturf; Controlled Products, LLC]
 - l. [Sprinturf; Specialty Surfaces International]
 - m. [SYNLawn; a SportGroup company]
 - n. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [A-Turf Inc.; an Ecore company]
 - b. [Act Global]
 - c. [AstroTurf; a SportGroup company]

- d. [Challenger Turf, Inc.]
- e. [Desso Sports Systems North America]
- f. [Domo Sports Grass]
- g. [FieldTurf, a Tarkett Sports Company]
- h. [ForeverLawn]
- i. [Mondo]
- j. [Shaw Sports Turf Division of Berkshire Hathaway]
- k. [Sporturf; Controlled Products, LLC]
- l. [Sprinturf; Specialty Surfaces International]
- m. [SYNLawn; a SportGroup company]
- n. <Insert manufacturer's name>

B. Synthetic Grass Surfacing for Landscaping: Complete surfacing system, consisting of synthetic yarns bound to water-permeable backing and infill indicated, suitable for [pet areas][playing fields][lawns][roof decks]<Insert application>.

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

- a. [Act Global]
- b. [Challenger Turf, Inc.]
- c. [Desso Sports Systems North America]
- d. [FieldTurf, a Tarkett Sports Company]
- e. [ForeverLawn]
- f. [Playfield Grass]
- g. [Sporturf; Controlled Products, LLC]
- h. [Sprinturf; Specialty Surfaces International]
- i. [SYNLawn; a SportGroup company]
- j. [XGrass]
- k. <Insert manufacturer's name>

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

- a. [Act Global]
- b. [Challenger Turf, Inc.]
- c. [Desso Sports Systems North America]
- d. [FieldTurf, a Tarkett Sports Company]
- e. [ForeverLawn]
- f. [Playfield Grass]
- g. [Sporturf; Controlled Products, LLC]
- h. [Sprinturf; Specialty Surfaces International]
- i. [SYNLawn; a SportGroup company]
- j. [XGrass]
- k. <Insert manufacturer's name>

C. Turf Fabric: Woven turf fabric with multicolored fiber and UV resistance, complying with the following:

- 1. Yarn Fiber: [Monofilament polyethylene][Slit-film polyethylene][Monofilament nylon][Multifiber monofilament and slit-film polyethylene]<Insert other fibers>.
- 2. Lead Content of Yarn Fiber: Maximum of [100]<Insert number> ppm in accordance with ASTM F2765.

3. Pile Weight: <Insert oz./sq. yd. (g/sq. m)> in accordance with ASTM D5848.
4. Pile Height: <Insert inches (mm)> in accordance with ASTM D5823.
- D. Backing: Manufacturer's standard woven or nonwoven polypropylene primary backing with urethane-coated secondary backing; provide perforations or drainage channels sufficient to meet permeability indicated.
- E. Infill: Manufacturer's standard [sand and rubber][rubber][sand][TPO][organic] infill.
 1. Infill Proportions: [70 percent rubber, 30 percent sand][50 percent rubber, 50 percent sand][Manufacturer's standard proportions]<Insert proportions>.
- F. Game Lines and Markings: Provide game lines and markers in widths and colors in accordance with requirements indicated on Drawings.
 1. Application Method: Tufted in to the maximum extent practicable, with remaining lines inlaid.
 2. Team Logo/Graphic: Provide inlaid team logo/graphic in colors and design indicated.
- G. Seaming Method: [Adhesive][Sewn][Hot melt].

2.3 MATERIALS

- A. Rubber Infill: Ground [latex-coated]SBR crumb rubber mesh free of metal, nonmetal fibers, and contaminants; mesh size as recommended by synthetic grass surfacing manufacturer.
- B. Sand Infill: Uniformly sized [latex-coated]silica sand free of silts, clays, and contaminants, and of subangular or rounder shape in accordance with ASTM F1632; mesh size as recommended by synthetic grass surfacing manufacturer.
- C. TPO Infill: Uniformly sized TPO granules free of contaminants; particle size as recommended by synthetic grass surfacing manufacturer.
- D. Organic Fiber Infill: Coconut or cork fiber granules free of contaminants, and as recommended by synthetic grass surfacing manufacturer.
- E. Seam Adhesive: One- or two-part urethane, recommended or approved by synthetic grass surfacing manufacturer, and suitable for ambient conditions at time of installation.
- F. Seam Tape: Synthetic grass manufacturer's recommended seam tape, minimum [12 inches (305 mm)][15 inches (381 mm)] wide, 18 inches (457 mm) wide for inlaid game lines.
- G. Seaming Cord: Seaming cord or thread, recommended by the synthetic grass surfacing manufacturer.
- H. Shock-Attenuation Pad: Porous composite consisting of rubber granules bound with urethane adhesive, [0.31 inch (8 mm)][0.39 inch (10 mm)][0.47 inch (12 mm)][0.59 inch (15 mm)]<Insert dimension> thick; [nondimpled][dimpled]; with drainage composite laminated to one side]. Provide shock-attenuation pad with permeability sufficient to meet synthetic grass surfacing assembly permeability indicated.
- I. Game Line Paint: Permanent paint as recommended or approved by synthetic grass surfacing manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine base and other conditions, with Installer present, for compliance with requirements for installation tolerances, permeability, and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF SYNTHETIC GRASS SURFACING

- A. Avoid disturbance of base during installation of [**shock-attenuation pad and**]turf fabric.
- B. Shock-Attenuation Pad Installation: Roll out pad and allow to relax a minimum of six hours prior to final fit and trim. Stagger head seams between adjacent rows. Fit seams snugly without stretching or forcing.
- C. Roll out turf fabric and allow to relax at least four hours prior to seaming.
- D. Provide seams flat and snug, with no gaps or fraying. Remove yarns that are trapped within seams. Attach turf fabric to perimeter restraint system as recommended by the manufacturer.
- E. Install inlaid game lines and markings by cutting through turf fabric and installing snugly fitting game line turf fabric. Provide seaming tape that extends minimum **6 inches (152 mm)** beyond seam.
- F. Repair loose seams and bubbles formed due to expansion of turf fabric prior to installation of infill.
- G. Evenly broadcast and groom infill by machine in proportions and depth after settling as recommended by the manufacturer, and to meet indicated performance requirements. Rake fibers trapped by infill to surface.
- H. Painted Game Lines: Apply lines and markings as recommended by the game line paint manufacturer.

3.3 FIELD QUALITY CONTROL

- A. Testing Agency: [**Owner will engage**][**Engage**] a qualified testing agency to perform tests and inspections.
- B. Perform the following tests and inspections:
 - 1. Permeability: **<Insert inches/h (mm/h)>** of rainfall capacity in accordance with ASTM F2898 or EN 15330-1.
 - 2. Shock Attenuation: No greater than **<Insert value>** G(max) at time of installation in accordance with ASTM F1936.

3.4 DEMONSTRATION

- A. Train Owner's maintenance personnel in proper maintenance procedures for synthetic grass surfacing.

END OF SECTION 32 18 23 13



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Task	Specification	Specification Description
32 18 23 13	32 92 00 00	Turf and Grasses
32 18 23 23	32 92 00 00	Turf and Grasses
32 31 11 00	32 31 13 00	Chain Link Fences And Gates



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SECTION 32 31 13 00 - CHAIN LINK FENCES AND GATES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Chain-link fence framework.
2. Chain-link fence fabric.
3. Chain-link fittings.
4. Chain-link wires and ties.
5. Chain-link swing gates.
6. Chain-link horizontal-slide gates.
7. Gate operators and controls.

B. Related Requirements:

1. Section 033000 "Cast-in-Place Concrete" for cast-in-place concrete for post footings[**and equipment bases/pads for gate operators and controls**].
2. Section 281500 "Integrated Access Control Hardware Devices" for gate controls.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at **[Project site]<Insert location>**.

1. Inspect and discuss **[electrical roughing-in,]** equipment bases, and other preparatory work specified elsewhere.
2. Review sequence of operation for each type of gate operator.
3. Review coordination of interlocked equipment specified in this Section and elsewhere.
4. Review required testing, inspecting, and certifying procedures.
5. **<Insert requirement>**.

1.3 ACTION SUBMITTALS

A. Product Data:

1. For each type of product.
 - a. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:
 - b. Fence **[and gate]** posts, rails, and fittings.
 - c. Chain-link fabric, reinforcements, **[gate types, hardware,]** and attachments.
 - d. Accessories: **[Privacy slats][Barbed wire][Barbed tape]<Insert item>**.
 - e. Gates and hardware.
 - f. Gate operators, including operating instructions and motor characteristics.

B. Shop Drawings: For each type of fence **[and gate]** assembly.

1. Include plans, elevations, sections, ground details, **[mounting,]** post spacing, and attachments to

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- other work.
 - 2. Include accessories, hardware, gate operation, and operational clearances.
 - 3. Gate Operator: Show locations and details for installing operator components, switches, and controls. Indicate motor size, electrical characteristics, drive arrangement, mounting, and grounding provisions.
 - 4. Wiring Diagrams: For power, signal, and control wiring.
- C. Samples for Initial Selection: For each type of factory-applied finish.
- D. Samples for Verification: For each type of component with factory-applied finish, prepared on Samples of size indicated below:
- 1. Polymer-Coated Components: In **6-inch (150-mm)** lengths for components and on full-sized units for accessories.
- E. Delegated Design Submittal: For structural performance of chain-link fence and gate frameworks, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For **[professional engineer][testing agency][factory-authorized service representative]**.
- B. Product Certificates: For each type of chain-link fence, **[operator,]** and gate.
- C. Product Test Reports: For framework strength in accordance with ASTM F1043, for tests performed by **[manufacturer and witnessed by a qualified testing agency][or][a qualified testing agency]**.
- D. Field quality-control reports.
- E. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For gate operators to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: For testing fence grounding; member company of NETA or an NRTL.
 - 1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.
- B. Emergency Access Requirements: In accordance with requirements of authorities having jurisdiction for gates with automatic gate operators serving as a required means of access.
- C. Mockups: Build mockups to set quality standards for fabrication and installation.
 - 1. Build mockup for typical chain-link fence **[and gate]**, including accessories.

- a. Size: [10 ft. (3 m)]<Insert dimension> length of fence.

1.7 FIELD CONDITIONS

- A. Field Measurements: Verify layout information for chain-link fences and gates shown on Drawings in relation to property survey and existing structures. Verify dimensions by field measurements.

1.8 WARRANTY

- A. Special Warranty: **[Manufacturer agrees][Installer agrees]** to repair or replace components of fences[, **gates, operators, and controls**] that fail in materials or workmanship within specified warranty period.
 1. Failures include, but are not limited to, the following:
 - a. Failure to comply with performance requirements.
 - b. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
 - c. Faulty operation of gate operators and controls.
 - d. **<Insert failure modes>**.
 2. Warranty Period: **[Five][15]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design chain-link fence and gate frameworks.
- B. Structural Performance: Chain-link fence and gate frameworks are to withstand the design wind loads and stresses for fence height(s) and under exposure conditions indicated in accordance with **[ASCE/SEI 7]<Insert requirement>**.
 1. Design Wind Load: **[As indicated on Drawings]<Insert loads>**.
 - a. Minimum Post Size: Determine in accordance with ASTM F1043 for post spacing not to exceed **[10 feet (3 m)]<Insert dimension>** for Material **[Group IA, ASTM F1043, Schedule 40 steel pipe][Group IC, electric-resistance-welded round steel pipe]<Insert material group>**.
 - b. Minimum Post Size and Maximum Spacing: Determine in accordance with CLFMI WLG 2445, based on mesh size and pattern specified.
- C. Lightning Protection System: Maximum resistance-to-ground value of 25 ohms at each grounding location along fence under normal dry conditions.
- D. Accessibility: Pedestrian gates to comply with the United States Access Board's ADA-ABA Accessibility Guidelines.

2.2 CHAIN-LINK FENCES, GENERAL

- A. CLFMI Publications: Comply with the CLFMI Product Manual unless modified by requirements in the

Contract Documents.

- B. Chain-Link Fence and Gate Assemblies: Include materials applicable for a complete assembly of application types, consisting of commercial, industrial, and security chain-link fences and gates.

1. Source Limitations: Obtain chain-link fence and gate components from single source or manufacturer.

2.3 CHAIN-LINK FENCE FRAMEWORK

- A. Posts and Rails **<Insert drawing designation>**: ASTM F1043 for framework, including rails, braces, and line; terminal; and corner posts. Provide members with minimum dimensions and wall thicknesses in accordance with ASTM F1043 **[or ASTM F1083]** based on the following:
1. Fence Height: **[72 inches (1830 mm)][96 inches (2440 mm)][As indicated on Drawings]<Insert dimension>**.
 2. Light-Industrial-Strength Material: **[Group IC-L, round steel pipe, electric-resistance-welded pipe][Group II-L, roll-formed-steel C-section shapes][Group III-L, hot-rolled H-beam shapes][Group IV, Alternative Design]**.
 - a. Line Post: **[1.9 inches (48 mm) in diameter][2.375 inches (60 mm) in diameter][2.875 inches (73 mm) in diameter][2.25 by 1.7 inches (57 by 43 mm)]<Insert dimension(s)>**.
 - b. End, Corner, and Pull Posts: **[2.375 inches (60 mm)][2.875 inches (73 mm)][4.0 inches (102 mm)][2.25 by 1.7 inches (57 by 43 mm)]<Insert dimension(s)>**.
 3. Heavy-Industrial-Strength Material: **[Group IA, round steel pipe, Schedule 40][Group IC, round steel pipe, electric-resistance-welded pipe][Group II, roll-formed-steel C-section shapes][Group III, hot-rolled H-beam shapes][Group IV, Alternative Design]**.
 - a. Line Post: **[1.9 inches (48 mm) in diameter][2.375 inches (60 mm) in diameter][2.875 inches (73 mm) in diameter][4.0 inches (102 mm) in diameter][6.625 inches (168 mm) in diameter][1.875 by 1.63 inches (48 by 41 mm)][2.25 by 1.70 inches (57 by 43 mm)][3.25 by 2.50 inches (83 by 64 mm)]<Insert dimension(s)>**.
 - b. End, Corner, and Pull Posts: **[2.375 inches (60 mm) in diameter][2.875 inches (73 mm) in diameter][4.0 inches (102 mm) in diameter][6.625 inches (168 mm) in diameter][2.25 by 1.70 inches (57 by 43 mm)][3.25 by 2.50 inches (83 by 64 mm)]<Insert dimension(s)>**.
 4. Horizontal Framework Members: **[Intermediate][top][and][bottom]** rails in accordance with ASTM F1043.
 - a. Top Rail: **[1.66 inches (42 mm) in diameter][1.25 by 1.63 inches (32 by 41 mm)]<Insert dimension(s)>**.
 5. Brace Rails: ASTM F1043.
 6. Metallic Coating for Steel Framework:
 - a. Type A: Not less than minimum **2.0 oz./sq. ft. (0.61 kg/sq. m)** average zinc coating in accordance with ASTM A123/A123M or **4.0 oz./sq. ft. (1.22 kg/sq. m)** zinc coating in accordance with ASTM A653/A653M.
 - b. Type B: Zinc with organic overcoat, consisting of a minimum of **0.9 oz./sq. ft. (0.27 kg/sq. m)** of zinc after welding, a chromate conversion coating, and a clear, verifiable

- polymer film.
 - c. External, Type B: Zinc with organic overcoat, consisting of a minimum of **0.9 oz./sq. ft. (0.27 kg/sq. m)** of zinc after welding, a chromate conversion coating, and a clear, verifiable polymer film. Internal, Type D, consisting of 81 percent, not less than **0.3-mil- (0.0076-mm-)** thick, zinc-pigmented coating.
 - d. Type C: Zn-5-Al-MM alloy, consisting of not less than **1.8 oz./sq. ft. (0.55 kg/sq. m)** coating.
 - e. Coatings: Any coating above.
 - 7. Polymer coating over metallic coating.
 - a. Color: **[Match chain-link fabric][Dark green][Olive green][Brown][Black][As selected by Architect from manufacturer's full range]**, in accordance with ASTM F934.

2.4 CHAIN-LINK FENCE FABRIC

- A. General: Provide fabric in one-piece heights measured between top and bottom of outer edge of selvage knuckle or twist in accordance with "CLFMI Product Manual" and requirements indicated below:
 - 1. Fabric Height: **<Insert dimension>[As indicated on Drawings]**.
 - 2. Steel Wire for Fabric: Wire diameter of **[0.192 inch (4.88 mm)][0.148 inch (3.76 mm)][0.120 inch (3.05 mm)][0.113 inch (2.87 mm)]<Insert dimension>**.
 - a. Mesh Size: **[2-1/8 inches (54 mm)][2 inches (50 mm)][1-3/4 inches (44 mm)][1 inch (25 mm)]<Insert dimension>**.
 - b. Aluminum-Coated Fabric: ASTM A491, Type I, **[0.40 oz./sq. ft. (122 g/sq. m)][0.35 oz./sq. ft. (107 g/sq. m)][0.30 oz./sq. ft. (92 g/sq. m)]**.
 - c. Zinc-Coated Fabric: ASTM A392, Type II, **[Class 1, 1.2 oz./sq. ft. (366 g/sq. m)][Class 2, 2.0 oz./sq. ft. (610 g/sq. m)]** with zinc coating applied **[before][after]** weaving.
 - d. Zn-5-Al-MM Aluminum-Mischmetal-Coated Fabric: ASTM F1345, Type III, **[Class 1, 0.60 oz./sq. ft. (183 g/sq. m)][Class 2, 1.0 oz./sq. ft. (305 g/sq. m)]**.
 - e. Polymer-Coated Fabric: ASTM F668, **[Class 1][Class 2a][Class 2b]** over **[aluminum][zinc][Zn-5-Al-MM-alloy]**-coated steel wire.
 - 1) Color: **[Dark green][Olive green][Brown][Black][As selected by Architect from manufacturer's full range]**, in accordance with ASTM F934.
 - f. Coat selvage ends of metallic-coated fabric before the weaving process with manufacturer's standard clear protective coating.
 - 3. Aluminum Wire Fabric: ASTM F1183, with **[mill][caustic-cleaned or etched]** finish, and wire diameter of **[0.148 inch (3.76 mm)][0.192 inch (4.88 mm)]**.
 - a. Mesh Size: **[2 inches (50 mm)][1 inch (25 mm)]**.
 - 4. Selvage: **[Knuckled at both selvages][Twisted top and knuckled bottom]**.

2.5 CHAIN-LINK FITTINGS

- A. Provide fittings in accordance with ASTM F626.
- B. Post Caps: Provide for each post.

1. Provide line post caps with loop to receive tension wire or top rail.
- C. Rail and Brace Ends: For each gate, corner, pull, and end post.
- D. Rail Fittings: Provide the following:
1. Top Rail Sleeves: **[Pressed-steel or round-steel tubing][Aluminum Alloy 6063]** not less than **6 inches (152 mm)** long.
 2. Rail Clamps: Line and corner boulevard clamps for connecting **[intermediate][and][bottom]** rails to posts.
- E. Tension and Brace Bands: **[Pressed steel][Aluminum Alloy 6063]**.
- F. Tension Bars: **[Steel][Aluminum][Fiberglass]**, length not less than **2 inches (50 mm)** shorter than full height of chain-link fabric. Provide one bar for each gate and end post, and two for each corner and pull post, unless fabric is integrally woven into post.
- G. Truss Rod Assemblies: **[Steel, hot-dip galvanized after threading][Mill-finished aluminum]** rod and turnbuckle or other means of adjustment.
- H. Barbed Wire Arms: **[Pressed steel or cast iron][Aluminum]**, with clips, slots, or other means for attaching strands of barbed wire[, **and means for attaching to posts**][, **integral with post cap**], for each post unless otherwise indicated, and as follows:
1. Provide line posts with arms that accommodate top rail or tension wire.
 2. Provide corner arms at fence corner posts unless extended posts are indicated.
 3. Single-Arm Type: **[Type I, slanted arm][Type II, vertical arm]**.
 4. Double-Arm Type: **[Type III, V-shaped arm][Type IV, A-shaped arm]**.
- I. Tie Wires, Clips, and Fasteners: In accordance with ASTM F626.
1. Standard Round Wire Ties: For attaching chain-link fabric to posts, rails, and frames, in accordance with the following:
 - a. Hot-Dip Galvanized Steel: **[0.106-inch- (2.69-mm-)][0.148-inch- (3.76-mm-)]** diameter wire[; **galvanized coating thickness matching coating thickness of chain-link fence fabric**].
 - b. Aluminum: ASTM B211/B211M; Alloy 1350-H19; **[0.148-inch- (3.76-mm-)][0.192-inch- (4.88-mm-)]** diameter, mill-finished wire.
- J. Finish:
1. Metallic Coating for Pressed Steel or Cast Iron: Not less than **1.2 oz./sq. ft. (366 g/sq. m)** of zinc.
 - a. Polymer coating over metallic coating.
 2. Aluminum: Mill finish.
- 2.6 CHAIN-LINK WIRE AND TIES
- A. Metallic-Coated Steel Wire: **0.177-inch- (4.5-mm-)** diameter, marcelled tension wire in accordance with ASTM A817 or ASTM A824, with the following metallic coating:

1. Type I: Aluminum coated (aluminized).
 2. Type II: Zinc coated (galvanized) by **[hot-dip][electrolytic]** process, with the following minimum coating weight:
 - a. Class 3: Not less than **0.8 oz./sq. ft. (244 g/sq. m)** of uncoated wire surface.
 - b. Class 4: Not less than **1.2 oz./sq. ft. (366 g/sq. m)** of uncoated wire surface.
 - c. Class 5: Not less than **2 oz./sq. ft. (610 g/sq. m)** of uncoated wire surface.
 - d. Matching chain-link fabric coating weight.
 3. Type III: Zn-5-Al-MM alloy with the following minimum coating weight:
 - a. Class 60: Not less than **0.6 oz./sq. ft. (183 g/sq. m)** of uncoated wire surface.
 - b. Class 100: Not less than **1 oz./sq. ft. (305 g/sq. m)** of uncoated wire surface.
 - c. Matching chain-link fabric coating weight.
- B. Polymer-Coated Steel Wire: **[0.177-inch- (4.5-mm-)][0.148-inch- (3.8-mm-)]** diameter, tension wire in accordance with ASTM F1664, **[Class 1][Class 2a][Class 2b]** over **[aluminum][zinc][Zn-5-Al-MM-alloy]**-coated steel wire.
1. Color: **[Match chain-link fabric][Dark green][Olive green][Brown][Black][As selected by Architect from manufacturer's full range]**, in accordance with ASTM F934.
- C. Aluminum Wire: **0.192-inch- (4.88-mm-)** diameter tension wire, mill finished, in accordance with **ASTM B211 (ASTM B211M)**, Alloy 6061-T94 with **50,000-psi (344-MPa)** minimum tensile strength.

2.7 CHAIN-LINK SWING GATES

- A. General: ASTM F900 for gate posts and **[single][double]** swing gate types. **[Provide automated vehicular gates in accordance with ASTM F2200.]**
1. Gate Leaf Width: **[36 inches (914 mm)][As indicated]<Insert width>**.
 2. Framework Member Sizes and Strength: Based on gate fabric height **[of 72 inches (1830 mm) or less][of more than 72 inches (1830 mm)][as indicated]<Insert dimension>**.
- B. Swing Gate Pipe and Tubing:
1. Swing Gate Posts: **[Round tubular steel][Rectangular tubular steel][Round tubular aluminum][Rectangular tubular aluminum]**.
 2. Gate Frames and Bracing: **[Round tubular steel][Rectangular tubular steel][Round tubular aluminum][Rectangular tubular aluminum]**.
 3. Zinc-Coated Steel: ASTM F1043 and ASTM F1083; **[protective coating and finish to match fence framework][manufacturer's standard protective coating and finish]<Insert finish>**.
 4. Aluminum: ASTM B429/B429M; **[mill][manufacturer's standard]<Insert finish>** finish.
- C. Swing Frame Corner Construction: **[Welded][or][assembled with corner fittings]**.
- D. Swing Gate Extended Posts and Frame Members: Fabricate gate posts and frame end members to extend **[12 inches (300 mm)][as indicated]<Insert dimension>** above top of chain-link fabric at both ends of gate frame to attach barbed **[wire][tape]** assemblies.
- E. Swing Gate Hardware:
1. Hinges: **[180-degree inward][180-degree outward][360-degree inward and outward]** swing.
 2. Latch: Permitting operation from both sides of gate **[with provision for padlocking accessible from both sides of gate]**.

3. Lock: **[Manufacturer's standard]<Insert requirement>** internal device.
4. Padlock and Chain: **<Insert requirements>**.
5. Closer: **[Manufacturer's standard]<Insert requirement>**.
6. **<Insert hardware items and accessories>**.

2.8 CHAIN-LINK HORIZONTAL-SLIDE GATES

- A. Chain-Link Horizontal-Slide Gates: ASTM F1184 for gate posts and **[single][double]** sliding gate types for **[pedestrian][and][vehicle]** assembly. **[Provide automated vehicular gates in accordance with ASTM F2200.]**
 1. Classification:
 - a. Type I Overhead Slide:
 - 1) Gate Leaf Width: **[As indicated]<Insert width>**.
 - 2) Framework Member Sizes and Strength: Based on gate fabric height **[of 72 inches (1830 mm) or less][of more than 72 inches (1830 mm)][as indicated]<Insert dimension>**.
 - b. Type II Cantilever Slide, **[Class 1 with external][Class 2 with internal]** roller assemblies:
 - 1) Slide Gate Frame Width and Height: **[48 inches (1220 mm) wide or less by 72 inches (1830 mm) high or less][More than 48 inches (1220 mm) wide by any height][As indicated]<Insert dimension>**.
- B. Slide Gate Pipe and Tubing Finish:
 1. Zinc-Coated Steel: **[Protective coating and finish to match fence framework][Manufacturer's standard protective coating and finish]<Insert finish>**.
 2. Aluminum: ASTM B429/B429M; **[mill][manufacturer's standard]<Insert finish>** finish.
 3. Sliding Gate Posts: ASTM F1184. Provide **[round tubular steel][rectangular tubular steel][round tubular aluminum][rectangular tubular aluminum]** posts.
 4. Sliding Gate Frames and Bracing: **[Round tubular steel][Rectangular tubular steel][Round tubular aluminum][Rectangular tubular aluminum]**.
- C. Slide Gate Frame Corner Construction: **[Welded][or][assembled with corner fittings]**.
- D. Slide Extended Gate Posts and Frame Members: Extend gate posts and frame end members above top of chain-link fabric at both ends of gate frame **[12 inches (300 mm)][as indicated]<Insert dimension>** as required to attach barbed **[wire][tape]** assemblies.
- E. Overhead Track Assembly: Manufacturer's standard track, with overhead framework supports, bracing, and accessories, engineered to support size, weight, width, operation, and design of gate and roller assemblies.
- F. Slide Gate Hardware:
 1. Hangers, Roller Assemblies, and Stops: Fabricated from **[galvanized steel][galvanized malleable iron][mill-finished Grade 319 aluminum-alloy casting with stainless steel fasteners]**.
 2. Latch: Permitting operation from both sides of gate **[with provision for padlocking accessible from both sides of gate]**.
 3. Lock: **[Manufacturer's standard]<Insert requirement>** internal device.

4. Padlock and Chain: <Insert requirements>.
5. <Insert hardware items and accessories>.

2.9 ACCESSORIES

A. Privacy Slats:

1. Fiber-Glass-Reinforced Plastic Slats: UV-light-stabilized fiber-glass-reinforced plastic, not less than **0.06 inch (1.5 mm)** thick, sized to fit mesh specified for direction indicated[, **with vandal-resistant fasteners and lock strips**].
2. Tubular Polyethylene Slats: Minimum **0.023-inch (0.58-mm)**-thick tubular polyethylene, manufactured for chain-link fences from virgin polyethylene with UV inhibitor, sized to fit mesh specified for direction indicated, with [**vandal-resistant fasteners and lock strips**][**fins for increased privacy factor**].
3. Aluminum Slats: Minimum **0.01-inch (0.25-mm)**-thick aluminum, sized to fit mesh specified for direction indicated.
4. Redwood Slats: **5/16-inch (7.9-mm)**-thick redwood, sized to fit mesh specified for direction indicated.
5. Hedge-Type Slats: UV-light-stabilized[, **flame-resistant**], PVC "needles" woven into braided, galvanized wire core, sized to fit mesh specified for direction indicated.
6. Color: [**As indicated by manufacturer's designations**][**Match Architect's samples**][**As selected by Architect from manufacturer's full range**][**As indicated on Drawings**]<Insert color>.

B. Barbed Wire:

1. Steel Barbed Wire: ASTM A121, two-strand barbed wire, **0.099-inch- (2.51-mm-)** diameter line wire with **0.080-inch- (2.03-mm-)** diameter, four-point round barbs spaced not more than **5 inches (127 mm)** o.c.
 - a. Aluminum Coating: Type A.
 - b. Zinc Coating: Type Z, Class 3.
2. Polymer-Coated, Galvanized-Steel Barbed Wire: ASTM F1665, two-strand barbed wire, **0.080-inch- (2.03-mm-)** diameter line wire with **0.080-inch- (2.03-mm-)** diameter, four-point, round [**aluminum alloy**][**galvanized-steel**] barbs spaced not more than **5 inches (127 mm)** o.c.
 - a. Polymer Coating: [**Class 1**][**Class 2a**][**Class 2b**] over [**aluminum**][**zinc**][**Zn-5-Al-MM-alloy**]-coated steel wire.
 - 1) Color: [**Match chain-link fabric**][**Dark green**][**Olive green**][**Brown**][**Black**][**As selected by Architect from manufacturer's full range**] in accordance with ASTM F934.
3. Barbed Tape:
 - a. Wire-Reinforced Tape: ASTM F1910; continuous coils with four-point, needle-sharp barbs permanently cold clenched around a core wire.
 - b. Core Wire: High-tensile-strength, [**zinc-coated steel**][**or**][**stainless steel**].
 - c. Configuration: [**Single**][**Double**] coil.
 - d. Style: [**Helical**][**Concertina**] pattern.
 - e. Coil Diameter(s): [**18-inch (457-mm)**][**24 inches (610 mm)**][**24-inch (610-mm) inner coil and 30-inch (762-mm) outer coil**][**As indicated on Drawings**]<Insert diameter>.
 - f. Coil Loop Spacing(s): [**12 inches (300 mm)**][**Manufacturer's standard**][**As indicated on Drawings**]<Insert spacing>.

- g. Barb Length Classification: **[Long, 1.2-inch (30.5-mm)]****[Medium, 0.4-inch (10.2-mm)]****[Short, 0.1875-inch (4.76-mm)]** barb.
 - h. Barb Spacing: **[4 inches (102 mm)]****<Insert dimension>** o.c.
 - i. Barb Set: **[Straight]****[Offset]****[Manufacturer's standard]**.
- 4. Clips: Stainless steel, **0.065 inch (1.7 mm)** thick by **0.375 inch (9.5 mm)** wide, capable of withstanding a minimum **150-lbf (667-N)** pull load to limit extension of coil, resulting in a concertina pattern when deployed.
 - 5. Tie Wires: Stainless steel, **0.065 inch (1.7 mm)** in diameter.
- C. Touch-up Paint: Liquid polymer for field coating with polymer coated fencing components as recommended by manufacturer.

2.10 GATE OPERATORS AND CONTROLS

- A. Provide factory-assembled automatic operating system designed for **[pedestrian]****[and]****[vehicle]** gate size, type, weight, and operation frequency. Provide operation control system with characteristics suitable for Project conditions, with **[remote-control stations]**, safety devices, and weatherproof enclosures; coordinate electrical requirements with building electrical system.
- 1. Provide operator designed so motor may be removed without disturbing limit-switch adjustment and without affecting auxiliary emergency operator.
 - 2. Provide **[UL 325 listed operators for swing gates]****[BHMA A156.19 listed operators for pedestrian gates]****[ASTM F2200 for automated vehicular gates]**.
- B. Comply with NFPA 70.
- C. Emergency Access Requirements: Comply with requirements of authorities having jurisdiction for automatic gate operators on gates that must provide emergency access.
- D. Motor Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, within installed environment, with indicated operating sequence, and without exceeding nameplate rating or considering service factor. Comply with NEMA MG 1 and the following:
- 1. Voltage: **[110 V]****[220 V]****[24 V dc]****[NEMA standard voltage selected to operate on nominal circuit voltage to which motor is connected]****<Insert voltage>**.
 - 2. Phase: **[One]****[Polyphase]**.
 - 3. Enclosure: **[Open dripproof]****[Totally enclosed]****[Manufacturer's standard]**.
 - 4. Duty: Continuous duty at ambient temperature of **105 deg F (40 deg C)** and at altitude of **3300 ft. (1005 m)** above sea level.
 - 5. Service Factor: 1.15 for open dripproof motors; 1.0 for totally enclosed motors.
- E. Gate Operators: **[Gate]****[Concrete base]****[Post]****[In-ground]** mounted and as follows:
- 1. Hydraulic Gate Operators: **[Swing]****[Slide]**.
 - a. Duty: **[Light]****[Medium]****[Heavy]** duty, **[residential]****[commercial/industrial]**.
 - b. Gate Speed: Minimum **[45 feet (13.7 m)]****[60 feet (18.2 m)]** per minute.
 - c. Maximum Gate Weight: **[800 lb (363 kg)]****<Insert value>**.
 - d. Frequency of Use: **[10 cycles per hour]****[25 cycles per hour]****[Continuous duty]**.
 - e. Hydraulic Fluid: Viscosity required for gate operation at ambient temperature range for Project.
 - f. Locking: Hydraulic in both directions.

2. Mechanical Gate Operators: **[Swing][Slide]**.
 - a. Duty: **[Light][Medium][Heavy]** duty, **[residential][commercial/industrial]**.
 - b. Gate Speed: Minimum **[45 feet (13.7 m) per minute][60 feet (18.2 m) per minute][variable speed]<Insert speed>**.
 - c. Maximum Gate Weight: **[600 lb (272 kg)][800 lb (363 kg)][3000 lb (1360 kg)]<Insert value>**.
 - d. Frequency of Use: **[10 cycles per hour][25 cycles per hour][60 cycles per hour][Continuous duty]**.
 - e. Operating Type: **[Crank arm][Wheel-and-rail drive][Roller chain]**.
 - f. **<Insert feature>**.

- F. Activation Controls: Electric controls separated from gate and motor and drive mechanism, with **[NEMA ICS 6, Type 1][NEMA ICS 6, Type 4]<Insert type of enclosure>** enclosure for **[surface][recessed or flush][concrete base][pedestal]<Insert mounting>** mounting, and with space for additional optional equipment. Provide the following remote-control device(s):
 1. Control Station:
 - a. Keyed, **[two][three]**-position switch with open[, **stop**,] and close function; located remotely from gate. Provide two keys per station.
 - b. Momentary-contact, **[single][three]**-button-operated with open[, **stop**,] and close function; located remotely from gate. **[Key switch to lock out open and close buttons.]**
 - c. **<Insert other type>**.

 2. Card Reader: Functions only when authorized card is presented. Programmable, **[multiple][single]**-code system[, **permitting four different access periods**]; **face-lighted unit fully visible at night**.
 - a. Reader Type: **[Touch plate][Swipe][Insertion][Proximity]**.
 - b. Card Reader Features:
 - 1) Usage Features: **[Timed antipassback][Limited-time usage][Capable of monitoring and auditing gate activity]**.

 3. **<Insert other reader type and features>**.
 4. Digital Keypad Entry Unit: **[Programmable]**, multiple-code capability of not less than **[five][500][2500]<Insert number>** possible individual codes, consisting of **[1- to 7][4][5]**-digit codes[, **and permitting four different access periods**].
 5. Face-lighted unit with **[metal-keyed][keyless-membrane]** keypad fully visible at night.
 6. Radio Control: Digital system consisting of code-compatible universal receiver for each gate, located where indicated, with remote antenna with coaxial cable and mounting brackets designed to operate gates. Provide **[one][two]<Insert number>** programmable transmitter(s) with multiple-code capability permitting validating or voiding of not less than **[1000][10,000]<Insert number>** codes per channel configured for the following functions:
 - a. Transmitters: **[Single][Three]**-button operated, with open **[and close]** function.
 - b. Channel Settings: **[Two][Three][Four]<Insert number>** independent channel settings controlling separate receivers for operating more than one gate from each transmitter.

 7. Telephone Entry System: Hands-free, voice-communication system for connection to building telephone system with digital-entry code activation of gate operator **[and auxiliary keypad entry]**.
 - a. Residential System: Designed to be wired to same line with telephone.
 - b. Multiunit System: Designed to be wired to a dedicated telephone line, with capacity to

- access [20][100]<Insert number> telephones[, and with electronic directory].
- c. <Insert other system type and features>.
 - d. Intercom System: <Insert requirements>.
- G. Vehicle Sensing System: System includes automatic closing timer with adjustable time delay[, **timer cutoff switch**,] and loop detector designed to [open and close gate][hold gate open until traffic clears][reverse gate]<Insert functions>. System includes electronic detector with adjustable detection patterns, adjustable sensitivity and frequency settings, and panel indicator light designed to detect presence or transit of a vehicle over an embedded loop of wire and to emit a signal activating the gate operator. System includes number of loops consisting of multiple strands of wire, number of turns, loop size, and method of placement, as recommended in writing by detection system manufacturer for function indicated, at location indicated on Drawings.
- H. Obstruction Detection Devices: Provide each motorized gate with automatic safety sensor(s). Activation of sensor(s) causes operator to immediately function as follows:
1. Action: [**Reverse gate in both opening and closing cycles and hold until clear of obstruction**][Stop gate in opening cycle and reverse gate in closing cycle and hold until clear of obstruction].
 2. Internal Sensor: Built-in torque or current monitor senses gate is obstructed.
 3. Sensor Edge: Contact-pressure-sensitive safety edge, profile, and sensitivity designed for type of gate and component indicated, in locations as recommended by manufacturer.
 4. Photoelectric/Infrared Sensor System: Designed to detect an obstruction in gate's path when infrared beam in the zone pattern is interrupted.
- I. Emergency Release Mechanism: Quick-disconnect release of operator drive system of the following type, permitting manual operation if operator fails. Design system so control-circuit power is disconnected during manual operation.
1. Type: [**Integral fail-safe release, allowing gate to be pushed open without mechanical devices, keys, cranks, or special knowledge**][Mechanical device, key, or crank-activated release].
- J. Operating Features:
1. Digital Microprocessor Control: Electronic programmable means for setting, changing, and adjusting control features[**with capability for monitoring and auditing gate activity**]. Provide unit that is isolated from voltage spikes and surges.
 2. System Integration: With controlling circuit board capable of accepting any type of input from external devices.
 3. Master/Slave Capability: Control stations designed and wired for gate pair operation.
 4. Automatic Closing Timer: With adjustable time delay before closing[**and timer cutoff switch**].
 5. Open Override Circuit: Designed to override closing commands.
 6. Reversal Time Delay: Designed to protect gate system from shock load on reversal in both directions.
 7. Maximum Run Timer: Designed to prevent damage to gate system by shutting down system if normal time to open gate is exceeded.
 8. Clock Timer: [24-hour][Seven-day]<Insert time> programmable for regular events.
- K. Accessories:
1. Warning Module: [**Audio**][Visual], [constant][strobe]-light alarm sounding three to five seconds in advance of gate operation and continuing until gate stops moving; compliant with the United States Access Board's ADA-ABA Accessibility Guidelines.
 2. Battery Backup System: Battery-powered drive and access-control system, independent of

primary drive system.

- a. Fail-Safe: Gate opens and remains open until power is restored.
 - b. Fail-Secure: Gate cycles on battery power, then fail-safe when battery is drained.
3. External electric-powered **[solenoid][magnetic]** lock with delay timer allowing time for lock to release before gate operates.
 4. **[Fire][Postal]** box.
 5. Fire **[strobe][siren]** sensor.
 6. Instructional, Safety, and Warning Labels and Signs: **[In accordance with UL 325][Manufacturer's standard for components and features specified][As indicated on Drawings]<Insert requirements>**.
 7. Equipment Bases/Pads: Precast concrete, **[depth not less than 12 inches (305 mm)]<Insert depth>**, dimensioned and reinforced in accordance with gate operator component manufacturer's written instructions and as indicated on Drawings.

2.11 GROUT AND ANCHORING CEMENT

- A. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C1107/C1107M. Provide grout, recommended in writing by manufacturer, for exterior applications.
- B. Anchoring Cement: Factory-packaged, nonshrink, nonstaining, hydraulic-controlled expansion cement formulation for mixing with water at Project site to create pourable anchoring, patching, and grouting compound. Provide formulation that is resistant to erosion from water exposure without needing protection by a sealer or waterproof coating, and that is recommended in writing by manufacturer for exterior applications.

2.12 CONCRETE

- A. Concrete Post Footings: Minimum 28-day compressive strength of **2500 psi (17.2 MPa)**.

2.13 GROUNDING MATERIALS

- A. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Connectors and Grounding Rods: Listed and labeled for complying with UL 467.
 1. Connectors for Below-Grade Use: Exothermic welded type.
 2. Grounding Rods: Copper-clad steel, **5/8 by 96 inches (16 by 2440 mm)**.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for **a certified survey of property lines and legal boundaries,** site clearing, earthwork, pavement work, and other conditions affecting performance of the Work.
 1. Do not begin installation before final grading is completed unless otherwise permitted by

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Architect.

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

3.2 PREPARATION

- A. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of **500 feet (152 m)** or line of sight between stakes. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.

3.3 INSTALLATION OF CHAIN-LINK FENCES

- A. Install chain-link fencing in accordance with ASTM F567 and more stringent requirements specified.
 - 1. Install fencing on established boundary lines inside property line.
- B. Post Excavation: Drill or hand-excavate holes for posts to diameters and spacings indicated, in firm, undisturbed soil.
- C. Post Setting: Set posts **[in concrete][with mechanical anchors][by mechanically driving into soil]** at indicated spacing into firm, undisturbed soil.
 - 1. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during setting with concrete or mechanical devices.
 - 2. Concrete Fill: Place concrete around posts to dimensions indicated and vibrate or tamp for consolidation. Protect aboveground portion of posts from concrete splatter.
 - a. Exposed Concrete: Extend **2 inches (50 mm)** above grade; shape and smooth to shed water.
 - b. Concealed Concrete: Place top of concrete **[2 inches (50 mm)]<Insert dimension>** below grade **[as indicated on Drawings]** to allow covering with surface material.
 - c. Posts Set into Sleeves in Concrete: Use steel pipe sleeves preset and anchored into concrete for installing posts. After posts are inserted into sleeves, fill annular space between post and sleeve with **[nonshrink, nonmetallic grout][or][anchoring cement]**, mixed and placed in accordance with anchoring material manufacturer's written instructions. Finish anchorage joint to slope away from post to drain water.
 - d. Posts Set into Holes in Concrete: Form or core drill holes not less than **5 inches (127 mm)** deep and **3/4 inch (20 mm)** larger than OD of post. Clean holes of loose material, insert posts, and fill annular space between post and concrete with **[nonshrink, nonmetallic grout][or][anchoring cement]**, mixed and placed in accordance with anchoring material manufacturer's written instructions. Finish anchorage joint to slope away from post to drain water.
 - 3. Mechanically Driven Posts: Drive into soil to depth of **[30 inches (762 mm)][36 inches (914 mm)]<Insert dimension>**. Protect post top to prevent distortion.
- D. Terminal Posts: Install terminal end, corner, and gate posts in accordance with ASTM F567 and terminal pull posts at changes in horizontal or vertical alignment of **[15 degrees or more][30 degrees or more][as indicated on Drawings]<Insert requirement>**. For runs exceeding **500 feet (152 m)**, space pull posts an equal distance between corner or end posts.
- E. Line Posts: Space line posts uniformly at **[96 inches (2440 mm)][10 feet (3 m)]<Insert dimension>** o.c.

- F. Post Bracing and Intermediate Rails: Install in accordance with ASTM F567, maintaining plumb position and alignment of fence posts. Diagonally brace terminal posts to adjacent line posts with truss rods and turnbuckles. Install braces at end and gate posts and at both sides of corner and pull posts.
1. Locate horizontal braces at midheight of fabric **72 inches (1830 mm)** or higher, on fences with top rail, and at two-third fabric height on fences without top rail. Install so posts are plumb when diagonal rod is under proper tension.
- G. Tension Wire: Install in accordance with ASTM F567, maintaining plumb position and alignment of fence posts. Pull wire taut, without sags. Fasten fabric to tension wire with **0.120-inch- (3.05-mm-)** diameter hog rings of same material and finish as fabric wire, spaced a maximum of **24 inches (610 mm)** o.c. Install tension wire in locations indicated before stretching fabric. Provide horizontal tension wire at the following locations:
1. Extended along **[top][and][bottom]** of fence fabric. Install top tension wire through post cap loops. Install bottom tension wire within **6 inches (152 mm)** of bottom of fabric and tie to each post with not less than same diameter and type of wire.
 2. Extended along top of **[barbed wire arms][extended posts]** and top of fence fabric to support barbed tape.
 3. **[As indicated on Drawings]<Insert requirements>**.
- H. Top Rail: Install in accordance with ASTM F567, maintaining plumb position and alignment of fence posts. Run rail continuously through line post caps, bending to radius for curved runs and terminating into rail end attached to posts or post caps fabricated to receive rail at terminal posts. Provide expansion couplings as recommended in writing by fencing manufacturer.
- I. Intermediate and Bottom Rails: Secure to posts with fittings.
- J. Chain-Link Fabric: Apply fabric to **[outside][inside]** of enclosing framework. Leave **[1-inch (25-mm)][2-inch (50-mm)]** bottom clearance between finish grade or surface and bottom selvage unless otherwise indicated. Pull fabric taut and tie to posts, rails, and tension wires. Anchor to framework so fabric remains under tension after pulling force is released.
- K. Tension or Stretcher Bars: Thread through fabric and secure to end, corner, pull, and gate posts, with tension bands spaced not more than **15 inches (380 mm)** o.c.
- L. Tie Wires: Use wire of proper length to firmly secure fabric to line posts and rails. Attach wire at one end to chain-link fabric, wrap wire around post a minimum of 180 degrees, and attach other end to chain-link fabric in accordance with ASTM F626. Bend ends of wire to minimize hazard to individuals and clothing.
1. Maximum Spacing: Tie fabric to line posts at **12 inches (300 mm)** o.c. and to braces at **24 inches (610 mm)** o.c.
- M. Fasteners: Install nuts for tension bands and carriage bolts on the side of fence opposite the fabric side. **[Peen ends of bolts or score threads to prevent removal of nuts.]**
- N. Privacy Slats: Install slats in direction indicated, securely locked in place.
1. **[Vertically][Horizontally], for privacy factor of 70 to 75]<Insert privacy factor range>**.
 2. Diagonally **[for privacy factor of 80 to 85]<Insert privacy factor range>**.
 3. Direction **[and privacy factor]** as indicated on Drawings.
- O. Barbed Wire: Install barbed wire uniformly spaced **[, angled toward security side of fence][as indicated on Drawings]**. Pull wire taut, install securely to extension arms, and secure to end post or terminal arms.

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- P. Barbed Tape: Install in accordance with ASTM F1911. Install barbed tape uniformly in configurations indicated and fasten securely to prevent movement or displacement.

3.4 INSTALLATION OF GATES

- A. Install gates in accordance with manufacturer's written instructions, level, plumb, and secure for full opening without interference. Attach fabric as for fencing. Attach hardware using tamper-resistant or concealed means. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation.

3.5 INSTALLATION OF GATE OPERATORS

- A. Install gate operators in accordance with manufacturer's written instructions, aligned and true to fence line and grade.
- B. Excavation: Hand-excavate holes for posts, pedestals, and equipment bases/pads, in firm, undisturbed soil to dimensions and depths and at locations in accordance with gate-operator component manufacturer's written instructions and as indicated.
- C. Vehicle Loop Detector System: **[Cut grooves in pavement, bury, and seal][Bury]** wire loop in accordance with manufacturer's written instructions. Connect to equipment operated by detector.
- D. Ground electric-powered motors, controls, and other devices in accordance with NFPA 70 and manufacturer's written instructions.

3.6 GROUNDING AND BONDING

- A. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Fence and Gate Grounding:
 - 1. Ground for fence and fence posts is to be a separate system from ground for gate and gate posts.
 - 2. Install ground rods and connections at maximum intervals of **[1500 feet (450 m)]<Insert dimension>**.
 - 3. Fences within 100 ft. (30 m) of Buildings, Structures, Walkways, and Roadways: Ground at maximum intervals of **[750 ft. (225 m)]<Insert dimension>**.
 - 4. Ground fence on each side of gates and other fence openings.
 - a. Bond metal gates to gate posts.
 - b. Bond across openings, with and without gates, except openings indicated as intentional fence discontinuities. Use No. 2 AWG wire and bury it at least **18 inches (457 mm)** below finished grade.
- C. Protection at Crossings of Overhead Electrical Power Lines: Ground fence at location of crossing and at a ground rod located a maximum distance of **150 feet (45 m)** on each side of crossing.
- D. Fences Enclosing Electrical Power Distribution Equipment: Ground in accordance with IEEE C2 unless otherwise indicated.
- E. Grounding Method: At each grounding location, drive a grounding rod vertically until the top is **6 inches**

(152 mm) below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at grounding location.

1. Make grounding connections to each barbed wire strand with wire-to-wire connectors designed for this purpose.
2. Make grounding connections to each barbed tape coil with connectors designed for this purpose.

F. Connections:

1. Make connections with clean, bare metal at points of contact.
2. Make aluminum-to-steel connections with stainless steel separators and mechanical clamps.
3. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
4. Make above-grade ground connections with mechanical fasteners.
5. Make below-grade ground connections with exothermic welds.
6. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

G. Bonding to Lightning Protection System: Ground fence and bond fence grounding conductor to lightning protection down conductor or lightning protection grounding conductor in accordance with NFPA 780.

H. Comply with requirements in Section 264113 "Lightning Protection for Structures."

3.7 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests.
- B. Grounding Tests: Comply with requirements in Section 264113 "Lightning Protection for Structures."
- C. Prepare test reports.

3.8 ADJUSTING

- A. Gates: Adjust gates to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.
- B. Automatic Gate Operator: Energize circuits to electrical equipment and devices, start units, and verify proper motor rotation and unit operation.
 1. Hydraulic Operator: Purge operating system, adjust pressure and fluid levels, and check for leaks.
 2. Test and adjust operators, controls[, **alarms,**] and safety devices. Replace damaged and malfunctioning controls and equipment.
 3. Lubricate operator and related components.
- C. Lubricate hardware and other moving parts.

3.9 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain chain-link fences and gates.



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END OF SECTION 32 31 13 00

SECTION 32 31 13 13 - HIGH-SECURITY CHAIN LINK FENCES AND GATES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section Includes:

1. High-security chain-link fences.
2. Swing gates.
3. Horizontal-slide gates.
4. Soil sterilization.

B. Related Requirements:

1. Section 013513.16 "Special Project Procedures for Detention Facilities" for general requirements of detention work, including responsibilities of a single-source detention specialist.
2. **[Section 033000 "Cast-in-Place Concrete"]****[Section 033053 "Miscellaneous Cast-in-Place Concrete"]** for cast-in-place concrete **[equipment bases/pads for gate operators and controls]****[post footings]****[and]****[continuous concrete grade beam]**.
3. Section 119814 "Detention Door Hardware" for detention door hinges and locks for swing and slide gates.
4. Section 281500 "Access Control Hardware Devices" for gate controls.
5. Section 281643 "Perimeter Security Systems" for fence-mounted gate-movement detectors.
6. Section 285213 "Detention Monitoring and Control System and Interfaces" for detection and alarm systems and for gate controls.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at **[Project site]**<Insert location>.

1. Inspect and discuss electrical roughing-in, equipment bases, and other preparatory work specified elsewhere.
2. Review coordination of soil sterilization with work specified elsewhere.
3. Review sequence of operation for each type of gate operator.
4. Review coordination of interlocked equipment specified in this Section and elsewhere.
5. Review required testing, inspecting, and certifying procedures.
6. <Insert requirement>.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:
 - a. Fence and gate posts, rails, and fittings.
 - b. Chain-link fabric, reinforcements, and attachments.
 - c. Accessories: **[Barbed wire]****[Barbed tape]**<Insert item>.
 - d. Gates and hardware.

e. Gate operator, including operating instructions and motor characteristics.

B. Shop Drawings: For each type of fence and gate assembly.

1. Include plans, elevations, sections, details, and attachments to other work.
2. Include accessories, hardware, gate operation, and operational clearances.
3. Gate Operator: Show locations and details for installing operator components, switches, and controls. Indicate motor size, electrical characteristics, drive arrangement, mounting, and grounding provisions.
4. Wiring Diagrams: For power, signal, and control wiring.

C. Samples for Initial Selection: For each type of factory-applied finish.

D. Samples for Verification: For each type of component with factory-applied finish, prepared on Samples of size indicated below:

1. Polymer-Coated Components: In **6-inch (150-mm)** lengths for components and on full-sized units for accessories.

E. Delegated Design Submittal: For structural performance of chain-link fence and gate frameworks, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For **[professional engineer][testing agency][factory-authorized service representative]**.

B. Product Certificates: For each type of chain-link fence[, **operator,**] and gate.[**Soil-sterilization certificate of treatment stating materials and quantities used, and date of application.**]

C. Product Test Reports: For framework strength in accordance with ASTM F1043, for tests performed by **[manufacturer and witnessed by a qualified testing agency][or][a qualified testing agency]**.

D. Field quality-control reports.

E. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

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

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: For testing fence grounding; member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

B. Emergency Access Requirements: According to requirements of authorities having jurisdiction for gates with automatic gate operators serving as a required means of access.

- C. Mockups: Build mockups to set quality standards for fabrication and installation.
 - 1. Build mockup for typical chain-link fence[**and gate**], including accessories.
 - a. Size: **[10-foot (3-m)]<Insert dimension>** length of fence.

1.7 FIELD CONDITIONS

- A. Field Measurements: Verify layout information for chain-link fences and gates shown on Drawings in relation to property survey and existing structures. Verify dimensions by field measurements.

1.8 WARRANTY

- A. Special Warranty: **[Manufacturer agrees][Installer agrees]** to repair or replace components of high-security chain-link fences and gates that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Failure to comply with performance requirements.
 - b. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
 - c. Faulty operation of gate operators and controls.
 - d. **<Insert failure modes>**.
 - 2. Warranty Period: **[Five][15]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design chain-link fence and gate frameworks.
- B. Structural Performance: Chain-link fence and gate frameworks shall withstand the design wind loads and stresses for fence height(s) and under exposure conditions indicated in accordance with **[ASCE/SEI 7]<Insert requirement>**:
 - 1. Design Wind Load: **[As indicated on Drawings]<Insert loads>**.
 - a. Minimum Post Size: Determine in accordance with ASTM F1043 for post spacing not to exceed **[10 feet (3 m)]<Insert dimension>** for Material **[Group IA, ASTM F1043, Schedule 40 steel pipe][Group IC, electric-resistance-welded round steel pipe]<Insert material group>**.
 - b. Minimum Post Size and Maximum Spacing: Provide line posts of size and in spacing indicated, but not less than sizes and spacings determined in accordance with CLFMI WLG 2445, based on mesh size and pattern specified.
- C. Deflection Limits: Fence deflections shall be within the following limits:
 - 1. Fabric Tension: Maximum **[2.5 inches (64 mm)]<Insert dimension>** when tested by applying a **30-lbf (133-N)** force at midpoint between rails and horizontally between posts for every eighth

lower panel along the fence line. Measure fabric movement from the relaxed position at the point where the force is applied.

2. Fence Post Rigidity: Maximum [3/4 inch (19 mm)]<Insert dimension> when a 50-lbf (222-N) force is applied at midheight of every eighth post along the fence line. Measure post movement from the relaxed position at the point where the force is applied.

- D. Lightning Protection System: Maximum resistance-to-ground value of 25 ohms at each grounding location along fence under normal dry conditions.

2.2 CHAIN-LINK FENCE FABRIC

- A. General: Provide fabric in height measured between top and bottom of outer edge of selvage in accordance with "CLFMI Product Manual" and requirements indicated below:

1. Fabric Height: One piece <Insert dimension>[as indicated on Drawings].
 - a. Steel Wire for Fabric: Wire diameter of [0.192 inch (4.88 mm)][0.148 inch (3.76 mm)][0.120 inch (3.05 mm)]<Insert dimension>.
 - 1) Mesh Size: [2 inches (50 mm)][1 inch (25 mm)][3/8 inch (9.5 mm)]<Insert dimension>.
2. Fabric Heights and Overlap: Two-piece height with lower fabric height of <Insert dimension> and upper fabric height of <Insert dimension>[as indicated on Drawings].
 - a. Steel Wire Lower Fabric: Wire diameter of [0.192 inch (4.88 mm)][0.148 inch (3.76 mm)][0.120 inch (3.05 mm)]<Insert dimension>.
 - 1) Mesh Size: [2 inches (50 mm)][1 inch (25 mm)][3/8 inch (9.5 mm)]<Insert dimension>.
 - b. Steel Wire Upper Fabric: Wire diameter of [0.120 inch (3.05 mm)]<Insert dimension>.
 - 1) Mesh Size: [3/8 inch (9.5 mm)]<Insert dimension>.
3. Aluminum-Coated Fabric: ASTM A491, Type I, [0.40 oz./sq. ft. (122 g/sq. m)][0.35 oz./sq. ft. (107 g/sq. m)][0.30 oz./sq. ft. (92 g/sq. m)].
4. Zinc-Coated Fabric: ASTM A392, Type II, [Class 1, 1.2 oz./sq. ft. (366 g/sq. m)][Class 2, 2.0 oz./sq. ft. (610 g/sq. m)] with zinc coating applied [before][after] weaving.
5. Zn-5Al-MM Aluminum-Mischmetal-Coated Fabric: ASTM F1345, Type III, Class 2, 1.0 oz./sq. ft. (305 g/sq. m).
6. Polymer-Coated Fabric: ASTM F668, Class 2b over [aluminum][zinc][Zn-5-Al-MM-alloy]-coated steel wire.
 - a. Color: [Dark green][Olive green][Brown][Black][As selected by Architect from manufacturer's full range], in accordance with ASTM F934.
7. Coat selvage ends of metallic-coated fabric before the weaving process with manufacturer's standard clear protective coating.
8. Selvage: Twisted and barbed top and bottom.

2.3 SECURITY FENCE FRAMEWORK

- A. Posts and Rails<Insert drawing designation>: ASTM F1043 for framework, including rails, braces, and line; terminal; and corner posts.
1. Fence Height: [96 inches (2440 mm)][12 feet (3.66 m)][As indicated on Drawings]<Insert dimension>.
 2. Heavy-Industrial-Strength Material: [Group IA, round steel pipe, Schedule 40][Group IC, round steel pipe, electric-resistance-welded pipe].
 - a. Line Post: [2.375 inches (60 mm) in diameter][2.875 inches (73 mm) in diameter][4.0 inches (102-mm) in diameter][6.625 inches (168 mm) in diameter][8.625 inches (219 mm) in diameter][2.25 by 1.70 inches (57 by 43 mm)][3.25 by 2.50 inches (83 by 64 mm)]<Insert dimension(s)>.
 - b. End, Corner, and Pull Posts: [2.875 inches (73 mm) in diameter][4.0 inches (102 mm) in diameter][6.625 inches (168 mm) in diameter][8.625 inches (219 mm) in diameter]<Insert dimension>.
 3. Rail Members: [Intermediate][top][bottom][and][brace] rails in accordance with ASTM F1043 for Heavy Industrial.
 4. Metallic Coating for Steel Framework:
 - a. Type A: Not less than minimum 2.0-oz./sq. ft. (0.61-kg/sq. m) average zinc coating in accordance with ASTM A123/A123M or 4.0-oz./sq. ft. (1.22-kg/sq. m) zinc coating in accordance with ASTM A653/A653M.
 - b. Type B: Zinc with organic overcoat, consisting of a minimum of 0.9 oz./sq. ft. (0.27 kg/sq. m) of zinc after welding, a chromate conversion coating, and a clear, verifiable polymer film.
 - c. External, Type B: Zinc with organic overcoat, consisting of a minimum of 0.9 oz./sq. ft. (0.27 kg/sq. m) of zinc after welding, a chromate conversion coating, and a clear, verifiable polymer film. Internal, Type D, consisting of 81 percent, not less than 0.3-mil- (0.0076-mm-) thick, zinc-pigmented coating.
 - d. Type C: Zn-5-Al-MM alloy, consisting of not less than 1.8-oz./sq. ft. (0.55-kg/sq. m) coating.
 - e. Coatings: Any coating above.
 5. Polymer coating over metallic coating.
 - a. Color: [Match chain-link fabric][Dark green][Olive green][Brown][Black][As selected by Architect from manufacturer's full range], in accordance with ASTM F934.

2.4 TENSION WIRE

- A. Metallic-Coated Steel Wire: 0.177-inch- (4.5-mm-) diameter, marcelled tension wire in accordance with ASTM A817 or ASTM A824, with the following metallic coating:
1. Type I: Aluminum coated (aluminized).
 2. Type II: Zinc coated (galvanized) by [hot-dip][electrolytic] process, with Class 5 minimum coating weight of not less than 2.0 oz./sq. ft. (610 g/sq. m) of uncoated wire surface.
- B. Polymer-Coated Steel Wire: 0.177-inch- (4.5-mm-) diameter, tension wire in accordance with ASTM F1664, Class 2b over [aluminum][zinc][Zn-5-Al-MM-alloy]-coated steel wire.
1. Color: [Match chain-link fabric][Dark green][Olive green][Brown][Black][As selected by Architect from manufacturer's full range], in accordance with ASTM F934.

2.5 SWING GATES

- A. General: ASTM F900 for gate posts and **[single][double]** swing gate types. **[Provide automated vehicular gates in accordance with ASTM F2200.]**
 - 1. Gate Leaf Width: **[36 inches (914 mm)][As indicated]<Insert width>.**
 - 2. Framework Member Sizes and Strength: Based on gate fabric height **[of 72 inches (1830 mm) or less][of more than 72 inches (1830 mm)][as indicated]<Insert dimension>.**
- B. Pipe and Tubing:
 - 1. Zinc-Coated Steel: ASTM F1043 and ASTM F1083; **[protective coating and finish to match fence framework][manufacturer's standard protective coating and finish]<Insert finish>.**
 - 2. Aluminum: ASTM B429/B429M; **[mill][manufacturer's standard]<Insert finish> finish.**
 - 3. Gate Posts: **[Round tubular steel][Rectangular tubular steel][Round tubular aluminum][Rectangular tubular aluminum].**
 - 4. Gate Frames and Bracing: **[Round tubular steel][Rectangular tubular steel][Round tubular aluminum][Rectangular tubular aluminum].**
- C. Frame Corner Construction: **[Welded][or][assembled with corner fittings]** and 3/8-inch- (9.5-mm-) diameter, adjustable truss rods for panels **60 inches (1520 mm)** or wider.
- D. Extended Gate Posts and Frame Members: Fabricate gate posts and frame end members to extend **[12 inches (300 mm)][as indicated]<Insert dimension>** above top of chain-link fabric at both ends of gate frame as required to attach barbed **[wire][tape]** assemblies.
- E. Provisions for Electronic Detection System: Isolate gate from fencing to prevent transference of vibration. Gate hinge posts and latch posts may share the same footing but shall not be in contact with fence terminal posts.
 - 1. Separation between Hinge and Latch Posts and Fence Termination Posts: **2 inches (50 mm)** minimum, **2-1/2 inches (63.5 mm)** maximum.
- F. Hardware:
 - 1. Hinges: **[180-degree inward][180-degree outward][360-degree inward and outward]** swing.
 - 2. Latch: Permitting operation from **[one side][both sides]** of gate **[with provision for padlocking accessible from both sides of gate].**
 - 3. Lock: **[Manufacturer's standard]<Insert requirement>** internal device.
 - 4. Padlock and Chain: **<Insert requirements>.**
 - 5. Closer: **[Manufacturer's standard]<Insert requirement>.**
 - 6. Tall Gates: For gates **14 feet (4.27 m)** and higher, add locking device to transom.
 - 7. **<Insert hardware items and accessories>.**

2.6 HORIZONTAL-SLIDE GATES

- A. General: ASTM F1184 for gate posts and **[single][double]** sliding gate types. **[Provide automated vehicular gates in accordance with ASTM F2200.]**
 - 1. Classification: Type I Overhead Slide.
 - a. Gate Leaf Width: **[As indicated]<Insert width>.**
 - b. Framework Member Sizes and Strength: Based on gate fabric height **[of 72 inches (1830 mm) or less][of more than 72 inches (1830 mm)][as indicated]<Insert dimension>.**

2. Classification: Type II Cantilever Slide, **[Class 1 with external][Class 2 with internal]** roller assemblies.
 - a. Gate Frame Width and Height: **[48 inches (1220 mm) wide or less by 72 inches (1830 mm) high or less][More than 48 inches (1220 mm) wide by any height][As indicated]<Insert dimension>**.

B. Pipe and Tubing:

1. Zinc-Coated Steel: **[Protective coating and finish to match fence framework][Manufacturer's standard protective coating and finish]<Insert finish>**.
2. Aluminum: ASTM B429/B429M; **[mill][manufacturer's standard]<Insert finish>** finish.
3. Gate Posts: ASTM F1184Provide **[round tubular steel][rectangular tubular steel][round tubular aluminum][rectangular tubular aluminum]** posts.
4. Gate Frames and Bracing: **[Round tubular steel][Rectangular tubular steel][Round tubular aluminum][Rectangular tubular aluminum]**.

C. Frame Corner Construction: [Welded][or][assembled with corner fittings] and 3/8-inch- (9.5-mm-) diameter, adjustable truss rods for panels 60 inches (1520 mm) or wider.

D. Extended Gate Posts and Frame Members: Extend gate posts and frame end members above top of chain-link fabric at both ends of gate frame [12 inches (300 mm)][as indicated]<Insert dimension> as required to attach barbed [wire][tape] assemblies.

E. Overhead Track Assembly: Manufacturer's standard track, with overhead framework supports, bracing, and accessories, engineered to support size, weight, width, operation, and design of gate and roller assemblies.

F. Hardware:

1. Hangers, Roller Assemblies, and Stops: Fabricated from **[galvanized steel][galvanized malleable iron][mill-finished Grade 319 aluminum-alloy casting with stainless steel fasteners]**.
2. Latch: Permitting operation from **[one side][both sides]** of gate **[with provision for padlocking accessible from both sides of gate]**.
3. Lock: **[Manufacturer's standard]<Insert requirement>** internal device.
4. Padlock and Chain: **<Insert requirements>**.
5. **<Insert hardware items and accessories>**.

2.7 FITTINGS

A. Provide fittings in accordance with ASTM F626.

B. Post Caps: Provide for each post.

1. Provide line post caps with loop to receive tension wire or top rail.

C. Rail and Brace Ends: For each gate, corner, pull, and end post.

D. Rail Fittings: Provide the following:

1. Top-Rail Sleeves: Pressed-steel or round-steel tubing not less than **6 inches (152 mm)** long.
2. Rail Clamps: Line and corner boulevard clamps for connecting **[intermediate][and][bottom]** rails to posts.

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- E. Tension and Brace Bands, Tension Bars, and Truss Rod Assemblies: In accordance with ASTM F2611.
- F. Barbed Wire Arms: **[Pressed steel or cast iron][Aluminum]**, with clips, slots, or other means for attaching strands of barbed wire, **[and means for attaching to posts][, integral with post cap]**, for each post unless otherwise indicated, and as follows:
 - 1. Provide line posts with arms that accommodate top rail or tension wire.
 - 2. Provide corner arms at fence corner posts unless extended posts are indicated.
 - 3. Single-Arm Type: **[Type I, slanted arm][Type II, vertical arm]**.
 - 4. Double-Arm Type: **[Type III, V-shaped arm][Type IV, A-shaped arm]**.
 - 5. Use bolts or rivets for connection to posts.
- G. Tie Wires, Clips, and Fasteners: In accordance with ASTM F626.
 - 1. High-Security Round Wire Ties: For attaching chain-link fabric to posts, rails, and frames, according to the following:
 - a. Metallic-Coated Steel: **[0.148-inch- (3.76-mm-)][0.192-inch- (4.88-mm-)]** diameter wire; **[zinc][aluminum]** coating.
 - b. Stainless steel.
- H. Power-Driven Fabric Fasteners: As recommended in writing by manufacturer.
- I. Finish:
 - 1. Metallic Coating for Pressed Steel or Cast Iron: Not less than **1.2 oz. /sq. ft. (366 g/sq. m)** of zinc.
 - a. Polymer coating over metallic coating.
 - 2. Aluminum: Mill finish.

2.8 BARBED WIRE

- A. Steel Barbed Wire: ASTM A121, High Security Grade, two-strand barbed wire; **0.099-inch- (2.51-mm-)** diameter line wire with **0.080-inch- (2.03-mm-)** diameter, four-point round barbs spaced not more than **3 inches (76 mm)** o.c.
 - 1. Aluminum Coating: Type A.
- B. Polymer-Coated, Galvanized-Steel Barbed Wire: ASTM F1665, Type II, two-strand barbed wire; **0.080-inch- (2.03-mm-)** diameter line wire with **0.080-inch- (2.03-mm-)** diameter, four-point, round **[aluminum-alloy][galvanized-steel]** barbs spaced not more than **3 inches (76 mm)** o.c.
 - 1. Polymer Coating: Class 2b over **[aluminum][zinc][Zn-5-Al-MM-alloy]**-coated steel wire.
 - a. Color: **[Match chain-link fabric][Dark green][Olive green][Brown][Black][As selected by Architect from manufacturer's full range]** in accordance with ASTM F934.

2.9 BARBED TAPE

- A. Wire-Reinforced Tape: ASTM F1910; continuous coil with four-point, needle-sharp barbs permanently

cold clenched around a core wire.

1. Core Wire: High-tensile-strength, [zinc-coated steel][or][stainless steel].
 2. Configuration: [Single][Double] coil.
 3. Style: [Helical][Concertina] pattern.
 4. Coil Diameter(s): [18-inch (457-mm)][24 inches (610 mm)][24-inch (610-mm) inner coil and 30-inch (762-mm) outer coil][As indicated on Drawings]<Insert diameter>.
 5. Coil Loop Spacing(s): [12 inches (305 mm)][Manufacturer's standard][As indicated on Drawings]<Insert spacing>.
 6. Barb Length Classification: [Long, 1.2-inch (30.5-mm)][Medium, 0.4-inch (10.2-mm)][Short, 0.1875-inch (4.76-mm)] barb.
 7. Barb Spacing: [4 inches (102 mm)]<Insert dimension> o.c.
 8. Barb Set: [Straight][Offset][Manufacturer's standard].
- B. Clips: Stainless steel, 0.065 inch (1.65 mm) thick by 0.375 inch (9.5 mm) wide; capable of withstanding a minimum 150-lbf (667-N) pull load to limit extension of coil, resulting in a concertina pattern when deployed.
- C. Tie Wires: Stainless steel, 0.065 inch (1.65 mm) in diameter.
- D. Ground-Barrier Stakes: 3/8-inch- (9.5-mm-) diameter galvanized reinforcing bar, 18 inches (457 mm) long with 180-degree end hook 3-1/2 inches (89 mm) long.

2.10 GATE OPERATORS

- A. Operators: Factory-assembled, automatic gate-operating system designed for gate size, type, weight, and frequency of use. Control system shall have characteristics suitable for Project conditions, with control stations, safety devices, and weatherproof enclosures.
1. Operator design shall allow for removal of cover or motor without disturbing limit-switch adjustment and without affecting auxiliary emergency operation.
 2. Electronic components shall have built-in troubleshooting diagnostic feature.
 3. Unit shall be designed and wired for both right-hand/left-hand opening, permitting universal installation.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. UL Standard: Manufacture and label gate operators in accordance with UL 325.
- D. Motors: Comply with NEMA MG 1.
1. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet (1000 m) above sea level.
 2. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
 3. Service Factor: 1.15.
 4. Electrical Characteristics:
 - a. Horsepower: [1][2][5]<Insert horsepower>.
 - b. Voltage: [115 V ac, single phase, 60 hertz][208 V ac, single phase, 60 hertz][230 V ac, single phase, 60 hertz][208 V ac, three phase, 60 hertz][230 V ac, three phase, 60 hertz][460 V ac, three phase, 60 hertz].

- E. Gate Operators: **[Gate][Equipment base/pad][Pedestal post][In ground]** mounted and as follows:
1. Hydraulic **[Swing][Slide]** Gate Operators:
 - a. Duty: **[Medium][Heavy]**.
 - b. Gate Speed: Minimum **[45 feet (13.7 m)][60 feet (18.2 m)]** per minute.
 - c. Maximum Gate Weight: **[800 lb (363 kg)]<Insert value>**.
 - d. Frequency of Use: **[10 cycles per hour][25 cycles per hour][60 cycles per hour][Continuous duty]<Insert requirement>**.
 - e. Operating Type: Wheel and rail drive **[with manual release]**.
 - f. Hydraulic Fluid: Of viscosity required for gate operation at ambient temperature range for Project.
 - g. Locking: Hydraulic in both directions.
 - h. Heater: Manufacturer's standard track and roller heater with thermostatic control.
 2. Mechanical **[Swing][Slide]** Gate Operators:
 - a. Duty: **[Medium][Heavy]**.
 - b. Gate Speed: Minimum **[45 feet (13.7 m) per minute][60 feet (18.2 m) per minute][variable speed]<Insert requirement>**.
 - c. Maximum Gate Weight: **[800 lb (363 kg)][3000 lb (1360 kg)]<Insert value>**.
 - d. Frequency of Use: **[10 cycles per hour][25 cycles per hour][60 cycles per hour][Continuous duty]<Insert requirement>**.
 - e. Operating Type: **[Crank arm][Enclosed][Wheel and rail drive][Roller chain]**, **[with manual release]**.
 - f. Drive Type:
 - 1) Enclosed worm gear **[and chain-and-sprocket]** reducers, roller-chain drive.
 - 2) **[V-belt and][worm gear][chain-and-sprocket]** reducers, roller-chain drive.
- F. Controls: Electric controls separated from gate and motor and drive mechanism, with **[NEMA 250, Type 3R][NEMA 250, Type 4]<Insert enclosure type>** enclosure for **[surface][recessed or flush][equipment base/pad][pedestal]<Insert mounting>** mounting and with space for additional optional equipment.
- G. Control Devices:
1. Control Station, Keyed: **[Two][Three]**-position switch, located remotely from gate. Provide two keys per station.
 - a. Function: Open[, **stop**,] and close.
 2. Control Station, Momentary Contact: **[Single][Three]**-button operated, located remotely from gate. **[Key switch to lock out open and close buttons.]**
 - a. Function: Open[, **stop**,] and close.
 3. Card Reader: Functions only when authorized card is presented. Programmable, magnetic **[multiple][single]**-code system[, **permitting four different access time periods**]; **face-lighted unit fully visible at night**.
 - a. Reader Type: **[Touch plate][Swipe][Insertion][Proximity]**.
 - b. Features: **[Timed anti-passback][Limited-time usage][Capable of monitoring and auditing gate activity]**.

4. Digital Keypad Entry Unit: Multiple-[**programmable**]-code capability of not less than [**five**][**500**][**2500**]**<Insert number>** possible individual codes, consisting of [**one- to seven**][**four**][**five**]-digit codes[**and permitting four different access time periods**].
 - a. Features: [**Timed anti-passback**][**Limited-time usage**][**Capable of monitoring and auditing gate activity**].
 - b. Face-lighted unit with [**metal-keyed**][**keyless-membrane**] keypad fully visible at night.
5. Radio Control: Digital system consisting of code-compatible universal receiver for each gate, located where indicated, with remote antenna with coaxial cable and mounting brackets designed to operate gates. Provide [**one**][**two**]**<Insert number>** programmable transmitter(s) with multiple-code capability, permitting validating or voiding of not less than [**1000**][**10,000**]**<Insert number>** codes per channel configured for the following functions:
 - a. Transmitters: [**Single**][**Three**]-button operated, with open[**and close**] function.
 - b. Channel Settings: [**Two**][**Three**][**Four**]**<Insert number>** independent channel settings controlling separate receivers for operating more than one gate from each transmitter.
6. Telephone Entry System: Hands-free voice-communication system for connection to building telephone system, with digital-entry code activation of gate operator[**and auxiliary keypad entry**].
 - a. System: Designed to be wired to same line with telephone.
 - b. Multiunit System: Designed to be wired to a dedicated telephone line, with capacity to access [**20**][**100**]**<Insert number>** telephones[**and with electronic directory**].
7. Vehicle Loop Detector: System that includes automatic closing timer with adjustable time delay before closing[, **timer cut-off switch**,] and loop detector designed to [**open and close gate**][**hold gate open until traffic clears**][**reverse gate**]**<Insert function>**. Provide electronic detector with adjustable detection patterns, adjustable sensitivity and frequency settings, and panel indicator light designed to detect presence or transit of a vehicle over an embedded loop of wire and to emit a signal activating the gate operator. Provide number of loops consisting of multiple strands of wire, number of turns, loop size, and method of placement at location shown on Drawings, and as recommended in writing by detection system manufacturer for function indicated.
 - a. Loop: [**Field-assembled**][**Factory-preformed**] wire, in size indicated, for [**pave-over**][**saw-cut with epoxy-grouted**] installation.
8. Vehicle Presence Detector: System that includes automatic closing timer with adjustable time delay before closing[, **timer cut-off switch**,] and presence detector designed to [**open and close gate**][**hold gate open until traffic clears**][**reverse gate**]**<Insert functions>**.
 - a. Provide [**retroreflective**][**emitter/receiver**] detector with adjustable detection zone pattern and sensitivity, designed to detect presence or transit of a vehicle in gate pathway when an infrared beam in zone pattern is interrupted, and to emit a signal activating the gate operator.
- H. Obstruction Detection Devices: Provide each motorized gate with automatic safety sensor(s). Activation of sensor(s) causes operator to immediately function as follows:
 1. Action: [**Reverse gate in both opening and closing cycles and hold until clear of obstruction**][**Stop gate in opening cycle and reverse gate in closing cycle and hold until clear of obstruction**].
 2. Internal Sensor: Built-in torque or current monitor senses gate is obstructed.
 3. Sensor Edge: Contact-pressure-sensitive safety edge, profile, and sensitivity designed for type of gate and component indicated, in locations as follows. Connect to control circuit using [**take-up**

cable reel][self-coiling cable][gate edge transmitter and operator receiver system].

- a. Along entire gate leaf leading edge.
 - b. Along entire gate leaf trailing edge.
 - c. Across entire gate leaf bottom edge.
 - d. Along entire length of gate posts.
 - e. Along entire length of gate guide posts.
 - f. Where indicated on Drawings.
 - g. **<Insert extent and location>.**
4. Photoelectric/Infrared Sensor: System designed to detect an obstruction in gate's path when infrared beam in the zone pattern is interrupted.
- I. Limit Switches: Adjustable switches, interlocked with motor controls and set to automatically stop gate at fully open and fully closed positions.
 - J. Emergency Release Mechanism: Quick-disconnect release of operator drive system, permitting manual operation if operator fails. Control circuit power is disconnected during manual operation.
 1. Type: **[Integral fail-safe release, allowing gate to be pushed open without mechanical devices, keys, cranks, or special knowledge][Mechanical device, key, or crank-activated release].**
 - K. Operating Features:
 1. Digital Microprocessor Control: Electronic programmable means for setting, changing, and adjusting control features **[with capability of monitoring and auditing gate activity]**. Provide unit that is isolated from voltage spikes and surges.
 2. System Integration: With controlling circuit board capable of accepting any type of input from external devices.
 3. Master/Slave Capability: Control stations designed and wired for gate pair operation.
 4. Automatic Closing Timer: With adjustable time delay before closing **[and timer cut-off switch]**.
 5. Open Override Circuit: Designed to override closing commands.
 6. Reversal Time Delay: Designed to protect gate system from shock load on reversal in both directions.
 7. Maximum Run Timer: Designed to prevent damage to gate system by shutting down system if normal time to open gate is exceeded.
 8. Clock Timer: **[24 hour][Seven day]<Insert time period>**, programmable for regular events.
 - L. Accessories:
 1. Warning Module: **[Audio][Visual], [constant][strobe]-light alarm sounding three to five seconds in advance of gate operation and continuing until gate stops moving and in accordance with [the U.S. Access Board's ADA-ABA Accessibility Guidelines for Buildings and Facilities][and][ICC A117.1].**
 2. Battery Backup System: Battery-powered drive and access-control system, independent of primary drive system.
 - a. Fail Safe: Gate opens and remains open until power is restored.
 - b. Fail Secure: Gate cycles on battery power, then fail safe when battery is discharged.
 3. External electric-powered **[solenoid][magnetic]** lock with delay timer allowing time for lock to release before gate operates.
 4. **[Fire][Postal]** box.
 5. Fire **[strobe][siren]** sensor.

6. Intercom System: **<Insert requirements>**.
7. Instructional, Safety, and Warning Labels and Signs: **[In accordance with UL 325][Manufacturer's standard for components and features specified][As indicated on Drawings]<Insert requirements>**.
8. Equipment Bases/Pads: Precast concrete, **[depth not less than 12 inches (305 mm)]<Insert depth 6 to 12 inches (152 to 305 mm) below frost line or detail on Drawings>**, dimensioned and reinforced according to gate-operator component manufacturer's written instructions and as indicated on Drawings.

2.11 GROUT AND ANCHORING CEMENT

- A. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C1107/C1107M. Provide grout, recommended in writing by manufacturer, for exterior applications.
- B. Anchoring Cement: Factory-packaged, nonshrink, nonstaining, hydraulic-controlled expansion cement formulation for mixing with water at Project site to create pourable anchoring, patching, and grouting compound. Provide formulation that is resistant to erosion from water exposure without needing protection by a sealer or waterproof coating, and that is recommended in writing by manufacturer for exterior applications.

2.12 GROUNDING MATERIALS

- A. Comply with requirements in Section 260526 "Grounding and Bonding."
- B. Connectors and Grounding Rods: Listed and labeled for complying with UL 467.
 1. Connectors for Below-Grade Use: Exothermic welded type.
 2. Grounding Rods: Copper-clad steel, **5/8 by 96 inches (16 by 2440 mm)**.

2.13 SOIL-STERILIZATION MATERIALS

- A. Soil Sterilant: Commercial herbicide for weed control, approved by authorities having jurisdiction.
- B. Polyethylene Sheeting: **6 mils (0.15 mm)** thick, black, and serving as soil-separation fabric.
- C. Stone Ground Cover: Random-size range of **[3/4- to 2-inch (19- to 50-mm)]<Insert dimensions>** crushed stone or washed gravel.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for **[a certified survey of property lines and legal boundaries,]** site clearing, earthwork, pavement work, and other conditions affecting performance of the Work.
 1. Do not begin installation before final grading is completed unless otherwise permitted by Architect.

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

3.2 PREPARATION

- A. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of **500 feet (152 m)** or line of sight between stakes. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.

3.3 INSTALLATION OF CHAIN-LINK FENCING

- A. Install chain-link fencing in accordance with ASTM F567 and more stringent requirements specified.

1. Install fencing on established boundary lines inside property line.

- B. Post Excavation: Drill or hand-excavate holes for posts to diameters and spacings indicated, in firm, undisturbed soil.

- C. Post Setting: Set posts [**in concrete**][**with mechanical anchors**] at indicated spacing into firm, undisturbed soil.

1. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during setting with concrete or mechanical devices.

2. Concrete Fill: Place concrete around posts to dimensions indicated and vibrate or tamp for consolidation. Protect aboveground portion of posts from concrete splatter.

- a. Exposed Concrete: Extend **2 inches (50 mm)** above grade[**or to same elevation as concrete grade beam**]; shape and smooth to shed water.
- b. Concealed Concrete: Place top of concrete [**2 inches (50 mm)**]**<Insert dimension>** below grade[**as indicated on Drawings**] to allow covering with surface material.
- c. Posts Set into Sleeves in Concrete: Use steel pipe sleeves preset and anchored into concrete for installing posts. After posts are inserted into sleeves, fill annular space between post and sleeve with [**nonshrink, nonmetallic grout**][**or**][**anchoring cement**], mixed and placed according to anchoring material manufacturer's written instructions. Finish anchorage joint to slope away from post to drain water.
- d. Posts Set into Holes in Concrete: Form or core drill holes not less than **5 inches (127 mm)** deep and **3/4 inch (19 mm)** larger than OD of post. Clean holes of loose material, insert posts, and fill annular space between post and concrete with [**nonshrink, nonmetallic grout**][**or**][**anchoring cement**], mixed and placed according to anchoring material manufacturer's written instructions. Finish anchorage joint to slope away from post to drain water.

- D. Terminal Posts: Install terminal end, corner, and gate posts in accordance with ASTM F567 and terminal pull posts at changes in horizontal or vertical alignment of 15 degrees or more, at any abrupt change in grade, and at intervals not greater than **500 feet (152 m)**. For runs exceeding **500 feet (152 m)**, space pull posts an equal distance between corner or end posts.

- E. Line Posts: Space line posts uniformly at [**96 inches (2440 mm)**][**10 feet (3 m)**]**<Insert dimension>** o.c.

- F. Post Bracing and Intermediate Rails: Install in accordance with ASTM F567, maintaining plumb position and alignment of fence posts. Diagonally brace terminal posts to adjacent line posts with truss rods and turnbuckles. Install braces at end and gate posts and at both sides of corner and pull posts.

1. Locate horizontal braces at midheight of fabric **72 inches (1830 mm)** or higher, on fences with

top rail, and at two-third fabric height on fences without top rail. Install so posts are plumb when diagonal rod is under proper tension.

- G. Barbed Wire Arms: Bolt or rivet to top of post. Angle single arms away from approach side of fence.
- H. Tension Wire: Install in accordance with ASTM F567, maintaining plumb position and alignment of fence posts. Pull wire taut, without sags. Fasten fabric to tension wire with **0.120-inch- (3.05-mm-)** diameter hog rings of same material and finish as fabric wire, spaced a maximum of **24 inches (610 mm)** o.c. Install tension wire in locations indicated before stretching fabric. Provide horizontal tension wire at the following locations:
 - 1. Extended along **[top][and][bottom]** of fence fabric. Install top tension wire through post cap loops. Install bottom tension wire within **6 inches (152 mm)** of bottom of fabric and tie to each post with not less than same diameter and type of wire.
 - 2. Extended along top of **[barbed wire arms][extended posts]** and top of fence fabric to support barbed tape.
 - 3. **[As indicated on Drawings]<Insert requirements>**.
- I. Top Rail: Install in accordance with ASTM F567, maintaining plumb position and alignment of fence posts. Run rail continuously through line post caps, bending to radius for curved runs and terminating into rail end attached to posts or post caps fabricated to receive rail at terminal posts. Provide expansion couplings as recommended in writing by fencing manufacturer.
- J. Bottom Rails: Secure to posts with fittings; anchor rail at midspan to concrete **[footing][continuous grade beam]**.
- K. Chain-Link Fabric: Apply fabric on the approach side of fence, inside of enclosing framework. Pull fabric taut and tie to posts, rails, and tension wires. Anchor to framework so fabric remains under tension after pulling force is released.
 - 1. Overlapping Fabric: Overlap ends of fence fabric at or between posts or rails; overlap **6 inches (152 mm)** and secure with wire ties or steel strap method.
 - 2. Bottom Clearance: Leave **[1-1/2 inches (38 mm)][2 inches (50 mm)]** between finish grade or surface and bottom selvage unless otherwise indicated.
 - 3. Buried Fabric: Where indicated, bury the bottom **[12 inches (300 mm) of a continuous 18-inch- (457-mm-) wide][24 inches (610 mm) of a continuous 30-inch- (762-mm-) wide]**, polymer-coated chain-link fabric in a vertical trench below the fencing; overlap above-grade fence fabric **6 inches (152 mm)** and secure to bottom rail with tie wires. Backfill and compact trench.
- L. Tension or Stretcher Bars: Thread through fabric and secure to end, corner, pull, and gate posts with tension bands spaced not more than **15 inches (380 mm)** o.c.
- M. Tie Wires: Power-fastened or manually fastened ties configured to wrap a full 360 degrees around rail or post and a minimum of one complete diamond of fabric. Twist ends one and one-half machine twists or three full manual twists, and cut off protruding ends to preclude untwisting by hand.
 - 1. Maximum Spacing: Tie fabric to line posts at **12 inches (305 mm)** o.c. and to braces at **24 inches (610 mm)** o.c.
- N. Power-Fastening of Fabric: Fasten **0.192- or 0.148-inch (4.87- or 3.76-mm)** wire fabric with **2- or 1-inch (50- or 25-mm)** mesh size. Fasten fabric to line posts **12 inches (300 mm)** o.c. and to braces **24 inches (610 mm)** o.c.
- O. Fasteners: Install nuts for tension bands and carriage bolts on the side of fence opposite the fabric side. **[Peen ends of bolts or score threads to prevent removal of nuts.]**

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- P. Barbed Wire: Install barbed wire uniformly spaced[, **angled toward security side of fence**][**as indicated on Drawings**]. Pull wire taut, install securely to extension arms, and secure to end post or terminal arms.
- Q. Barbed Tape: Install in accordance with ASTM F1911. Install barbed tape uniformly in configurations indicated and fasten securely to prevent movement or displacement.
- R. Ground Barrier: Stake barbed-tape coils at **10 feet (3 m)** o.c., driven into ground to full depth.
- S. Provisions for Electronic Detection System: Eliminate wind-induced vibrations and rattles of fabric against posts and rails by placing additional tie wires where necessary. Eliminate rattles from bolted end fittings and other component connections by applying additional tightening or diagonal truss rods secured to fabric with tie wires.

3.4 INSTALLATION OF GATES

- A. Install gates according to manufacturer's written instructions, level, plumb, and secure for full opening without interference. Attach fabric as for fencing. Attach hardware using tamper-resistant or concealed means. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation.

3.5 INSTALLATION OF GATE OPERATORS

- A. Install gate operators according to manufacturer's written instructions, aligned and true to fence line and grade.
- B. Excavation: Hand-excavate holes for posts, pedestals, and equipment bases/pads, in firm, undisturbed soil to dimensions and depths and at locations according to gate-operator component manufacturer's written instructions and as indicated.
- C. Vehicle Loop Detector System: [**Cut grooves in pavement, bury, and seal**][**Bury**] wire loop according to manufacturer's written instructions. Connect to equipment operated by detector.
- D. Ground electric-powered motors, controls, and other devices in accordance with NFPA 70 and manufacturer's written instructions.

3.6 GROUNDING AND BONDING

- A. Comply with requirements in Section 260526 "Grounding and Bonding."
- B. Fence and Gate Grounding:
 - 1. Ground for fence and fence posts shall be a separate system from ground for gate and gate posts.
 - 2. Install ground rods and connections at maximum intervals of [**100 feet (30 m)**]**<Insert dimension>**.
 - 3. Ground fence on each side of gates and other fence openings.
 - a. Bond metal gates to gate posts.
 - b. Bond across openings, with and without gates, except openings indicated as intentional fence discontinuities. Use No. 2 AWG wire and bury it at least **18 inches (457 mm)** below finished grade.

- C. Protection at Crossings of Overhead Electrical Power Lines: Ground fence at location of crossing and at a ground rod located a maximum distance of **150 feet (45 m)** on each side of crossing.
- D. Fences Enclosing Electrical Power Distribution Equipment: Ground in accordance with IEEE C2 unless otherwise indicated.
- E. Grounding Method: At each grounding location, drive a grounding rod vertically until the top is **6 inches (152 mm)** below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at grounding location.
 - 1. Make grounding connections to each barbed wire strand with wire-to-wire connectors designed for this purpose.
 - 2. Make grounding connections to each barbed tape coil with connectors designed for this purpose.
- F. Connections:
 - 1. Make connections with clean, bare metal at points of contact.
 - 2. Make aluminum-to-steel connections with stainless steel separators and mechanical clamps.
 - 3. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
 - 4. Make above-grade ground connections with mechanical fasteners.
 - 5. Make below-grade ground connections with exothermic welds.
 - 6. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.
- G. Bonding to Lightning Protection System: Ground fence and bond fence grounding conductor to lightning protection down conductor or lightning protection grounding conductor in accordance with NFPA 780.
- H. Comply with requirements in Section 264113 "Lightning Protection for Structures."

3.7 SOIL STERILIZATION

- A. Apply soil sterilant according to manufacturer's written instructions.
- B. Apply sterilant after completing grounding and other below-grade electrical work along fence line[**and within zone between double-row chain-link fence installation**].
- C. Polyethylene Sheeting: Install sheeting continuously between double-row chain-link fence installation, overlapping edges and punctures **6 inches (152 mm)**.
- D. Stone Ground Cover: Lay continuous **3-inch- (75-mm-)** deep bed of stone ground cover over polyethylene sheeting.
- E. Extent: Extend soil sterilization [**48 inches (1220 mm)**][**72 inches (1830 mm)**][**<Insert distance>**] beyond outside and inside of fence.

3.8 FIELD QUALITY CONTROL

- A. Testing Agency: [**Owner will engage**][**Engage**] a qualified testing agency to perform tests.
- B. Perform the following tests:
 - 1. Fabric Testing: Test fabric tension according to "Deflection Limits" Paragraph in "Performance

- Requirements" Article.
- 2. Fence Post Rigidity Testing: Test line posts for rigidity according to "Deflection Limits" Paragraph in "Performance Requirements" Article.
- 3. Grounding Tests: Comply with requirements in Section 264113 "Lightning Protection for Structures."

C. Prepare test reports.

3.9 ADJUSTING

- A. Gates: Adjust gates to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.
- B. Automatic Gate Operator: Energize circuits to electrical equipment and devices, start units, and verify proper motor rotation and unit operation.
 - 1. Hydraulic Operator: Purge operating system, adjust pressure and fluid levels, and check for leaks.
 - 2. Test and adjust operator, controls,[**alarms**,] and safety devices. Replace damaged and malfunctioning controls and equipment.
 - 3. Lubricate operator and related components.
- C. Lubricate hardware and other moving parts.

3.10 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain high-security chain-link fences and gates.

END OF SECTION 32 31 13 13



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Task	Specification	Specification Description
32 31 13 13	32 31 13 00	Chain Link Fences And Gates
32 31 13 33	32 31 13 00	Chain Link Fences And Gates



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SECTION 32 31 16 00 - WELDED WIRE FENCES AND GATES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metallic-coated-steel, welded-wire fences.
2. Swing gates.
3. Horizontal-slide gates.
4. Gate operators.

B. Related Requirements:

1. Section 033000 "Cast-in-Place Concrete" for concrete **[bases for gate operators, drives, and controls][and][post concrete fill]**.
2. Section 281500 "Integrated Access Control Hardware Devices" for access control devices installed at gates and provided as part of a security system.
3. Section 312000 "Earth Moving" for site excavation, fill, and backfill where welded-wire fences and gates are located.

1.2 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at **[Project site]<Insert location>**.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.

- B. Shop Drawings: For fencing and gates.

1. Include plans, elevations, sections, gate locations, post spacing, **[and][mounting][attachment] details[, and grounding details]**.
2. Gate Operator: Show locations and details for installing operator components, switches, and controls. Indicate motor size, electrical characteristics, drive arrangement, mounting, and grounding provisions.
3. Wiring Diagrams: Include diagrams for power, signal, and control wiring.

- C. Samples: For each fence material and for each color specified.

1. Provide Samples **[12 inches (300 mm)]<Insert dimension>** in length for linear materials.
2. Provide Samples **[12 inches (300 mm)]<Insert dimension>** square for wire mesh.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

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1.5 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For gate operators to include in maintenance manuals.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: Fabricator of products.
- B. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for fabrication and installation.
 - 1. Include **[10-ft. (3-m)]<Insert dimension>** length of fence complying with requirements.
 - 2. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Wind Loading:
 - 1. Fence Height: **[0 to 15 ft. (0 to 4.57 m)][15 to 20 ft. (4.57 to 6.10 m)]**.
 - 2. Wind Exposure Category: **[B][C][D]**.
 - 3. Design Wind Speed: **[105 mph (169 kph)][110 mph (177 kph)][120 mph (193 kph)][130 mph (209 kph)][140 mph (225 kph)][150 mph (241 kph)][160 mph (257 kph)][170 mph (274 kph)]<Insert wind speed>**.
 - 4. Design Wind Pressure: **<Insert wind pressure>**.
- B. Lightning-Protection System: Maximum grounding-resistance value of 25 ohms under normal dry conditions.

2.2 METALLIC-COATED-STEEL, WELDED-WIRE FENCES

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[A&T Iron Works, Inc]**
 - 2. **[Ameristar Perimeter Security; ASSA ABLOY]**
 - 3. **[Ametco Manufacturing Corporation]**
 - 4. **[BarnettBates Corporation]**
 - 5. **[Betafence; Praesidiad Group Limited]**
 - 6. **[Designmaster; Mid-Continent Steel and Wire, Inc.; Deacero S.A. DE C.V.]**
 - 7. **[Jerith Manufacturing LLC.; ASSA ABLOY]**
 - 8. **[Master-Halco, Inc.]**
 - 9. **[Merchants Metals, LLC]**
 - 10. **[Metalco; MFR Manufacturing Corp, Inc.]**
 - 11. **[Omega II Fence Systems; Metaltech-Omega Inc.]**
 - 12. **[Wallace Perimeter Security]**
 - 13. **<Insert manufacturer's name>**

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

1. **[A&T Iron Works, Inc]**
2. **[Ameristar Perimeter Security; ASSA ABLOY]**
3. **[Ametco Manufacturing Corporation]**
4. **[BarnettBates Corporation]**
5. **[Betafence; Praesidiad Group Limited]**
6. **[Designmaster; Mid-Continent Steel and Wire, Inc.; Deacero S.A. DE C.V.]**
7. **[Jerith Manufacturing LLC.; ASSA ABLOY]**
8. **[Master-Halco, Inc.]**
9. **[Merchants Metals, LLC]**
10. **[Metalco; MFR Manufacturing Corp, Inc.]**
11. **[Omega II Fence Systems; Metaltech-Omega Inc.]**
12. **[Wallace Perimeter Security]**
13. **<Insert manufacturer's name>**

- C. Fence Fabric: Metallic-coated-steel wire.

1. Spacing of Vertical Wires: **[1-3/4 inches (44 mm)][2 inches (51 mm)][3-1/2 inches (89 mm)][4 inches (102 mm)][As indicated on Drawings]<Insert spacing>**.
2. Vertical Wire Size: **[0.187 inch (4.76 mm)][0.192 inch (4.88 mm)][0.225 inch (5.72 mm)][0.25 inch (6.35 mm)][0.262 inch (6.67 mm)]<Insert size>**.
3. Spacing of Horizontal Wires: **[1-3/4 inches (44 mm)][2 inches (51 mm)][4 inches (102 mm)][8 inches (203 mm)][As indicated on Drawings]<Insert spacing>**.
4. Horizontal Wire Size: **[0.187 inch (4.76 mm)][0.192 inch (4.88 mm)][0.225 inch (5.72 mm)][0.25 inch (6.35 mm)][0.312 inch (7.94 mm)]<Insert size>**.

- D. Posts:

1. Line Posts: Square tubes **[2 by 2 inches (50 by 50 mm)][2-1/2 by 2-1/2 inches (64 by 64 mm)][3 by 3 inches (76 by 76 mm)]** formed from **[0.064-inch (1.63-mm)][0.079-inch (2.01-mm)][0.108-inch (2.74-mm)]** nominal-thickness, metallic-coated steel sheet or formed from **[0.060-inch (1.52-mm)][0.075-inch (1.90-mm)][0.105-inch (2.66-mm)]** nominal-thickness steel sheet and hot-dip galvanized after fabrication.
2. End and Corner Posts: Square tubes **[2-1/2 by 2-1/2 inches (64 by 64 mm)][3 by 3 inches (76 by 76 mm)]** formed from **0.108-inch (2.74-mm)** nominal-thickness, metallic-coated steel sheet or formed from **0.105-inch (2.66-mm)** nominal-thickness steel sheet and hot-dip galvanized after fabrication.
3. Posts at Swing Gate Openings:
 - a. Square tubes **3 by 3 inches (76 by 76 mm)** formed from **0.108-inch (2.74-mm)** nominal-thickness, metallic-coated steel sheet or formed from **0.105-inch (2.66-mm)** nominal-thickness steel sheet and hot-dip galvanized after fabrication.
 - b. Square steel tubing **[3 by 3 inches (76 by 76 mm)][4 by 4 inches (102 by 102 mm)]<Insert dimensions>** with **[3/16-inch (4.76-mm)]<Insert dimension>** wall thickness, hot-dip galvanized.
4. Posts at Horizontal-Slide Gate Openings up to 12 Ft. (3.7 m): Square steel tubing **[3 by 3 inches (76 by 76 mm)][4 by 4 inches (102 by 102 mm)]<Insert dimensions>** with **[3/16-inch (4.76-mm)]<Insert dimension>** wall thickness, hot-dip galvanized.
5. Posts at Horizontal-Slide Gate Openings Wider than 12 Ft. (3.7 m): Square steel tubing **4 by 4 inches (102 by 102 mm)** with **[3/16-inch (4.76-mm)]<Insert dimension>** wall thickness, hot-dip galvanized.
6. Guide Posts for Class 1 Horizontal-Slide Gates:

- a. Square tubes **3 by 3 inches (76 by 76 mm)** formed from **0.108-inch (2.74-mm)** nominal-thickness, metallic-coated steel sheet or formed from **0.105-inch (2.66-mm)** nominal-thickness steel sheet and hot-dip galvanized after fabrication; installed adjacent to gate post to permit gate to slide in space between.
 - b. Square steel tubing **3 by 3 inches (76 by 76 mm)****[4 by 4 inches (102 by 102 mm)]****<Insert dimensions>** with **3/16-inch (4.76-mm)****<Insert dimension>** wall thickness, hot-dip galvanized; installed adjacent to gate post to permit gate to slide in space between.
- E. Post Caps: **[Formed from steel sheet and hot-dip galvanized after forming]****[UV-resistant plastic]****[Aluminum castings]****[Aluminum castings with round ball finials]**.
- F. Rails: Rectangular tubes.
 - 1. Size: **[1-3/16 by 1-1/2 inches (30 by 38 mm)]****[1-3/8 by 1-1/2 inches (35 by 38 mm)]** or **1-1/2 by 1-1/2 inches (38 by 38 mm)**.
 - 2. Metal and Thickness: **[0.064-inch (1.63-mm)]****[0.079-inch (2.01-mm)]** nominal-thickness, metallic-coated steel sheet or **[0.060-inch (1.52-mm)]****[0.075-inch (1.90-mm)]** nominal-thickness, uncoated steel sheet, hot-dip galvanized after fabrication.
- G. Fasteners: Manufacturer's standard **[tamperproof]**, corrosion-resistant, color-coated fasteners matching fence components **[with resilient polymer washers or clips]**.
- H. Finish: **[Organic coating complying with requirements in ASTM F2408]****[Powder coating]**.

2.3 SWING GATES

- A. Gate Configuration: **[Single leaf]****[Double leaf]** for **[pedestrian]****[and]****[vehicle]** systems.
- B. Gate Frame Height: **[72 inches (1830 mm)]****[As indicated on Drawings]****<Insert height>**.
- C. Gate Opening Width: **[36 inches (914 mm)]****[As indicated on Drawings]****<Insert width>**.
- D. Gate Type: **[As indicated on Drawings]****[Pedestrian gate assembly]****[Automated pedestrian gates in accordance with BHMA A156.19 or A156.10]**.
 - 1. Automated vehicular gates are to comply with ASTM F2200, **[Class I]****[Class II]****[Class III]****[Class IV]**.
- E. Galvanized-Steel Frames and Bracing: Fabricate members from square tubes **1-1/2 by 1-1/2 inches (38 by 38 mm)****[1-3/4 by 1-3/4 inches (45 by 45 mm)]****[2 by 2 inches (50 by 50 mm)]****[2-1/2 by 2-1/2 inches (64 by 64 mm)]** formed from **0.108-inch (2.74-mm)** nominal-thickness, metallic-coated steel sheet or formed from **0.105-inch (2.66-mm)** nominal-thickness steel sheet and hot-dip galvanized after fabrication.
- F. Frame Corner Construction: **[Welded]****[or]****[assembled with corner fittings]****[and 5/16-inch- (7.9-mm-) diameter, adjustable truss rods for panels 5 ft. (1.52 m) wide or wider]**.
- G. Additional Rails: Complying with requirements for fence rails.
- H. Gate Infill: Welded-wire fence fabric matching adjacent fence.
- I. Hardware: Latches permitting operation from both sides of gate, hinges, and keepers for each gate leaf more than **5 ft. (1.52 m)** wide. Provide **[center gate stops]****[and]****[cane bolts]** for pairs of gates.

Fabricate latches with integral eye openings for padlocking; padlock accessible from both sides of gate.]

1. **<Insert requirements for padlocks and chains if not Owner furnished>.**

J. Spring Hinges: BHMA A156.17, Grade 1, suitable for exterior use.

1. Function: **[320 - Gate spring pivot hinge. Adjustable tension][321 - Gate spring pivot hinge. Fixed tension].**
2. Material: Malleable iron; galvanized.

K. Hinges: BHMA A156.1, Grade 1, suitable for exterior use.

1. Function: 39 - Full surface, triple weight, antifriction bearing.
2. Material: Wrought steel, forged steel, cast steel, or malleable iron; galvanized.

L. Rim Locks: BHMA A156.5, Grade 1, suitable for exterior use.

1. Function: **[621 - Latchbolt by key from outside and by turn from inside. Latchbolt is held retracted by device from inside][622 - Deadbolt by key from outside and by turn from inside][626 - Interlocking deadbolt operated by key from either side][627 - Interlocking deadbolt operated by key from outside and by turn from inside][629 - Deadlocking latchbolt by key from outside and by turn from inside]<Insert function>.**
2. Material: Cast, forged, or extruded brass or bronze.
3. Mounting Plate: Configuration necessary for mounting locks. Fabricate from **1/8-inch- (3.2-mm-)** thick steel plate; hot-dip galvanize after fabrication.

M. Mortise Locks: BHMA A156.13, Grade 1, suitable for exterior use.

1. Function: **[F06 - Holdback lock][F07 - Storeroom or closet lock][F09 - Apartment, exit, or public toilet lock][F16 - Double-cylinder deadlock][F17 - Deadlock]<Insert function>.**
2. Material: Brass or bronze.
3. Levers: Cast, forged, or extruded brass or bronze.
4. Mounting Box: Configuration necessary to enclose locks. Fabricate from **1/8-inch- (3.2-mm-)** thick steel plate; hot-dip galvanize after fabrication.

N. Electric Strikes: BHMA A156.31, Grade 1, of configuration required for use with lock specified, fail**[- safe][-secure]**, and suitable for exterior use.

1. Mounting Plate: Configuration necessary for mounting electric strikes. Fabricate from **1/8-inch- (3.2-mm-)** thick steel plate; hot-dip galvanize after fabrication.
2. Mounting: Mortise into post.

O. Exit Hardware: BHMA A156.3, Grade 1, Type 1 (rim exit device), with push-pad-actuating bar, suitable for exterior use.

1. Function: **[01 - Exit only, no trim or blank escutcheon][04 - Entrance by trim when latch bolt is released by key or set in a retracted position by key][08 - Entrance by lever. Key locks or unlocks lever][09 - Entrance by lever only when released by key. Key removable only when locked]<Insert function>.**
2. Mounting Channel: Bent-plate channel formed from **1/8-inch- (3.2-mm-)** thick steel plate; hot-dip galvanized after fabrication. Channel spans gate frame. Exit device is mounted on channel web, recessed between flanges, with flanges extending **1/8 inch (3.2 mm)** beyond push-pad surface.

P. Cane Bolts: Provide for inactive leaf of pairs of gates. Fabricated from **[1/2-inch- (12.7-mm-)][3/4-inch- (19-mm-)]** diameter round steel bars, hot-dip galvanized after fabrication. Finish to match gates. Provide

galvanized-steel pipe strikes to receive cane bolts in **[closed position][both open and closed positions]**.

- Q. Finish exposed welds to comply with NOMMA Guideline 1, **[Finish #2 - completely sanded joint, some undercutting and pinholes okay][Finish #3 - partially dressed weld with splatter removed][Finish #4 - good-quality, uniform undressed weld with minimal splatter]**.
- R. Metallic-Coated-Steel Finish: **[High-performance coating][Galvanized finish]**.

2.4 HORIZONTAL-SLIDE GATES

- A. Gate Configuration: **[Single leaf][Double leaf]** for **[pedestrian][and][vehicle]** assembly.
 - 1. Type:
 - a. Overhead slide.
 - b. Cantilever slide, with **[external][internal]** roller assemblies.
- B. Gate Frame Height: **[72 inches (1830 mm)][As indicated on Drawings]<Insert height>**.
- C. Gate Opening Width: **[36 inches (914 mm)][As indicated on Drawings]<Insert width>**.
- D. Automated vehicular gates are to comply with ASTM F2200, **[Class I][Class II][Class III][Class IV]**.
- E. Galvanized-Steel Frames and Bracing: Fabricate members from square tubing.
 - 1. Frame Members: Square tubes **[1-1/2 by 1-1/2 inches (38 by 38 mm)][1-3/4 by 1-3/4 inches (45 by 45 mm)][2 by 2 inches (50 by 50 mm)][2-1/2 by 2-1/2 inches (64 by 64 mm)]** formed from **0.108-inch (2.74-mm)** nominal-thickness, metallic-coated steel sheet or formed from **0.105-inch (2.66-mm)** nominal-thickness steel sheet and hot-dip galvanized after fabrication.
 - 2. Bracing Members: Square tubes **[1-1/2 by 1-1/2 inches (38 by 38 mm)][1-3/4 by 1-3/4 inches (45 by 45 mm)][2 by 2 inches (50 by 50 mm)][2-1/2 by 2-1/2 inches (64 by 64 mm)]** formed from **0.108-inch (2.74-mm)** nominal-thickness, metallic-coated steel sheet or formed from **0.105-inch (2.66-mm)** nominal-thickness steel sheet and hot-dip galvanized after fabrication.
- F. Frame Corner Construction:
 - 1. Welded frame **[with panels assembled with bolted or riveted corner fittings][and 5/16-inch- (7.9-mm-) diameter, adjustable truss rods for panels 5 ft. (1.52 m) wide or wider]**.
 - 2. Overhead Slide Gates: Welded or assembled with corner fittings **[including 5/16-inch- (7.9-mm-) diameter, adjustable truss rods for panels 5 ft. (1.52 m) wide or wider]**.
- G. Additional Rails: Complying with requirements for fence rails.
- H. Gate Infill: Comply with requirements for adjacent fence.
- I. Overhead Track Assembly: Manufacturer's standard track, with overhead framing supports, bracing, and accessories, engineered to support size, weight, width, operation, and design of gate and roller assemblies.
- J. Hardware: Latches permitting operation from both sides of gate, **[locking devices][hangers][roller assemblies]<Insert hardware items and accessories>** and stops fabricated from **[galvanized steel][galvanized malleable iron][mill-finished, Grade 319 aluminum-alloy casting with stainless**

steel fasteners].[Fabricate latches with integral eye openings for padlocking; padlock accessible from both sides of gate.]

1. <Insert requirements for padlocks and chains if not Owner furnished>.

K. Finish exposed welds to comply with NOMMA Guideline 1, [Finish #2 - completely sanded joint, some undercutting and pinholes okay][Finish #3 - partially dressed weld with splatter removed][Finish #4 - good-quality, uniform undressed weld with minimal splatter].

L. Metallic-Coated-Steel Finish: [High-performance coating][Galvanized finish].

2.5 GATE OPERATORS

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

1. [Amazing Gates of America LLC]
2. [AutoGate, Inc.]
3. [Begley Automated Gate Systems]
4. [Bryan Systems, Inc.]
5. [CAME Americas Automation LLC]
6. [Chamberlain Group, Inc. (The)]
7. [DoorKing, Inc]
8. [Eagle Access Control Systems, Inc.]
9. [FAAC USA]
10. [Gates That Open, LLC]
11. [Hy-Security Gate, Inc.; Nice North America; Nice group]
12. [Nice USA; Nice North America; Nice group]
13. [TORXUN Inc.]
14. [Tymetal Corp.; The Fort Miller Group, Inc.]
15. [USAutomatic Inc.]
16. [Viking Access Systems LLC; FAAC International Inc.; FAAC SpA]
17. <Insert manufacturer's name>

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

1. [Amazing Gates of America LLC]
2. [AutoGate, Inc.]
3. [Begley Automated Gate Systems]
4. [Bryan Systems, Inc.]
5. [CAME Americas Automation LLC]
6. [Chamberlain Group, Inc. (The)]
7. [DoorKing, Inc]
8. [Eagle Access Control Systems, Inc.]
9. [FAAC USA]
10. [Gates That Open, LLC]
11. [Hy-Security Gate, Inc.; Nice North America; Nice group]
12. [Nice USA; Nice North America; Nice group]
13. [TORXUN Inc.]
14. [Tymetal Corp.; The Fort Miller Group, Inc.]
15. [USAutomatic Inc.]
16. [Viking Access Systems LLC; FAAC International Inc.; FAAC SpA]
17. <Insert manufacturer's name>

- C. Gate Operator Components: Provide factory-assembled automatic operating system designed for gate size, type, weight, and operation frequency. Provide operation control system with characteristics suitable for Project conditions, with remote-control stations, safety devices, and weatherproof enclosures; coordinate electrical requirements with building electrical system.
 - 1. Design operator so that motor may be removed without disturbing limit-switch adjustment and without affecting auxiliary emergency operator.
 - 2. Provide **[UL325 listed operators for swing gates][ANSI 156.19 listed operators for pedestrian gates][ASTM F2200 for automated vehicular gates]**.
- D. Comply with NFPA 70.
- E. UL Standard: Manufacturer and label gate operators to comply with UL 325.
- F. Emergency Access Requirements: Comply with requirements of authorities having jurisdiction for automatic gate operators on gates that must provide emergency access.
- G. Motor Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, within installed environment, with indicated operating sequence, and without exceeding nameplate rating or considering service factor. Comply with NEMA MG 1 and the following:
 - 1. Voltage: **[110 V][220 V][24 V dc][NEMA standard voltage selected to operate on nominal circuit voltage to which motor is connected]<Insert voltage>**.
 - 2. Phase: **[One][Polyphase]**.
 - 3. Enclosure: **[Open dripproof][Totally enclosed][Manufacturer's standard]**.
 - 4. Duty: Continuous duty at ambient temperature of **105 deg F (40 deg C)** and at altitude of **3300 ft. (1005 m)** above sea level.
 - 5. Service Factor: 1.15 for open dripproof motors; 1.0 for totally enclosed motors.
- H. Gate Operator Supports: **[Gate][Concrete base][Post][In-ground]** mounted and as follows:
 - 1. Hydraulic Gate Operators: **[Swing][Slide]**.
 - a. Duty: **[Light][Medium][Heavy]** duty, **[residential][commercial/industrial]**.
 - b. Gate Speed: Fully open to fully close. Speed as recommended in writing by manufacturer.
 - c. Maximum Gate Weight: **[800 lb (363 kg)]<Insert value>**.
 - d. Frequency of Use: **[10 cycles per hour][25 cycles per hour][Continuous duty]**.
 - e. Hydraulic Fluid: Of viscosity required for gate operation at ambient temperature range for Project.
 - f. Locking: Hydraulic in both directions.
 - 2. Mechanical Gate Operators: **[Swing][Slide]**.
 - a. Duty: **[Light][Medium][Heavy]** duty, **[residential][commercial/industrial]**.
 - b. Gate Speed: Fully open to fully close. Speed as recommended in writing by manufacturer.
 - c. Maximum Gate Weight: **[600 lb (272 kg)][800 lb (363 kg)][3000 lb (1360 kg)]<Insert value>**.
 - d. Frequency of Use: **[10 cycles per hour][25 cycles per hour][60 cycles per hour][Continuous duty]**.
 - e. Operating Type: **[Crank arm][Wheel-and-rail drive][Roller chain][, with manual release]**.
 - f. **<Insert gate operator feature>**.
- I. Activation Controls: Electric controls separated from gate and motor and drive mechanism, with **[NEMA ICS 6, Type 1][NEMA ICS 6, Type 4]<Insert type of enclosure>** enclosure for **[surface][recessed or flush][concrete base][pedestal]<Insert mounting>** mounting, and with space for additional optional

equipment. Provide the following remote-control device(s):

1. Control Station:
 - a. Keyed, **[two][three]**-position switch with open[, **stop**,] and close function; located remotely from gate. Provide two keys per station.
 - b. Momentary-contact, **[single][three]**-button-operated with open[, **stop**,] and close function; located remotely from gate. **[Key switch to lock out open and close buttons.]**
 - c. **<Insert other control station type>**
2. Card Reader: Functions only when authorized card is presented. Programmable, **[multiple][single]**-code system[, **permitting four different access periods**]; **face-lighted unit fully visible at night**.
 - a. Reader Type: **[Touch plate][Swipe][Insertion][Proximity]**.
 - b. Features: **[Timed antipassback][Limited-time usage][Capable of monitoring and auditing gate activity]**.
 - c. **<Insert other card reader type and features>**.
3. Digital Keypad Entry Unit: **[Programmable]**, multiple-code capability of not less than **[five][500][2500]****<Insert number>** possible individual codes, consisting of **[1- to 7][4][5]**-digit codes[, **and permitting four different access periods**].
 - a. Features: **[Timed antipassback][Limited-time usage][Capable of monitoring and auditing gate activity]**.
 - b. Face-lighted unit with **[metal-keyed][keyless-membrane]** keypad fully visible at night.
4. Radio Control: Digital system consisting of code-compatible universal receiver for each gate, located where indicated on Drawings, with remote antenna with coaxial cable and mounting brackets designed to operate gates. Provide **[one][two]****<Insert number>** programmable transmitter(s) with multiple-code capability permitting validating or voiding of not less than **[1000][10,000]****<Insert number>** codes per channel configured for the following functions:
 - a. Transmitters: **[Single][Three]**-button operated, with open **[and close]**function.
5. Telephone Entry System: Hands-free, voice-communication system for connection to building telephone system with digital-entry code activation of gate operator **[and auxiliary keypad entry]**.
 - a. Residential System: Designed to be wired to same line with telephone.
 - b. Multiunit System: Designed to be wired to a dedicated telephone line, with capacity to access **[20][100]****<Insert number>** telephones[, **and with electronic directory**].
 - c. **<Insert other telephone-entry system type and features>**.
 - d. Intercom System: **<Insert requirements>**.
- J. Vehicle-Sensing System: System includes automatic closing timer with adjustable time delay[, **timer cutoff switch**,] and loop detector designed to **[open and close gate][hold gate open until traffic clears][reverse gate]****<Insert function>**. System includes electronic detector with adjustable detection patterns, adjustable sensitivity and frequency settings, and panel indicator light designed to detect presence or transit of a vehicle over an embedded loop of wire and to emit a signal that activates the gate operator. Consult detection system manufacturer's written recommendations for number of loops consisting of multiple strands of wire, number of turns, loop size, and method of placement, and indicate locations on Drawings.
- K. Obstruction-Detection Devices: Provide each motorized gate with automatic safety sensor(s). Activation of sensor(s) causes operator to immediately function as follows:

1. Action: **[Reverse gate in both opening and closing cycles, and hold until clear of obstruction]. [Stop gate in opening cycle and reverse gate in closing cycle, and hold until clear of obstruction].**
 2. Internal Sensor: Built-in torque or current monitor senses gate is obstructed.
 3. Sensor Edge: Contact-pressure-sensitive safety edge, profile, and sensitivity designed for type of gate and component indicated, on Drawings in locations as recommended in writing by manufacturer. Connect to control circuit using **[take-up cable reel][self-coiling cable][gate edge transmitter and operator receiver system].**
 4. **<Insert other obstruction-detection device>.**
 5. Photoelectric/Infrared Sensor System: Designed to detect an obstruction in gate's path when infrared beam in the zone pattern is interrupted.
- L. Emergency Release Mechanism: Quick-disconnect release of operator drive system of the following type, permitting manual operation if operator fails. Design system so control-circuit power is disconnected during manual operation.
1. Type: **[Integral fail-safe release, allowing gate to be pushed open without mechanical devices, keys, cranks, or special knowledge][Mechanical device, key, or crank-activated release].**
- M. Operating Features:
1. Digital Microprocessor Control: Electronic programmable means for setting, changing, and adjusting control features **[with capability for monitoring and auditing gate activity]**. Provide unit that is isolated from voltage spikes and surges.
 2. System Integration: With controlling circuit board capable of accepting any type of input from external devices.
 3. Primary/Secondary Capability: Control stations designed and wired for gate pair operation.
 4. Automatic Closing Timer: With adjustable time delay before closing **[and timer cutoff switch]**.
 5. Open Override Circuit: Designed to override closing commands.
 6. Reversal Time Delay: Designed to protect gate system from shock load on reversal in both directions.
 7. Maximum Run Timer: Designed to prevent damage to gate system by shutting down system if normal time to open gate is exceeded.
- N. Clock Timer: **[24-hour][Seven-day]<Insert time>** programmable for regular events.
- O. Battery Backup System: Battery-powered drive and access-control system, independent of primary drive system.
1. Fail-Safe: Gate opens and remains open until power is restored.
 2. Fail-Secure: Gate cycles on battery power, then fail-safe when battery is drained.
- P. Accessories:
1. Warning Module: **[Audio][Visual], [constant][strobe]-light** alarm sounding three to five seconds in advance of gate operation and continuing until gate stops moving; compliant with the United States Access Board's ADA-ABA Accessibility Guidelines.
 2. External electric-powered **[solenoid][magnetic]** lock with delay timer allowing time for lock to release before gate operates.
 3. **[Fire][Postal]** box.
 4. Fire **[strobe][siren]** sensor.
 5. Instructional, Safety, and Warning Labels and Signs: **[In accordance with UL 325][Manufacturer's standard for components and features specified][As indicated on Drawings]<Insert requirements>.**

6. Equipment Bases/Pads: Precast concrete, [**depth not less than 12 inches (300 mm)**]**<Insert depth>**, dimensioned and reinforced in accordance with gate-operator-component manufacturer's written instructions and as indicated on Drawings.

2.6 STEEL AND IRON MATERIALS

- A. Metallic-Coated-Steel Wire: Welded-wire fence fabric, hot-dip galvanized after fabrication. Weight of zinc coating is not to be less than **1.0 oz./sq. ft. (305 g/sq. m)**.
- B. Plates, Shapes, and Bars: ASTM A36/A36M.
- C. Tubing: ASTM A500/A500M, cold-formed steel tubing.
- D. Uncoated Steel Sheet: [**Hot-rolled steel sheet, ASTM A1011/A1011M, Structural Steel, Grade 45 (Grade 310)**]**[or][cold-rolled steel sheet, ASTM A1008/A1008M, Structural Steel, Grade 50 (Grade 340)]**.
 1. Interior surface of tubes formed from uncoated steel sheet is to be [**hot-dip zinc coated same as exterior**]**[or][coated with zinc-rich thermosetting coating to comply with ASTM F2408]**.
- E. Metallic-Coated Steel Sheet: Galvanized-steel sheet or aluminum-zinc, alloy-coated steel sheet.
- F. Galvanized-Steel Sheet: ASTM A653/A653M, structural quality, **Grade 50 (Grade 340)**, with [**G90 (Z275)**]**[G60 (Z180)]** coating.
- G. Aluminum-Zinc, Alloy-Coated Steel Sheet: ASTM A792/A792M, structural quality, **Grade 50 (Grade 340)**, with **AZ60 (AZM180)** coating.
- H. Iron Castings: Either gray or malleable iron unless otherwise indicated.
 1. Gray Iron: ASTM A48/A48M, Class 30.
 2. Malleable Iron: ASTM A47/A47M.
- I. Aluminum Castings: ASTM B26/B26M, Alloy A356.0-T6.
- J. Galvanizing: For components indicated to be galvanized and for which galvanized coating is unspecified, hot-dip galvanize to comply with ASTM A123/A123M. For hardware items, hot-dip galvanize to comply with ASTM A153/A153M.

2.7 COATING MATERIALS

- A. Epoxy Primer for Galvanized Steel: Epoxy primer recommended in writing by topcoat manufacturer.
 1. Products: Subject to compliance with requirements, [**provide the following**]**[provide one of the following][available products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **<Insert manufacturer's name; product name or designation>**.
- B. Polyurethane Intermediate Coat and Topcoat: Complying with MPI #72 and compatible with undercoat.
 1. Products: Subject to compliance with requirements, [**provide the following**]**[provide one of the following][available products that may be incorporated into the Work include, but are not**

limited to, the following]:

- a. <Insert manufacturer's name; product name or designation>.

2.8 MISCELLANEOUS MATERIALS

- A. Welding Rods and Bare Electrodes: Select in accordance with AWS specifications for metal alloy welded.
 1. For aluminum, provide type and alloy as recommended in writing by producer of metal to be welded and as required for strength and compatibility in fabricated items.
- B. Concrete: Normal-weight, air-entrained, ready-mix concrete complying with requirements in Section 033000 "Cast-in-Place Concrete" with a minimum 28-day compressive strength of **3000 psi (20 MPa)**, **3-inch (75-mm)** slump, and **1-inch (25-mm)** maximum aggregate size[**or dry, packaged, normal-weight concrete mix complying with ASTM C387/C387M mixed with potable water in accordance with manufacturer's written instructions**].
- C. Nonshrink Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C1107/C1107M and specifically recommended in writing by manufacturer for exterior applications.

2.9 GROUNDING MATERIALS

- A. Comply with requirements of Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Grounding Conductors: Size as indicated on Drawings. Bare, solid wire for No. 6 AWG and smaller; stranded wire for No. 4 AWG and larger.
 1. Material above Finished Grade: **[Copper][Aluminum]**.
 2. Material on or below Finished Grade: Copper.
 3. Bonding Jumpers: Braided copper tape, **1-5/8 inch (41 mm)** wide and **1/16 inch (1.6 mm)** thick, woven of No. 30 AWG bare copper wire, terminated with copper ferrules.
- C. Grounding Connectors and Grounding Rods: Comply with UL 467.
 1. Connectors for Below-Grade Use: Exothermic-welded type.
 2. Grounding Rods: Copper-clad steel.
 - a. Size: **5/8 by 96 inches (16 by 2440 mm)**.

2.10 STEEL FINISHES

- A. Surface Preparation: Clean surfaces in accordance with **[SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning."][SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."]** After cleaning, apply a conversion coating compatible with the organic coating to be applied over it.
- B. Primer Application: Apply zinc-rich epoxy primer immediately after cleaning, to provide a minimum dry film thickness of **2 mils (0.05 mm)** per applied coat, to surfaces that are exposed after assembly and installation, and to concealed surfaces.

- C. Shop-Painted Finish: Comply with [Section 099113 "Exterior Painting."][Section 099600 "High-Performance Coatings."]
- D. High-Performance Coating: Apply intermediate and polyurethane topcoats to prime-coated surfaces. Comply with coating manufacturer's written instructions and with requirements in SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting. Apply at spreading rates recommended in writing by coating manufacturer.
 - 1. Match approved Samples for color, texture, and coverage. Remove and refinish, or recoat work that does not comply with specified requirements.

2.11 METALLIC-COATED-STEEL FINISHES

- A. Galvanized Finish: Clean welds, mechanical connections, and abraded areas and repair galvanizing to comply with ASTM A780/A780M.
- B. Surface Preparation: Clean surfaces of oil and other contaminants. Use cleaning methods that do not leave residue. After cleaning, apply a [zinc-phosphate]conversion coating compatible with the organic coating to be applied over it. Clean welds, mechanical connections, and abraded areas and apply galvanizing repair paint, complying with SSPC-Paint 20, to comply with ASTM A780/A780M.
- C. Powder Coating: Immediately after cleaning and pretreating, apply manufacturer's standard two-coat finish consisting of [zinc-rich]epoxy prime coat and TGIC polyester topcoat to a minimum dry film thickness of **2 mils (0.05 mm)**. Comply with coating manufacturer's written instructions to achieve a minimum total dry film thickness of **4 mils (0.10 mm)**.
 - 1. Color and Gloss: [As indicated by manufacturer's designations][Match Architect's sample][As selected by Architect from manufacturer's full range]<Insert color and gloss>.
 - 2. Comply with surface finish testing requirements in ASTM F2408[except change corrosion-resistance requirement to 3000 hours without failure].
- D. High-Performance Coating: Apply epoxy primer, polyurethane intermediate coat, and polyurethane topcoat to prepared surfaces. Comply with coating manufacturer's written instructions and with requirements in SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting. Apply at spreading rates recommended in writing by coating manufacturer.
 - 1. Match approved Samples for color, texture, and coverage. Remove and refinish, or recoat work that does not comply with specified requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for site clearing, earthwork, pavement work, construction layout, and other conditions affecting performance of the Work.
- B. Do not begin installation before final grading is completed unless otherwise permitted by Architect.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

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3.2 PREPARATION

- A. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of **500 ft. (152.5 m)** or line of sight between stakes. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.
 - 1. Construction layout and field engineering are specified in Section 017300 "Execution."

3.3 INSTALLATION OF FENCES

- A. Install fences in accordance with manufacturer's written instructions.
- B. Install fences by setting posts as indicated on Drawings and fastening **[rails][and][infill panels]** to posts. **[Peen threads of bolts after assembly to prevent removal.]**
- C. Post Excavation: Drill or hand-excavate holes for posts in firm, undisturbed soil. Excavate holes to a diameter of not less than 4 times post size and a depth of not less than **24 inches (600 mm)** plus **3 inches (75 mm)** for each **foot (300 mm)** or fraction of a **foot (300 mm)** that fence height exceeds **4 ft. (1.2 m)**.
- D. Post Setting: Set posts **[in concrete][with mechanical anchors][by mechanically driving into soil]** at indicated spacing into firm, undisturbed soil.
 - 1. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during setting with concrete or mechanical devices.
 - 2. Concrete Fill: Place concrete around **[posts][and][sleeves]** and vibrate or tamp for consolidation. Protect aboveground portion of posts from concrete splatter.
 - a. Exposed Concrete: Extend **2 inches (50 mm)** above grade. Finish and slope top surface to drain water away from post.
 - b. Concealed Concrete: Top **[2 inches (50 mm)]<Insert dimension>** below grade **[as indicated on Drawings]** to allow covering with surface material. Slope top surface of concrete to drain water away from post.
 - 3. Posts Set in Concrete: Extend post to within **6 inches (150 mm)** of specified excavation depth, but not closer than **3 inches (75 mm)** to bottom of concrete.
 - 4. Posts Set into Concrete in Sleeves: Use galvanized-steel pipe sleeves with inside diameter at least **3/4 inch (20 mm)** larger than outside diagonal dimension of post, preset and anchored into concrete for installing posts.
 - a. Extend posts at least **5 inches (125 mm)** into sleeve.
 - b. After posts have been inserted in sleeves, fill annular space between post and sleeve with nonshrink grout, mixed and placed to comply with grout manufacturer's written instructions; shape and smooth to shed water. Finish and slope top surface of grout to drain water away from post.
 - 5. Posts Set into Voids in Concrete: Form or core drill holes not less than **3/4 inch (20 mm)** larger than outside diagonal dimension of post.
 - a. Extend posts at least **5 inches (125 mm)** into concrete.
 - b. Clean holes of loose material, insert posts, and fill annular space between post and concrete with nonshrink grout, mixed and placed to comply with grout manufacturer's written instructions. Finish and slope top surface of grout to drain water away from post.

6. Mechanically Driven Posts: Drive into soil to depth of [30 inches (762 mm)][36 inches (914 mm)]<Insert dimension>. Protect post top to prevent distortion.
7. Space posts uniformly at [6 ft. (1.83 m)][8 ft. (2.44 m)]<Insert dimension> o.c.

3.4 INSTALLATION OF GATES

- A. Install gates in accordance with manufacturer's written instructions, level, plumb, and secure for full opening without interference. Attach hardware using tamper-resistant or concealed means. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation and lubricate where necessary.

3.5 INSTALLATION OF GATE OPERATORS

- A. General: Install gate operators in accordance with manufacturer's written instructions, aligned and true to fence line and grade.
- B. Excavation: Hand-excavate holes for [support posts][pedestals][concrete bases] in firm, undisturbed soil to dimensions and depths and at locations as required by gate operator component manufacturer's written instructions and as indicated on Drawings.
- C. Concrete Bases: Cast-in-place or precast concrete, [depth not less than 12 inches (300 mm)]<Insert depth>, dimensioned and reinforced in accordance with gate operator component manufacturer's written instructions and as indicated on Drawings.
- D. Vehicle-Sensing System: [Cut grooves in pavement and]bury and seal wire loop in accordance with manufacturer's written instructions. Connect to equipment operated by detector.
- E. Comply with NFPA 70 and manufacturer's written instructions for grounding of electric-powered motors, controls, and other devices.

3.6 GROUNDING AND BONDING

- A. Comply with Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Fence Grounding: Install at maximum intervals of [1500 ft. (450 m)]<Insert a lesser distance if grounding resistance is high> except as follows:
 1. Fences within 100 Ft. (30 m) of Buildings, Structures, Walkways, and Roadways: Ground at maximum intervals of [750 ft. (225 m)]<Insert a lesser distance if grounding resistance is high>.
 - a. Gates and Other Fence Openings: Ground fence on each side of opening.
 - 1) Bond metal gates to gate posts.
 - 2) Bond across openings, with and without gates, except at openings indicated as intentional fence discontinuities. Use No. 2 AWG wire and bury it at least 18 inches (460 mm) below finished grade.
- C. Protection at Crossings of Overhead Electrical Power Lines: Ground fence at location of crossing and at a maximum distance of 150 ft. (45 m) on each side of crossing.
- D. Fences Enclosing Electrical Power Distribution Equipment: Ground as required by IEEE C2 unless

otherwise indicated.

- E. Grounding Method: At each grounding location, drive a grounding rod vertically until the top is **6 inches (150 mm)** below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at grounding location.
- F. Bonding Method for Gates: Connect bonding jumper between gate post and gate frame.
- G. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.
 - 1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
 - 2. Make connections with clean, bare metal at points of contact.
 - 3. Make aluminum-to-steel connections with stainless steel separators and mechanical clamps.
 - 4. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
 - 5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.
- H. Bonding to Lightning-Protection System: If fence terminates at lightning-protected building or structure, ground the fence and bond the fence grounding conductor to lightning-protection down conductor or lightning-protection grounding conductor, complying with NFPA 780.

3.7 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
 - 1. Grounding-Resistance Tests: Subject completed grounding system to a megger test at each grounding location. Measure grounding resistance not less than two full days after last trace of precipitation, without soil having been moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural grounding resistance. Perform tests by two-point method in accordance with IEEE 81.
 - 2. Excessive Grounding Resistance: If resistance to grounding exceeds specified value, notify Architect promptly. Include recommendations for reducing grounding resistance and a proposal to accomplish recommended work.
 - 3. Report: Prepare test reports of grounding resistance at each test location, certified by a testing agency. Include observations of weather and other phenomena that may affect test results.

3.8 ADJUSTING

- A. Gates: Adjust gates to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.
- B. Automatic Gate Operators: Energize circuits to electrical equipment and devices. Adjust operators, controls, safety devices, **[alarms,]** and limit switches.
 - 1. Hydraulic Operators: Purge operating system, adjust pressure and fluid levels, and check for leaks.
 - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor

- rotation and unit operation.
3. Test and adjust controls[, **alarms,**] and safeties. Replace damaged and malfunctioning controls and equipment.

- C. Lubricate hardware[, **gate operators,**] and other moving parts.

3.9 DEMONSTRATION

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

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SECTION 32 31 19 00 - DECORATIVE METAL FENCES AND GATES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Decorative metallic-coated-steel tubular picket fences.
2. Decorative steel fences.
3. Decorative aluminum fences.
4. Swing gates.
5. Horizontal-slide gates.
6. Gate operators.

B. Related Requirements:

1. Section 033000 "Cast-in-Place Concrete" for concrete **[bases for gate operators, drives, and controls][and][post concrete fill]**.
2. Section 281500 "Integrated Access Control Hardware Devices" for access control devices installed at gates and provided as part of a security system.
3. Division 26 Sections for electrical service and connections for system disconnect switches and powered devices including, but not limited to, motor operators, controls, and limit switches.

1.2 PREINSTALLATION MEETINGS

- ##### A. Preinstallation Conference: Conduct conference at **[Project site]<Insert location>**.

1.3 ACTION SUBMITTALS

A. Product Data:

1. For each type of product.

B. Shop Drawings: For fencing and gates.

1. Include plans, elevations, sections, gate locations, post spacing, **[and][mounting][attachment] details[, and grounding details]**.
2. Gate Operator: Show locations and details for installing operator components, switches, and controls. Indicate motor size, electrical characteristics, drive arrangement, mounting, and grounding provisions.
3. Wiring Diagrams: Include diagrams for power, signal, and control wiring.

C. Samples: For each fence material and for each color specified.

1. Provide Samples **[12 inches (300 mm)]<Insert dimension>** in length for linear materials.
2. Provide Samples **[12 inches (300 mm)]<Insert dimension>** square for **[bar grating][and][sheet or plate materials]**.

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1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.
- B. Product Test Reports: For decorative metallic-coated-steel tubular picket fences, including finish, indicating compliance with referenced standards[**and other specified requirements**].

1.5 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For gate operators to include in maintenance manuals.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: Fabricator of products.
- B. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for fabrication and installation.
 - 1. Include **[10 ft. (3 m)]<Insert dimension>** length of fence complying with requirements.
 - 2. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Wind Loading:
 - 1. Fence Height: **[0 to 15 ft. (0 to 4.57 m)][15 to 20 ft. (4.57 to 6.10 m)]**.
 - 2. Wind Exposure Category: **[B][C][D]**.
 - 3. Design Wind Speed: **[105 mph (169 kph)][110 (mph (177 kph)][120 mph (193 kph)][130 mph (209 kph)][140 mph (225 kph)][150 mph (241 kph)][160 mph (257 kph)][170 mph (274 kph)]<Insert wind speed>**.
 - 4. Design Wind Pressure: **<Insert wind pressure>**.
- B. Lightning-Protection System: Maximum grounding-resistance value of 25 ohms under normal dry conditions.

2.2 DECORATIVE METALLIC-COATED-STEEL TUBULAR PICKET FENCES

- A. Decorative Metallic-Coated-Steel Tubular Picket Fence Assembly: Comply with ASTM F2408 for **[residential][light-industrial (commercial)][industrial]** application (class) unless otherwise indicated.
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Ameristar Perimeter Security; ASSA ABLOY]**
 - 2. **[Betafence; Praesidiad Group Limited]**

3. **[Builders Fence Company, Inc.]**
 4. **[Iron Eagle Industries, Inc.]**
 5. **[Iron World Manufacturing, LLC]**
 6. **[Master-Halco, Inc.]**
 7. **[Merchants Metals, LLC]**
 8. **[Virginia Railing and Gates, LLC]**
 9. **[XCEL Fence Inc.]**
 10. **<Insert manufacturer's name>**
- C. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[Ameristar Perimeter Security; ASSA ABLOY]**
 2. **[Betafence; Praesidiad Group Limited]**
 3. **[Builders Fence Company, Inc.]**
 4. **[Iron Eagle Industries, Inc.]**
 5. **[Iron World Manufacturing, LLC]**
 6. **[Master-Halco, Inc.]**
 7. **[Merchants Metals, LLC]**
 8. **[Virginia Railing and Gates, LLC]**
 9. **[XCEL Fence Inc.]**
 10. **<Insert manufacturer's name>**
- D. Posts:
1. End and Corner Posts: Square tubes **[2-1/2 by 2-1/2 inches (64 by 64 mm)]****[3 by 3 inches (76 by 76 mm)]** formed from **0.108-inch (2.74-mm)** nominal-thickness, metallic-coated steel sheet or formed from **0.105-inch (2.66-mm)** nominal-thickness steel sheet and hot-dip galvanized after fabrication.
 2. Posts at Swing Gate Openings:
 - a. Square tubes **3 by 3 inches (76 by 76 mm)** formed from **0.108-inch (2.74-mm)** nominal-thickness, metallic-coated steel sheet or formed from **0.105-inch (2.66-mm)** nominal-thickness steel sheet and hot-dip galvanized after fabrication.
 - b. Square steel tubing **[3 by 3 inches (76 by 76 mm)]****[4 by 4 inches (102 by 102 mm)]****<Insert dimensions>** with **[3/16-inch (4.76-mm)]****<Insert dimension>** wall thickness, hot-dip galvanized.
 3. Posts at Horizontal-Slide Gate Openings up to 12 Ft. (3.7 m): Square steel tubing **[3 by 3 inches (76 by 76 mm)]****[4 by 4 inches (102 by 102 mm)]****<Insert dimensions>** with **[3/16-inch (4.76-mm)]****<Insert dimension>** wall thickness, hot-dip galvanized.
 4. Posts at Horizontal-Slide Gate Openings Wider than 12 Ft. (3.7 m): Square steel tubing **4 by 4 inches (102 by 102 mm)** with **[3/16-inch (4.76-mm)]****<Insert dimension>** wall thickness, hot-dip galvanized.
 5. Guide Posts for Class 1 Horizontal-Slide Gates:
 - a. Square tubes **3 by 3 inches (76 by 76 mm)** formed from **0.108-inch (2.74-mm)** nominal-thickness, metallic-coated steel sheet or formed from **0.105-inch (2.66-mm)** nominal-thickness steel sheet and hot-dip galvanized after fabrication; installed adjacent to gate post to permit gate to slide in space between.
 - b. Square steel tubing **[3 by 3 inches (76 by 76 mm)]****[4 by 4 inches (102 by 102 mm)]****<Insert dimensions>** with **[3/16-inch (4.76-mm)]****<Insert dimension>** wall thickness, hot-dip galvanized; installed adjacent to gate post to permit gate to slide in space between.
- E. Post Caps: **[Formed from steel sheet and hot-dip galvanized after forming]****[UV-resistant plastic]****[Aluminum castings]****[Aluminum castings with round ball finials]**.

- F. Rails: **[Square tubes][Double-wall channels]**.
- Size: **[1-1/2 by 1-1/2 inches (38 by 38 mm)][1-3/4 by 1-3/4 inches (45 by 45 mm)]**.
 - Metal and Thickness: **0.079-inch (2.01-mm)** nominal-thickness, metallic-coated steel sheet or **0.075-inch (1.90-mm)** nominal-thickness, uncoated steel sheet, hot-dip galvanized after fabrication.
- G. Pickets: Square tubes.
- Picket Placement: **[Terminate tops of pickets at top rail for flush top appearance][Extend pickets beyond top rail as indicated on Drawings and terminate with UV-resistant plastic caps][Extend pickets beyond top rail as indicated on Drawings and terminate with galvanized-steel caps][Extend pickets beyond top rail as indicated on Drawings and press flat and trim to produce spear point shape]**.
 - Picket Spacing: **[6 inches (152.4 mm)][4 inches (101.6 mm)][1-3/4 inches (44 mm)]**<Insert dimension> clear, maximum.
- H. Fasteners:
- Manufacturer's standard concealed fastening system.
 - Manufacturer's standard **[tamperproof,]**corrosion-resistant, color-coated fasteners matching fence components**[with resilient polymer washers]**.
- I. Metallic-Coated Steel Sheet: Galvanized-steel sheet or aluminum-zinc, alloy-coated steel sheet.
- J. Interior surface of tubes formed from uncoated steel sheet are to be **[hot-dip zinc coated same as exterior][or][coated with zinc-rich thermosetting coating to comply with ASTM F2408]**.
- K. Galvanizing: For components indicated to be galvanized and for which galvanized coating is not specified in ASTM F2408, hot-dip galvanize to comply with ASTM A123/A123M. For hardware items, hot-dip galvanize to comply with ASTM A153/A153M.
- L. Finish: **[Organic coating complying with requirements in ASTM F2408][Powder coating]**.

2.3 DECORATIVE STEEL FENCES

- A. Decorative Steel Fence Assembly: Fences made from steel tubing**[bars]** and shapes**[, hot-dip galvanized]**.
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
- [A&T Iron Works, Inc]**
 - [Ameristar Perimeter Security; ASSA ABLOY]**
 - [Ametco Manufacturing Corporation]**
 - [BarnettBates Corporation]**
 - [Builders Fence Company, Inc.]**
 - [Fortress Building Products]**
 - [Metalco; MFR Manufacturing Corp, Inc.]**
 - <Insert manufacturer's name>
- C. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. [A&T Iron Works, Inc]
 2. [Ameristar Perimeter Security; ASSA ABLOY]
 3. [Ametco Manufacturing Corporation]
 4. [BarnettBates Corporation]
 5. [Builders Fence Company, Inc.]
 6. [Fortress Building Products]
 7. [Metalco; MFR Manufacturing Corp, Inc.]
 8. <Insert manufacturer's name>
- D. Posts: Square steel tubing.
1. Line Posts: [2 by 2 inches (51 by 51 mm)][2-1/2 by 2-1/2 inches (64 by 64 mm)][3 by 3 inches (76 by 76 mm)]<Insert dimensions> with [1/8-inch (3.2-mm)][3/16-inch (4.76-mm)]<Insert dimension> wall thickness.
 2. End and Corner Posts: [2-1/2 by 2-1/2 inches (64 by 64 mm)][3 by 3 inches (76 by 76 mm)][4 by 4 inches (102 by 102 mm)]<Insert dimensions> with [1/8-inch (3.2-mm)][3/16-inch (4.76-mm)]<Insert dimension> wall thickness.
 3. Swing Gate Posts: [3 by 3 inches (76 by 76 mm)][4 by 4 inches (102 by 102 mm)]<Insert dimensions> with [3/16-inch (4.76-mm)]<Insert dimension> wall thickness.
 4. Horizontal-Slide Gate Post, Openings up to 12 Ft. (3.7 m): [3 by 3 inches (76 by 76 mm)][4 by 4 inches (102 by 102 mm)]<Insert dimensions> with [3/16-inch (4.76-mm)]<Insert dimension> wall thickness.
 5. Horizontal-Slide Gate Post, Openings Wider than 12 Ft. (3.7 m): 4 by 4 inches (102 by 102 mm) with [3/16-inch (4.76-mm)]<Insert dimension> wall thickness.
 6. Guide Posts for Class 1 Horizontal-Slide Gates: [3 by 3 inches (76 by 76 mm)][4 by 4 inches (102 by 102 mm)]<Insert dimensions> with [3/16-inch (4.76-mm)]<Insert dimension> wall thickness; installed adjacent to gate post to permit gate to slide in space between.
- E. Post Caps: [Formed from steel sheet][Formed from steel sheet and hot-dip galvanized after forming][Aluminum castings][Aluminum castings with round ball finials].
- F. Rails:
1. Steel Tube Rails: Square steel tubing [2 by 2 inches (51 by 51 mm)][2-1/2 by 2-1/2 inches (64 by 64 mm)]<Insert dimensions> with [1/8-inch (3.2-mm)]<Insert dimension> wall thickness.
 2. Steel Channel Rails: Steel channels [2 by 1 inch (51 by 25 mm)][1-1/2 by 3/4 inch (38 by 19 mm)][1-1/2 by 1/2 inch (38 by 13 mm)]<Insert dimensions>.
- G. Pickets: [1/2-inch- (13-mm-) square steel bars][3/4-inch- (19-mm-) square steel bars][Decorative steel bars of pattern and size indicated on Drawings][5/8 inch (16 mm) square by 0.065-inch (1.65-mm) steel tubes][5/8 inch (16 mm) square by 0.083-inch (2.11-mm) steel tubes][3/4 inch (19 mm) square by 0.065-inch (1.65-mm) steel tubes][3/4 inch (19 mm) square by 0.083-inch (2.11-mm) steel tubes][1 inch (25 mm) square by 0.065-inch (1.65-mm) steel tubes][1 inch (25 mm) square by 0.083-inch (2.11-mm) steel tubes].
1. Picket Placement: [Terminate tops of pickets at top rail for flush top appearance][Extend pickets beyond top rail as indicated on Drawings and mill ends to pyramid-shaped points][Extend pickets beyond top rail as indicated on Drawings and press flat and trim to produce spear point shape][Extend pickets beyond top rail as indicated on Drawings and cap with metal spear point finial][Extend pickets beyond top rail as indicated on Drawings and cap with metal tripoint finial].
 2. Picket Spacing: [6 inches (152.4 mm)][4 inches (101.6 mm)][1-3/4 inches (44 mm)]<Insert dimension> clear, maximum.
 3. Treillage: Provide iron castings of pattern indicated between each pair of pickets.
- H. Forge-Welded-Steel Bar Grating Infill:

1. Perimeter Bars: Steel flat bars [1 by 1/8 inch (25 by 3.2 mm)]<Insert dimensions>.
 2. Vertical Main Bars: Steel flat bars [1 by 1/8 inch (25 by 3.2 mm)][1-3/16 by 5/32 inch (30 by 4 mm)]<Insert dimensions>.
 3. Vertical Main Bar Spacing: [1-21/32 inches (42 mm)][1-7/8 inches (48 mm)][2-7/16 inches (62 mm)]<Insert dimension> o.c.
 4. Horizontal Cross Rods: [3/16-inch- (4.8-mm-)][1/4-inch- (6.4-mm-)] diameter, steel rods.
 5. Horizontal Cross Rod Spacing: [1-3/4 inches (45 mm)][2-19/32 inches (66 mm)][5-3/16 inches (132 mm)]<Insert dimension> o.c.
- I. Custom Design Infill: As indicated on Drawings.
1. Bars: [1/2-inch- (12.7-mm-) square steel bars][3/4-inch- (19-mm-) square steel bars][1/2-inch- (12.7-mm-) diameter, round steel bars][3/4-inch- (19-mm-) diameter, round steel bars][1-by-1/8-inch (25-by-3.2-mm) steel flat bars][1-by-1/4-inch (25-by-6.4-mm) steel flat bars][1-by-1/2-inch (25-by-12.7-mm) steel flat bars]<Insert dimension> [unless otherwise indicated on Drawings].
 2. Square Tubes: Square steel tubing [2 by 2 inches (51 by 51 mm)][2-1/2 by 2-1/2 inches (64 by 64 mm)]<Insert dimensions> with [1/8-inch (3.2-mm)]<Insert dimension> wall thickness [unless otherwise indicated on Drawings].
 3. Round Tubes: [1-inch- (25-mm-)][1-1/2-inch- (38-mm-)][2-inch- (51-mm-)][2-1/2-inch- (64-mm-)]<Insert dimension> diameter, round steel tubing with [1/8-inch (3.2-mm)]<Insert dimension> wall thickness [unless otherwise indicated on Drawings].
 4. Steel Plate: [1/8 inch (3.2 mm)][3/16 inch (4.8 mm)][1/4 inch (6.4 mm)] thick [unless otherwise indicated on Drawings].
 5. Perforated Metal Sheet: Uncoated steel sheet, perforated as indicated on Drawings, [0.060-inch (1.52-mm)][0.075-inch (1.90-mm)][0.105-inch (2.66-mm)]<Insert dimension> nominal thickness.
- J. Fasteners: Stainless steel carriage bolts and [tamperproof]nuts.
- K. Fabrication:
1. Assemble fences into sections by welding pickets to rails.
 - a. Fabricate sections with clips welded to rails for field fastening to posts.
 - b. Drill posts and clips for fasteners before finishing to maximum extent possible.
 2. Fabricate bar grating infill into sections of size indicated on Drawings.
 - a. Fabricate rails with clips welded to rails for field fastening to posts.
 - b. Drill posts, [clips], and bar grating for fasteners before finishing to maximum extent possible.
- L. Finish exposed welds to comply with NOMMA Guideline 1, [Finish #2 - completely sanded joint, some undercutting and pinholes okay][Finish #3 - partially dressed weld with splatter removed][Finish #4 - good-quality, uniform undressed weld with minimal splatter].
- M. Galvanizing: For items other than hardware that are indicated to be galvanized, hot-dip galvanize to comply with ASTM A123/A123M. For hardware items, hot-dip galvanize to comply with ASTM A153/A153M.
1. Hot-dip galvanize posts [and rails].
 2. Hot-dip galvanize rail and picket assemblies after fabrication.
 3. Hot-dip galvanize bar grating infill after fabrication.
 4. Hot-dip galvanize custom-design rail and infill assemblies after fabrication.

- N. Finish for Bar Grating Infill: Powder coating.
- O. Finish for Steel Items: **[Primed][Shop painted][High-performance coating]**.
- P. Finish for Metallic-Coated-Steel Items: **[High-performance coating][Galvanized finish]**.

2.4 DECORATIVE ALUMINUM FENCES

- A. Decorative Aluminum Fence Assembly: Fences made from aluminum extrusions.
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Alumi-Guard; Barrette Outdoor Living, Inc.]**
 - 2. **[Ameristar Perimeter Security; ASSA ABLOY]**
 - 3. **[Carfaro, Inc.]**
 - 4. **[Delair Group, L.L.C.]**
 - 5. **[East & West Alum Craft Ltd.]**
 - 6. **[Elegant Aluminum Products, Inc.]**
 - 7. **[Elite Fence Products, Inc.]**
 - 8. **[Fortress Building Products]**
 - 9. **[Ideal Aluminum Products]**
 - 10. **[Iron Eagle Industries, Inc.]**
 - 11. **[Japra Group International]**
 - 12. **[Jerith Manufacturing LLC.; ASSA ABLOY]**
 - 13. **[Knotwood US LLC]**
 - 14. **[Master-Halco, Inc.]**
 - 15. **[Merchants Metals, LLC]**
 - 16. **[Royal Aluminum and Steel, Inc.]**
 - 17. **[Specrail]**
 - 18. **[Superior Aluminum Products, Inc]**
 - 19. **[Tek-Rail Inc.]**
 - 20. **[Ultra Aluminum Manufacturing Inc.]**
 - 21. **[Virginia Railing and Gates, LLC]**
 - 22. **<Insert manufacturer's name>**
- C. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Alumi-Guard; Barrette Outdoor Living, Inc.]**
 - 2. **[Ameristar Perimeter Security; ASSA ABLOY]**
 - 3. **[Carfaro, Inc.]**
 - 4. **[Delair Group, L.L.C.]**
 - 5. **[East & West Alum Craft Ltd.]**
 - 6. **[Elegant Aluminum Products, Inc.]**
 - 7. **[Elite Fence Products, Inc.]**
 - 8. **[Fortress Building Products]**
 - 9. **[Ideal Aluminum Products]**
 - 10. **[Iron Eagle Industries, Inc.]**
 - 11. **[Japra Group International]**
 - 12. **[Jerith Manufacturing LLC.; ASSA ABLOY]**
 - 13. **[Knotwood US LLC]**
 - 14. **[Master-Halco, Inc.]**
 - 15. **[Merchants Metals, LLC]**

16. [Royal Aluminum and Steel, Inc.]
17. [Specrail]
18. [Superior Aluminum Products, Inc]
19. [Tek-Rail Inc.]
20. [Ultra Aluminum Manufacturing Inc.]
21. [Virginia Railing and Gates, LLC]
22. <Insert manufacturer's name>

D. Posts: Square extruded tubes.

1. Line Posts: [2 by 2 inches (51 by 51 mm)][2-1/2 by 2-1/2 inches (64 by 64 mm)][3 by 3 inches (76 by 76 mm)]<Insert dimensions> with [0.062-inch (1.57-mm)][0.080-inch (2.03-mm)][0.093-inch (2.36-mm)][0.100-inch (2.54-mm)][0.125-inch (3.18-mm)]<Insert dimension> wall thickness.
2. End and Corner Posts: [2 by 2 inches (51 by 51 mm)][2-1/2 by 2-1/2 inches (64 by 64 mm)][3 by 3 inches (76 by 76 mm)]<Insert dimensions> with [0.062-inch (1.57-mm)][0.080-inch (2.03-mm)][0.093-inch (2.36-mm)][0.100-inch (2.54-mm)][0.125-inch (3.18-mm)]<Insert dimension> wall thickness.
3. Swing Gate Posts: [2-1/2 by 2-1/2 inches (64 by 64 mm)][3 by 3 inches (76 by 76 mm)][4 by 4 inches (102 by 102 mm)]<Insert dimensions> with [0.125-inch (3.18-mm)][0.250-inch (6.35-mm)]<Insert dimension> wall thickness.
4. Horizontal-Slide Gate Post, Openings up to 12 Ft. (3.7 m): [2-1/2 by 2-1/2 inches (64 by 64 mm)][3 by 3 inches (76 by 76 mm)][4 by 4 inches (102 by 102 mm)]<Insert dimensions> with [0.125-inch (3.18-mm)][0.250-inch (6.35-mm)]<Insert dimension> wall thickness.
5. Horizontal-Slide Gate Post, Openings Wider than 12 Ft. (3.7 m): [3 by 3 inches (76 by 76 mm)][4 by 4 inches (102 by 102 mm)][6 by 6 inches (152 by 152 mm)]<Insert dimensions> with [0.125-inch (3.18-mm)][0.250-inch (6.35-mm)]<Insert dimension> wall thickness.
6. Guide Posts for Class 1 Horizontal-Slide Gates: [2 by 2 inches (51 by 51 mm)][2-1/2 by 2-1/2 inches (64 by 64 mm)][3 by 3 inches (76 by 76 mm)]<Insert dimensions> with [0.062-inch (1.57-mm)][0.093-inch (2.36-mm)][0.125-inch (3.18-mm)]<Insert dimension> wall thickness; installed adjacent to gate post to permit gate to slide in space between.

E. Post Caps: Aluminum castings that [cover entire top of posts][project at least 1/4 inch (6 mm) beyond posts][with round ball finial].

F. Rails: Extruded-aluminum channels, [1-1/2 by 1-1/2 inches (38 by 38 mm), with 0.100-inch- (2.54-mm-) thick sidewalls and 0.070-inch- (1.78-mm-) thick top][1 by 1-1/2 inches (25 by 38 mm), with 0.082-inch- (2.08-mm-) thick sidewalls and 0.055-inch- (1.40-mm-) thick top][1-1/4 by 1-1/4 inches (32 by 32 mm), with 0.078-inch- (1.98-mm-) thick sidewalls and 0.062-inch- (1.57-mm-) thick top][1 by 1 inch (25 by 25 mm), with 0.080-inch- (2.03-mm-) thick sidewalls and 0.055-inch- (1.40-mm-) thick top][1 by 1 inch (25 by 25 mm), with 0.078-inch- (1.98-mm-) thick sidewalls and 0.062-inch- (1.57-mm-) thick top].

G. Pickets: Extruded-aluminum tubes, [1 inch (25 mm) square, with 0.062-inch (1.57-mm) wall thickness][1 inch (25 mm) square, with 0.060-inch (1.52-mm) wall thickness][3/4 inch (19 mm) square, with 0.050-inch (1.27-mm) wall thickness][1 by 5/8 inch (25 by 16 mm), with 0.050-inch (1.27-mm) wall thickness][5/8 inch (16 mm) square, with 0.050-inch (1.27-mm) wall thickness].

1. Picket Placement: [Terminate tops of pickets at top rail for flush top appearance][Extend pickets beyond top rail as indicated on Drawings and terminate with UV-resistant plastic caps][Extend pickets beyond top rail as indicated on Drawings and terminate with cast-aluminum caps][Extend pickets beyond top rail as indicated on Drawings and press flat and trim to produce spear point shape][Extend pickets beyond top rail as indicated on Drawings and terminate with cast-aluminum spear point finial][Extend pickets beyond top rail as indicated on Drawings and terminate with cast-aluminum tripoint finial].

2. Picket Spacing: [6 inches (152.4 mm)][4 inches (101.6 mm)][1-3/4 inches (44 mm)]<Insert dimension> clear, maximum.

H. Fasteners:

1. Manufacturer's standard concealed fastening system.
2. Manufacturer's standard [tamperproof,]corrosion-resistant, color-coated fasteners matching fence components[with resilient polymer washers].

I. Fabrication: Assemble fences into sections by [welding][fastening] pickets to rails.

1. Fabricate sections with clips welded to rails for field fastening to posts.
2. Drill clips for fasteners before finishing.

J. Finish exposed welds to comply with NOMMA Guideline 1, [Finish #2 - completely sanded joint, some undercutting and pinholes okay][Finish #3 - partially dressed weld with splatter removed][Finish #4 - good-quality, uniform undressed weld with minimal splatter].

K. Finish Coating: Baked enamel or powder coating.

2.5 SWING GATES

A. Gate Configuration: [Single leaf][Double leaf][As indicated on Drawings].

B. Gate Frame Height: [72 inches (1830 mm)][As indicated on Drawings]<Insert height>.

C. Gate Opening Width: [36 inches (914 mm)][As indicated on Drawings]<Insert width>.

D. Gate Type: [As indicated on Drawings][Pedestrian gate system][Automated pedestrian gates in accordance with BHMA A156.19 or A156.10].

1. Automated vehicular gates are to comply with ASTM F2200, [Class I][Class II][Class III][Class IV].

E. Galvanized-Steel Frames and Bracing: Fabricate members from square tubes [1-1/2 by 1-1/2 inches (38 by 38 mm)][1-3/4 by 1-3/4 inches (45 by 45 mm)][2 by 2 inches (51 by 51 mm)][2-1/2 by 2-1/2 inches (64 by 64 mm)] formed from 0.108-inch (2.74-mm) nominal-thickness, metallic-coated steel sheet or formed from 0.105-inch (2.66-mm) nominal-thickness steel sheet and hot-dip galvanized after fabrication.

F. Steel Frames and Bracing: Fabricate members from square steel tubing [1-1/2 by 1-1/2 inches (38 by 38 mm)][2 by 2 inches (51 by 51 mm)][2-1/2 by 2-1/2 inches (64 by 64 mm)]<Insert dimensions> with [1/8-inch (3.2-mm)]<Insert dimension> wall thickness.[Hot-dip galvanize frames after fabrication.]

G. Frame Corner Construction: [Welded][or][assembled with corner fittings][and 5/16-inch- (7.9-mm-) diameter, adjustable truss rods for panels 5 ft. (1.52 m) wide or wider].

H. Additional Rails: Provide as indicated, complying with requirements for fence rails.

I. Gate Infill: As indicated on Drawings.

J. Hardware: Latches permitting operation from both sides of gate, hinges, and keepers for each gate leaf more than 5 ft. (1.52 m) wide. Provide [center gate stops][and][cane bolts] for pairs of gates.[

Fabricate latches with integral eye openings for padlocking; padlock accessible from both sides of gate.]

1. **<Insert requirements for padlocks and chains if not Owner furnished>.**

K. Spring Hinges: BHMA A156.17, Grade 1, suitable for exterior use.

1. Function: **[320 - Gate spring pivot hinge. Adjustable tension][321 - Gate spring pivot hinge. Fixed tension].**
2. Material: Malleable iron; galvanized.

L. Hinges: BHMA A156.1, Grade 1, suitable for exterior use.

1. Function: 39 - Full surface, triple weight, antifriction bearing.
2. Material: Wrought steel, forged steel, cast steel, or malleable iron; galvanized.

M. Rim Locks: BHMA A156.5, Grade 1, suitable for exterior use.

1. Function: **[621 - Latchbolt by key from outside and by turn from inside. Latchbolt is held retracted by device from inside][622 - Deadbolt by key from outside and by turn from inside][626 - Interlocking deadbolt operated by key from either side][627 - Interlocking deadbolt operated by key from outside and by turn from inside][629 - Deadlocking latchbolt by key from outside and by turn from inside]<Insert function>.**
2. Material: Cast, forged, or extruded brass or bronze.
3. Mounting Plate: Configuration necessary for mounting locks. Fabricate from **1/8-inch- (3.2-mm-) thick [steel plate; galvanized][aluminum plate].**

N. Mortise Locks: BHMA A156.13, Grade 1, suitable for exterior use.

1. Function: **[F06 - Holdback lock][F07 - Storeroom or closet lock][F09 - Apartment, exit, or public toilet lock][F16 - Double-cylinder deadlock][F17 - Deadlock]<Insert function>.**
2. Material: Brass or bronze.
3. Levers: Cast, forged, or extruded brass or bronze.
4. Mounting Box: Configuration necessary to enclose locks. Fabricate from **1/8-inch- (3.2-mm-) thick [steel plate; galvanized][aluminum plate].**

O. Electric Strikes: BHMA A156.31, Grade 1, of configuration required for use with lock specified, fail[-**safe**][-**secure**], and suitable for exterior use.

1. Mounting Plate: Configuration necessary for mounting electric strikes. Fabricate from **1/8-inch- (3.2-mm-) thick [steel plate; galvanized][aluminum plate].**
2. Mounting: Mortise into post.

P. Exit Hardware: BHMA A156.3, Grade 1, Type 1 (rim exit device), with push-pad-actuating bar, suitable for exterior use.

1. Function: **[01 - Exit only, no trim or blank escutcheon][04 - Entrance by trim when latch bolt is released by key or set in a retracted position by key][08 - Entrance by lever. Key locks or unlocks lever][09 - Entrance by lever only when released by key. Key removable only when locked]<Insert function>.**
2. Mounting Channel: Bent-plate channel formed from **1/8-inch- (3.2-mm-) thick [steel][aluminum] plate.** Channel spans gate frame. Exit device is mounted on channel web, recessed between flanges, with flanges extending **1/8 inch (3.2 mm)** beyond push-pad surface.

Q. Cane Bolts: Provide for inactive leaf of pairs of gates. Fabricated from **[1/2-inch- (12.7-mm-)][3/4-inch-**

(19-mm-) diameter round steel bars, hot-dip galvanized after fabrication. Finish to match gates. Provide galvanized-steel pipe strikes to receive cane bolts in **[closed position][both open and closed positions]**.

- R. Finish exposed welds to comply with NOMMA Guideline 1, **[Finish #2 - completely sanded joint, some undercutting and pinholes okay][Finish #3 - partially dressed weld with splatter removed][Finish #4 - good-quality, uniform undressed weld with minimal splatter]**.
- S. Galvanizing: For items other than hardware that are indicated to be galvanized, hot-dip galvanize to comply with ASTM A123/A123M. For hardware items, hot-dip galvanize to comply with ASTM A153/A153M.
- T. Metallic-Coated-Steel Finish: **[High-performance coating][Galvanized finish]**.
- U. Steel Finish: **[Primed][Shop painted][High-performance coating]**.

2.6 HORIZONTAL-SLIDE GATES

- A. Gate Configuration: **[Single leaf][Double leaf]** for **[pedestrian][and][vehicle]** assembly.
 - 1. Type:
 - a. Overhead slide.
 - b. Cantilever slide, with **[external][internal]** roller assemblies.
 - c. Groundtrack slide.
- B. Gate Frame Height: **[72 inches (1830 mm)][As indicated on Drawings]<Insert height>**.
- C. Gate Opening Width: **[36 inches (914 mm)][As indicated on Drawings]<Insert width>**.
- D. Automated vehicular gates are to comply with ASTM F2200, **[Class I][Class II][Class III][Class IV]**.
- E. Galvanized-Steel Frames and Bracing: Fabricate members from square tubing.
 - 1. Frame Members: Square tubes **[1-1/2 by 1-1/2 inches (38 by 38 mm)][1-3/4 by 1-3/4 inches (45 by 45 mm)][2 by 2 inches (51 by 51 mm)][2-1/2 by 2-1/2 inches (64 by 64 mm)]** formed from **0.108-inch (2.74-mm)** nominal-thickness, metallic-coated steel sheet or formed from **0.105-inch (2.66-mm)** nominal-thickness steel sheet and hot-dip galvanized after fabrication.
 - 2. Bracing Members: Square tubes **[1-1/2 by 1-1/2 inches (38 by 38 mm)][1-3/4 by 1-3/4 inches (45 by 45 mm)][2 by 2 inches (51 by 51 mm)][2-1/2 by 2-1/2 inches (64 by 64 mm)]** formed from **0.108-inch (2.74-mm)** nominal-thickness, metallic-coated steel sheet or formed from **0.105-inch (2.66-mm)** nominal-thickness steel sheet and hot-dip galvanized after fabrication.
- F. Steel Frames and Bracing: Fabricate members from square tubing. **[Hot-dip galvanize frames after fabrication.]**
 - 1. Frame Members: Steel tubing **[1-1/2 by 1-1/2 inches (38 by 38 mm)][2 by 2 inches (51 by 51 mm)][2-1/2 by 2-1/2 inches (64 by 64 mm)]<Insert dimensions>** with **[1/8-inch (3.2-mm)]<Insert thickness>** wall thickness.
 - 2. Bracing Members: Steel tubing **[1-1/2 by 1-1/2 inches (38 by 38 mm)][2 by 2 inches (51 by 51 mm)][2-1/2 by 2-1/2 inches (64 by 64 mm)]<Insert dimensions>** with **[1/8-inch (3.2-mm)]<Insert dimension>** wall thickness.
- G. Frame Corner Construction:



1. Welded frame **[with panels assembled with bolted or riveted corner fittings][and 5/16-inch- (7.9-mm-) diameter, adjustable truss rods for panels 5 ft. (1.52 m) wide or wider]**.
2. Overhead Slide Gates: Welded or assembled with corner fittings **[including 5/16-inch- (7.9-mm-) diameter, adjustable truss rods for panels 5 ft. (1.52 m) wide or wider]**.

H. Additional Rails: Provide as indicated, complying with requirements for fence rails.

I. Gate Infill: As indicated on Drawings.

J. Overhead Track Assembly: Manufacturer's standard track, with overhead framing supports, bracing, and accessories, engineered to support size, weight, width, operation, and design of gate and roller assemblies.

K. Hardware: Latches permitting operation from both sides of gate, **[locking devices][hangers][roller assemblies]<Insert hardware items and accessories>** and stops fabricated from **[galvanized steel][galvanized malleable iron][mill-finished, Grade 319 aluminum-alloy casting with stainless steel fasteners]**. **[Fabricate latches with integral eye openings for padlocking; padlock accessible from both sides of gate.]**

1. **<Insert requirements for padlocks and chains if not Owner furnished>**.

L. Finish exposed welds to comply with NOMMA Guideline 1, **[Finish #2 - completely sanded joint, some undercutting and pinholes okay][Finish #3 - partially dressed weld with splatter removed][Finish #4 - good-quality, uniform undressed weld with minimal splatter]**.

M. Galvanizing: For items other than hardware that are indicated to be galvanized, hot-dip galvanize to comply with ASTM A123/A123M. For hardware items, hot-dip galvanize to comply with ASTM A153/A153M.

N. Metallic-Coated-Steel Finish: **[High-performance coating][Galvanized finish]**.

O. Steel Finish: **[Primed][Shop painted][High-performance coating]**.

2.7 GATE OPERATORS

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

1. **[Amazing Gates of America LLC]**
2. **[AutoGate, Inc.]**
3. **[Begley Automated Gate Systems]**
4. **[Bryan Systems, Inc.]**
5. **[CAME Americas Automation LLC]**
6. **[Chamberlain Group, Inc. (The)]**
7. **[DoorKing, Inc]**
8. **[Eagle Access Control Systems, Inc.]**
9. **[FAAC USA]**
10. **[Gates That Open, LLC]**
11. **[Hy-Security Gate, Inc.; Nice North America; Nice group]**
12. **[Nice USA; Nice North America; Nice group]**
13. **[TORXUN Inc.]**
14. **[Tymetal Corp.; The Fort Miller Group, Inc.]**
15. **[USAutomatic Inc.]**

16. [Viking Access Systems LLC; FAAC International Inc.; FAAC SpA]
 17. <Insert manufacturer's name>
- B. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. [Amazing Gates of America LLC]
 2. [AutoGate, Inc.]
 3. [Begley Automated Gate Systems]
 4. [Byan Systems, Inc.]
 5. [CAME Americas Automation LLC]
 6. [Chamberlain Group, Inc. (The)]
 7. [DoorKing, Inc]
 8. [Eagle Access Control Systems, Inc.]
 9. [FAAC USA]
 10. [Gates That Open, LLC]
 11. [Hy-Security Gate, Inc.; Nice North America; Nice group]
 12. [Nice USA; Nice North America; Nice group]
 13. [TORXUN Inc.]
 14. [Tymetal Corp.; The Fort Miller Group, Inc.]
 15. [USAutomatic Inc.]
 16. [Viking Access Systems LLC; FAAC International Inc.; FAAC SpA]
 17. <Insert manufacturer's name>
- C. Gate Operator Components: Provide factory-assembled automatic operating system designed for gate size, type, weight, and operation frequency. Provide operation control system with characteristics suitable for Project conditions, with remote-control stations, safety devices, and weatherproof enclosures; coordinate electrical requirements with building electrical system.
1. Design operator so that motor may be removed without disturbing limit-switch adjustment and without affecting auxiliary emergency operator.
 2. Provide [UL 325-listed operators for swing gates][BHMA A156.19-listed operators for pedestrian gates][ASTM F2200-listed automated vehicular gates].
- D. Comply with NFPA 70.
- E. Emergency Access Requirements: Comply with requirements of authorities having jurisdiction for automatic gate operators on gates that must provide emergency access.
- F. Motor Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, within installed environment, with indicated operating sequence, and without exceeding nameplate rating or considering service factor. Comply with NEMA MG 1 and the following:
1. Voltage: [110 V][220 V][24 V dc][NEMA standard voltage selected to operate on nominal circuit voltage to which motor is connected]<Insert voltage>.
 2. Phase: [One][Polyphase].
 3. Enclosure: [Open dripproof][Totally enclosed][Manufacturer's standard].
 4. Duty: Continuous duty at ambient temperature of 105 deg F (40 deg C) and at altitude of 3300 ft. (1005 m) above sea level.
 5. Service Factor: 1.15 for open dripproof motors; 1.0 for totally enclosed motors.
- G. Gate Operator Supports: [Gate][Concrete base][Post][In-ground] mounted and as follows:
1. Hydraulic Gate Operators: [Swing][Slide].
 - a. Duty: [Light][Medium][Heavy] duty, [residential][commercial/industrial].

- b. Gate Speed: Fully open to fully close. Speed as recommended in writing by manufacturer.
 - c. Maximum Gate Weight: **[800 lb (363 kg)]<Insert value>**.
 - d. Frequency of Use: **[10 cycles per hour][25 cycles per hour][Continuous duty]**.
 - e. Hydraulic Fluid: Of viscosity required for gate operation at ambient temperature range for Project.
 - f. Locking: Hydraulic in both directions.
 2. Mechanical Gate Operators: **[Swing][Slide]**.
 - a. Duty: **[Light][Medium][Heavy]** duty, **[residential][commercial/industrial]**.
 - b. Gate Speed: Fully open to fully close. Speed as recommended in writing by manufacturer.
 - c. Maximum Gate Weight: **[600 lb (272 kg)][800 lb (363 kg)][3000 lb (1360 kg)]<Insert value>**.
 - d. Frequency of Use: **[10 cycles per hour][25 cycles per hour][60 cycles per hour][Continuous duty]**.
 - e. Operating Type: **[Crank arm][Wheel-and-rail drive][Roller chain]**, **[with manual release]**.
 - f. **<Insert gate operator feature>**.
- H. Activation Controls: Electric controls separated from gate and motor and drive mechanism, with **[NEMA ICS 6, Type 1][NEMA ICS 6, Type 4]<Insert type of enclosure>** enclosure for **[surface][recessed or flush][concrete base][pedestal]<Insert mounting>** mounting, and with space for additional optional equipment. Provide the following remote-control device(s):
1. Control Station:
 - a. Keyed, **[two][three]**-position switch with open[, **stop**,] and close function; located remotely from gate. Provide two keys per station.
 - b. Momentary-contact, **[single][three]**-button-operated with open[, **stop**,] and close function; located remotely from gate. **[Key switch to lock out open and close buttons.]**
 - c. **<Insert other control station type>**.
 2. Card Reader: Functions only when authorized card is presented. Programmable, **[multiple][single]**-code system[, **permitting four different access periods**]; **face-lighted unit fully visible at night**.
 - a. Reader Type: **[Touch plate][Swipe][Insertion][Proximity]**.
 - b. Features: **[Timed antipassback][Limited-time usage][Capable of monitoring and auditing gate activity]**.
 - c. **<Insert other card reader type and features>**.
 3. Digital Keypad Entry Unit: **[Programmable]**, multiple-code capability of not less than **[five][500][2500]<Insert number>** possible individual codes, consisting of **[one- to seven][four][five]**-digit codes[, **and permitting four different access periods**].
 - a. Features: **[Timed antipassback][Limited-time usage][Capable of monitoring and auditing gate activity]**.
 - b. Face-lighted unit with **[metal-keyed][keyless-membrane]** keypad fully visible at night.
 4. Radio Control: Digital system consisting of code-compatible universal receiver for each gate, located where indicated on Drawings, with remote antenna with coaxial cable and mounting brackets designed to operate gates. Provide **[one][two]<Insert number>** programmable transmitter(s) with multiple-code capability permitting validating or voiding of not less than **[1000][10,000]<Insert number>** codes per channel configured for the following functions:
 - a. Transmitters: **[Single][Three]** button operated, with open **[and close]** function.

5. Telephone Entry System: Hands-free, voice-communication system for connection to building telephone system with digital-entry code activation of gate operator[**and auxiliary keypad entry**].
 - a. Residential System: Designed to be wired to same line with telephone.
 - b. Multiunit System: Designed to be wired to a dedicated telephone line, with capacity to access [20][100]<Insert number> telephones[, **and with electronic directory**].
 - c. <Insert other telephone entry-system type and features>.
 - d. Intercom System: <Insert requirements>.

- I. Vehicle-Sensing System: System includes automatic closing timer with adjustable time delay[, **timer cutoff switch**,] and presence detector designed to [open and close gate][hold gate open until traffic clears][reverse gate]<Insert functions>. System includes electronic detector with adjustable detection patterns, adjustable sensitivity and frequency settings, and panel indicator light designed to detect presence or transit of a vehicle over an embedded loop of wire and to emit a signal that activates the gate operator. Consult detection system manufacturer's written recommendations for number of loops consisting of multiple strands of wire, number of turns, loop size, and method of placement, and indicate locations on Drawings.

- J. Obstruction-Detection Devices: Provide each motorized gate with automatic safety sensor(s). Activation of sensor(s) causes operator to immediately function as follows:
 1. Action: [Reverse gate in both opening and closing cycles, and hold until clear of obstruction][Stop gate in opening cycle and reverse gate in closing cycle, and hold until clear of obstruction].
 2. Internal Sensor: Built-in torque or current monitor senses gate is obstructed.
 3. Sensor Edge: Contact-pressure-sensitive safety edge, profile, and sensitivity designed for type of gate and component indicated on Drawings, in locations as recommended in writing by manufacturer. [take-up cable reel][self-coiling cable][gate edge transmitter and operator receiver system].
 4. <Insert other obstruction-detection device>.
 5. Photoelectric/Infrared Sensor System: Designed to detect an obstruction in gate's path when infrared beam in the zone pattern is interrupted.

- K. Emergency Release Mechanism: Quick-disconnect release of operator drive system of the following type, permitting manual operation if operator fails. Design system so control-circuit power is disconnected during manual operation.
 1. Type: [Integral fail-safe release, allowing gate to be pushed open without mechanical devices, keys, cranks, or special knowledge][Mechanical device, key, or crank-activated release].

- L. Operating Features:
 1. Digital Microprocessor Control: Electronic programmable means for setting, changing, and adjusting control features[**with capability for monitoring and auditing gate activity**]. Provide unit that is isolated from voltage spikes and surges.
 2. System Integration: With controlling circuit board capable of accepting any type of input from external devices.
 3. Primary/Secondary Capability: Control stations designed and wired for gate pair operation.
 4. Automatic Closing Timer: With adjustable time delay before closing[**and timer cutoff switch**].
 5. Open Override Circuit: Designed to override closing commands.
 6. Reversal Time Delay: Designed to protect gate system from shock load on reversal in both directions.
 7. Maximum Run Timer: Designed to prevent damage to gate system by shutting down system if normal time to open gate is exceeded.

32 - Exterior Improvements

- M. Clock Timer: **[24-hour][Seven-day]<Insert time>** programmable for regular events.
- N. Battery Backup System: Battery-powered drive and access-control system, independent of primary drive system.
 - 1. Fail-Safe: Gate opens and remains open until power is restored.
 - 2. Fail-Secure: Gate cycles on battery power, then fail-safe when battery is drained.
- O. Accessories:
 - 1. Warning Module: **[Audio][Visual]**, **[constant][strobe]**-light alarm sounding three to five seconds in advance of gate operation and continuing until gate stops moving; compliant with the United States Access Board's ADA-ABA Accessibility Guidelines.
 - 2. External electric-powered **[solenoid][magnetic]** lock with delay timer allowing time for lock to release before gate operates.
 - 3. **[Fire][Postal]** box.
 - 4. Fire **[strobe][siren]** sensor.
 - 5. Instructional, Safety, and Warning Labels and Signs: **[In accordance with UL 325][Manufacturer's standard for components and features specified][As indicated on Drawings]<Insert requirements>**.
 - 6. Equipment Bases/Pads: Precast concrete, **[depth not less than 12 inches (300 mm)]<Insert depth>**, dimensioned and reinforced in accordance with gate operator component manufacturer's written instructions and as indicated on Drawings.

2.8 STEEL AND IRON MATERIALS

- A. Plates, Shapes, and Bars: ASTM A36/A36M.
- B. Tubing: ASTM A500/A500M, cold-formed steel tubing.
- C. Uncoated Steel Sheet: **[Hot-rolled steel sheet, ASTM A1011/A1011M, Structural Steel, Grade 45 (Grade 310)][or][cold-rolled steel sheet, ASTM A1008/A1008M, Structural Steel, Grade 50 (Grade 340)]**.
- D. Galvanized-Steel Sheet: ASTM A653/A653M, structural quality, **Grade 50 (Grade 340)**, with **[G90 (Z275)][G60 (Z180)]** coating.
- E. Aluminum-Zinc, Alloy-Coated Steel Sheet: ASTM A792/A792M, structural quality, **Grade 50 (Grade 340)**, with **AZ60 (AZM180)** coating.
- F. Castings: Either gray or malleable iron unless otherwise indicated on Drawings.
 - 1. Gray Iron: ASTM A48/A48M, Class 30.
 - 2. Malleable Iron: ASTM A47/A47M.

2.9 COATING MATERIALS

- A. Shop Primers for Steel: Provide primers that comply with **[Section 099113 "Exterior Painting."][Section 099600 "High-Performance Coatings.]**
- B. Shop Primer for Steel: Manufacturer's standard lead- and chromate-free, nonasphaltic, rust-inhibiting primer complying with MPI#79 and compatible with topcoat.

- C. Epoxy Zinc-Rich Primer for Uncoated Steel: Complying with MPI #20 and compatible with coating specified to be applied over it.
 - 1. Products: Subject to compliance with requirements, **[provide the following][provide one of the following][available products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **<Insert manufacturer's name; product name or designation>**.
- D. Epoxy Primer for Galvanized Steel: Epoxy primer recommended in writing by topcoat manufacturer.
 - 1. Products: Subject to compliance with requirements, **[provide the following][provide one of the following][available products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **<Insert manufacturer's name; product name or designation>**.
- E. Epoxy Intermediate Coat for Uncoated Steel: Complying with MPI #77 and compatible with primer and topcoat.
 - 1. Products: Subject to compliance with requirements, **[provide the following][provide one of the following][available products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **<Insert manufacturer's name; product name or designation>**.
- F. Intermediate Coat for Uncoated Steel: Epoxy or polyurethane intermediate recommended in writing by primer and topcoat manufacturer.
 - 1. Products: Subject to compliance with requirements, **[provide the following][provide one of the following][available products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **<Insert manufacturer's name; product name or designation>**.
- G. Polyurethane Topcoat: Complying with MPI #72 and compatible with undercoat.
 - 1. Products: Subject to compliance with requirements, **[provide the following][provide one of the following][available products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **<Insert manufacturer's name; product name or designation>**.

2.10 MISCELLANEOUS MATERIALS

- A. Welding Rods and Bare Electrodes: Select in accordance with AWS specifications for metal alloy welded.
- B. Concrete: Normal-weight, air-entrained, ready-mix concrete complying with requirements in Section 033000 "Cast-in-Place Concrete" with a minimum 28-day compressive strength of **3000 psi (20 MPa)**, **3-inch (75-mm)** slump, and **1-inch (25-mm)** maximum aggregate size[**or dry, packaged, normal-weight concrete mix complying with ASTM C387/C387M mixed with potable water in accordance with manufacturer's written instructions**].

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- C. Nonshrink Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C1107/C1107M and specifically recommended in writing by manufacturer for exterior applications.

2.11 GROUNDING MATERIALS

- A. Comply with requirements of Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Grounding Conductors: Size as indicated on Drawings. Bare, solid wire for No. 6 AWG and smaller; stranded wire for No. 4 AWG and larger.
 - 1. Material above Finished Grade: **Copper**[Aluminum].
 - 2. Material on or below Finished Grade: Copper.
 - 3. Bonding Jumpers: Braided copper tape, **1-5/8 inch (41 mm)** wide and **1/16 inch (1.6 mm)** thick, woven of No. 30 AWG bare copper wire, terminated with copper ferrules.
- C. Grounding Connectors and Grounding Rods: Comply with UL 467.
 - 1. Connectors for Below-Grade Use: Exothermic-welded type.
 - 2. Grounding Rods: Copper-clad steel.
 - a. Size: **5/8 by 96 inches (16 by 2440 mm)**.

2.12 STEEL FINISHES

- A. Surface Preparation: Clean surfaces in accordance with **[SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning."]****[SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."]** After cleaning, apply a conversion coating compatible with the organic coating to be applied over it.
- B. Primer Application: Apply zinc-rich epoxy primer immediately after cleaning, to provide a minimum dry film thickness of **2 mils (0.05 mm)** per applied coat, to surfaces that are exposed after assembly and installation, and to concealed surfaces.
- C. Shop-Painted Finish: Comply with **[Section 099113 "Exterior Painting."]****[Section 099600 "High-Performance Coatings."]**
- D. High-Performance Coating: Apply intermediate and polyurethane topcoats to prime-coated surfaces. Comply with coating manufacturer's written instructions and with requirements in SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting. Apply at spreading rates recommended in writing by coating manufacturer.
 - 1. Match approved Samples for color, texture, and coverage. Remove and refinish, or recoat work that does not comply with specified requirements.

2.13 METALLIC-COATED-STEEL FINISHES

- A. Galvanized Finish: Clean welds, mechanical connections, and abraded areas and repair galvanizing to comply with ASTM A780/A780M.
- B. Surface Preparation: Clean surfaces of oil and other contaminants. Use cleaning methods that do not leave residue. After cleaning, apply a **[zinc-phosphate]** conversion coating compatible with the organic

coating to be applied over it. Clean welds, mechanical connections, and abraded areas and apply galvanizing repair paint, complying with SSPC-Paint 20, to comply with ASTM A780/A780M.

- C. Powder Coating: Immediately after cleaning and pretreating, apply manufacturer's standard two-coat finish consisting of **[zinc-rich]**epoxy prime coat and TGIC polyester topcoat to a minimum dry film thickness of **2 mils (0.05 mm)**. Comply with coating manufacturer's written instructions to achieve a minimum total dry film thickness of **4 mils (0.10 mm)**.
 - 1. Color and Gloss: **[As indicated by manufacturer's designations][Match Architect's sample][As selected by Architect from manufacturer's full range]<Insert color and gloss>**.
 - 2. Comply with surface finish testing requirements in ASTM F2408[**except change corrosion-resistance requirement to 3000 hours without failure**].
- D. High-Performance Coating: Apply epoxy primer, polyurethane intermediate coat, and polyurethane topcoat to prepared surfaces. Comply with coating manufacturer's written instructions and with requirements in SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting. Apply at spreading rates recommended in writing by coating manufacturer.
 - 1. Match approved Samples for color, texture, and coverage. Remove and refinish, or recoat work that does not comply with specified requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for site clearing, earthwork, pavement work, construction layout, and other conditions affecting performance of the Work.
- B. Do not begin installation before final grading is completed unless otherwise permitted by Architect.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of **500 ft. (152.5 m)** or line of sight between stakes. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.
 - 1. Construction layout and field engineering are specified in Section 017300 "Execution."

3.3 INSTALLATION OF DECORATIVE FENCES

- A. Install fences in accordance with manufacturer's written instructions.
- B. Install fences by setting posts as indicated on Drawings and fastening **[rails][and][infill panels]** to posts.[**Peen threads of bolts after assembly to prevent removal.**]
- C. Post Excavation: Drill or hand-excavate holes for posts in firm, undisturbed soil. Excavate holes to a diameter of not less than 4 times post size and a depth of not less than **24 inches (600 mm)** plus **3 inches (75 mm)** for each **foot (300 mm)** or fraction of a **foot (300 mm)** that fence height exceeds **4 ft.**

(1.2 m).

- D. Post Setting: Set posts [in concrete][with mechanical anchors][by mechanically driving into soil] at indicated spacing into firm, undisturbed soil.
1. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during setting with concrete or mechanical devices.
 2. Concrete Fill: Place concrete around [posts][and][sleeves] and vibrate or tamp for consolidation. Protect aboveground portion of posts from concrete splatter.
 - a. Exposed Concrete: Extend **2 inches (51 mm)** above grade. Finish and slope top surface to drain water away from post.
 - b. Concealed Concrete: Top [**2 inches (51 mm)**]**<Insert dimension>** below grade [**as indicated on Drawings**]to allow covering with surface material. Slope top surface of concrete to drain water away from post.
 3. Posts Set in Concrete: Extend post to within **6 inches (150 mm)** of specified excavation depth, but not closer than **3 inches (75 mm)** to bottom of concrete.
 4. Posts Set into Concrete in Sleeves: Use galvanized-steel pipe sleeves with inside diameter at least **3/4 inch (20 mm)** larger than outside diagonal dimension of post, preset and anchored into concrete for installing posts.
 - a. Extend posts at least **5 inches (125 mm)** into sleeve.
 - b. After posts have been inserted in sleeves, fill annular space between post and sleeve with nonshrink grout, mixed and placed to comply with grout manufacturer's written instructions; shape and smooth to shed water. Finish and slope top surface of grout to drain water away from post.
 5. Posts Set into Voids in Concrete: Form or core drill holes not less than **3/4 inch (20 mm)** larger than outside diagonal dimension of post.
 - a. Extend posts at least **5 inches (125 mm)** into concrete.
 - b. Clean holes of loose material, insert posts, and fill annular space between post and concrete with nonshrink grout, mixed and placed to comply with grout manufacturer's written instructions. Finish and slope top surface of grout to drain water away from post.
 6. Mechanically Driven Posts: Drive into soil to depth of [**30 inches (762 mm)**][**36 inches (914 mm)**]**<Insert dimension>**. Protect post top to prevent distortion.
 7. Space posts uniformly at [**6 ft. (1.83 m)**][**8 ft. (2.44 m)**]**<Insert dimension>** o.c.

3.4 INSTALLATION OF GATES

- A. Install gates in accordance with manufacturer's written instructions, level, plumb, and secure for full opening without interference. Attach hardware using tamper-resistant or concealed means. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation and lubricate where necessary.

3.5 INSTALLATION OF GATE OPERATORS

- A. General: Install gate operators in accordance with manufacturer's written instructions, aligned and true to fence line and grade.
- B. Excavation: Hand-excavate holes for [**support posts**][**pedestals**][**concrete bases**] in firm, undisturbed

soil to dimensions and depths and at locations as required by gate operator component manufacturer's written instructions and as indicated on Drawings.

- C. Concrete Bases: Cast-in-place or precast concrete, [**depth not less than 12 inches (300 mm)**]**<Insert depth>**, dimensioned and reinforced in accordance with gate operator component manufacturer's written instructions and as indicated on Drawings.
- D. Vehicle-Sensing System: [**Cut grooves in pavement and**]bury and seal wire loop in accordance with manufacturer's written instructions. Connect to equipment operated by detector.
- E. Comply with NFPA 70 and manufacturer's written instructions for grounding of electric-powered motors, controls, and other devices.

3.6 GROUNDING AND BONDING

- A. Comply with Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Fence Grounding: Install at maximum intervals of [**1500 ft. (450 m)**]**<Insert a lesser distance if grounding resistance is high>** except as follows:
 - 1. Fences within 100 Ft. (30 m) of Buildings, Structures, Walkways, and Roadways: Ground at maximum intervals of [**750 ft. (225 m)**]**<Insert a lesser distance if grounding resistance is high>**.
 - a. Gates and Other Fence Openings: Ground fence on each side of opening.
 - 1) Bond metal gates to gate posts.
 - 2) Bond across openings, with and without gates, except at openings indicated as intentional fence discontinuities. Use No. 2 AWG wire and bury it at least **18 inches (460 mm)** below finished grade.
 - C. Protection at Crossings of Overhead Electrical Power Lines: Ground fence at location of crossing and at a maximum distance of **150 ft. (45 m)** on each side of crossing.
 - D. Fences Enclosing Electrical Power Distribution Equipment: Ground as required by IEEE C2 unless otherwise indicated.
 - E. Grounding Method: At each grounding location, drive a grounding rod vertically until the top is **6 inches (150 mm)** below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at grounding location.
 - F. Bonding Method for Gates: Connect bonding jumper between gate post and gate frame.
 - G. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.
 - 1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
 - 2. Make connections with clean, bare metal at points of contact.
 - 3. Make aluminum-to-steel connections with stainless steel separators and mechanical clamps.
 - 4. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
 - 5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

- H. Bonding to Lightning-Protection System: If fence terminates at lightning-protected building or structure, ground the fence and bond the fence grounding conductor to lightning-protection down conductor or lightning-protection grounding conductor, complying with NFPA 780.

3.7 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
 - 1. Grounding-Resistance Tests: Subject completed grounding system to a megger test at each grounding location. Measure grounding resistance not less than two full days after last trace of precipitation, without soil having been moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural grounding resistance. Perform tests by two-point method in accordance with IEEE 81.
 - 2. Excessive Grounding Resistance: If resistance to grounding exceeds specified value, notify Architect promptly. Include recommendations for reducing grounding resistance and a proposal to accomplish recommended work.
 - 3. Report: Prepare test reports of grounding resistance at each test location certified by a testing agency. Include observations of weather and other phenomena that may affect test results.

3.8 ADJUSTING

- A. Gates: Adjust gates to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.
- B. Automatic Gate Operators: Energize circuits to electrical equipment and devices. Adjust operators, controls, safety devices, **[alarms,]** and limit switches.
 - 1. Hydraulic Operators: Purge operating system, adjust pressure and fluid levels, and check for leaks.
 - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 3. Test and adjust controls, **[alarms,]** and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Lubricate hardware, **[gate operators,]** and other moving parts.

3.9 DEMONSTRATION

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

END OF SECTION 32 31 19 00



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Task	Specification	Specification Description
32 31 19 00	32 31 13 13	High-Security Chain Link Fences and Gates
32 31 34 00	32 31 13 00	Chain Link Fences And Gates
32 32 16 00	03 41 00 00	Precast Structural Concrete



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SECTION 32 32 23 00 - SEGMENTAL RETAINING WALLS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Segmental retaining walls.

B. Related Requirements:

1. Section 312000 "Earth Moving" for excavation for segmental retaining walls, base material, soil fill, fill placement and compaction, and field in-place density testing.

1.2 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at **[Project site]<Insert location>**.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.

B. Shop Drawings:

1. Show sizes, profiles, coursing, and locations of retaining wall units; including backfill and leveling base materials.
2. Show types, sizes, locations of soil reinforcing materials.
3. **<Insert requirements>**.
4. Signed and sealed by the qualified professional engineer responsible for their preparation.

- C. Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors and textures for segmental retaining wall units.

- D. Samples for Verification: Actual sample of finished products for each type of exposed finish of segmental retaining wall units.

1. Size: **[Manufacturers' standard size][full-size units][sections of units not less than 3 inches (75 mm) square]<Insert size>**.

- E. Delegated Design Submittals: For segmental retaining walls, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

F. Sustainable Design Submittals:

1. Product Certificates: For regional materials, indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project and cost for each regional material.
2. Environmental Product Declaration (EPD): For each product.
3. Product Certificates: For indigenous materials, indicating location of material manufacturer and

point of extraction, harvest, or recovery for each raw material. Include distance to Project, means of transportation, and cost for each indigenous material.

4. Environmental Product Declaration: For each product.
5. Product Certificates: For regional materials, indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project, means of transportation, and cost for each regional material.
6. Environmental Product Declaration: For each product.
7. Environmental Product Declaration: For each product.
8. Third-Party Certifications: For each product.
9. Third-Party Certified Life Cycle Assessment: For each product.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency.
- B. Product Certificates: For each type of segmental retaining wall unit[**and soil reinforcement**] from manufacturer.
 1. Include test data for shear strength between segmental retaining wall units in accordance with ASTM D6916.
 2. Include test data for connection strength between segmental retaining wall units and soil reinforcement in accordance with ASTM D6638.
- C. Test and Evaluation Reports:
 1. Product Test Reports: For each type of segmental retaining wall unit[**and soil reinforcement**], for tests performed by [qualified testing agency][manufacturer and witnessed by a qualified testing agency].
 - a. Include test data for shear strength between segmental retaining wall units in accordance with ASTM D6916.
 - b. Include test data for connection strength between segmental retaining wall units and soil reinforcement in accordance with ASTM D6638.
 2. Research Reports: For segmental retaining wall system, from [an agency acceptable to authorities having jurisdiction][ICC-ES]<Insert evaluation agency> showing compliance with [building code requirements]<Insert requirement>.
 3. Preconstruction Test Reports: For segmental retaining wall units[**and soil reinforcement**].
- D. Source Quality-Control Submittals:
 1. Source quality-control reports.
- E. Field Quality-Control Submittals:
 1. Field quality-control reports.
- F. Qualification Statements: For [testing agency]<Insert entity or specialist>.
- G. Delegated design engineer qualifications.

1.5 QUALITY ASSURANCE

A. Qualifications:

1. Installers: Entity that employs installers certified under the National Concrete Masonry Association (NCMA) Certified Segmental Retaining Wall Installer program at the **[Basic][Advanced Commercial]** certification level.
2. Delegated Design Engineer: A professional engineer who is legally qualified to practice in **[state]<Insert jurisdiction>** where Project is located and who is experienced in providing engineering services of the type indicated.
3. Testing Agency: Qualified in accordance with ASTM E329 for testing indicated.

1.6 MOCKUPS

A. Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects.

1. Build mockup of segmental retaining wall **[as indicated on Drawings][approximately 72 inches (1800 mm) long by not less than 36 inches (900 mm) high above finished grade at front of wall]**.
 - a. Include typical soil reinforcement.
 - b. Include typical base and cap or finished top construction.
 - c. Include backfill to typical finished grades at both sides of wall.
 - d. Include typical end construction at one end of mockup.
 - e. Include **36-inch (900-mm)** return at one end of mockup, with typical corner construction.
2. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.7 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Engage a qualified testing agency to perform the following preconstruction testing:

1. Test soil reinforcement and backfill materials for pullout resistance in accordance with ASTM D6706.
2. Test soil reinforcement and backfill materials for coefficient of friction in accordance with ASTM D5321/D5321M.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Store and handle concrete units and accessories to prevent deterioration or damage due to contaminants, breaking, chipping, or other causes.
- B. Store geosynthetics in manufacturer's original packaging with labels intact. Store and handle geosynthetics to prevent deterioration or damage due to sunlight, chemicals, flames, temperatures above **160 deg F (71 deg C)** or below **32 deg F (0 deg C)**, and other conditions that might damage them. Verify identification of geosynthetics before use, and examine them for defects as material is placed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design segmental retaining walls.
- B. Compliance Review: Qualified professional engineer responsible for segmental retaining wall design shall review and approve submittals and source and field quality-control reports for compliance of materials and construction with design.
- C. Structural Performance: Engineering design shall be based on the following loads and be in accordance with **[NCMA's "Design Manual for Segmental Retaining Walls."]**<Insert applicable requirement.>
 - 1. Gravity loads due to soil pressures resulting from grades **[and sloped backfill]** indicated.
 - 2. Superimposed loads (surcharge) indicated on Drawings.
 - 3. Horizontal Peak Ground Acceleration (A) for Project: **<Insert value>**.

2.2 SEGMENTAL RETAINING WALL UNITS

- A. Concrete Units: ASTM C1372, Normal Weight, except that **[maximum water absorption shall not exceed 7 percent by weight and]** units shall not differ in height more than plus or minus **1/16 inch (1.6 mm)** from specified dimension.
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Allan Block Corporation]**
 - b. **[Anchor Wall Systems, Inc]**
 - c. **[CornerStone Wall Solutions Inc.]**
 - d. **[GeoStone Retaining Wall Systems, Inc.]**
 - e. **[Keystone Retaining Wall Systems LLC]**
 - f. **[Nicolock]**
 - g. **[Risi Stone Inc.]**
 - h. **[Rockwood Retaining Walls, Inc.]**
 - i. **[Select ICD; Innovative Concrete Design Corporation]**
 - j. **[Stone Strong Systems]**
 - k. **[Tensar International Corporation]**
 - l. **[Versa-Lok Retaining Wall Systems]**
 - m. **[WestBlock Systems]**
 - n. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Allan Block Corporation]**
 - b. **[Anchor Wall Systems, Inc]**
 - c. **[CornerStone Wall Solutions Inc.]**
 - d. **[GeoStone Retaining Wall Systems, Inc.]**
 - e. **[Keystone Retaining Wall Systems LLC]**

- f. [Nicolock]
 - g. [Risi Stone Inc.]
 - h. [Rockwood Retaining Walls, Inc.]
 - i. [Select ICD; Innovative Concrete Design Corporation]
 - j. [Stone Strong Systems]
 - k. [Tensar International Corporation]
 - l. [Versa-Lok Retaining Wall Systems]
 - m. [WestBlock Systems]
 - n. <Insert manufacturer's name>
3. Provide units that comply with requirements in ASTM C1372 for freeze-thaw durability[**as determined by testing**].
 4. Provide units that interlock with courses above and below by means of [integral lugs, lips, or tongues and grooves][pins][clips][splines][or][and][hollow cores filled with drainage fill].
- B. Regional Materials: Units shall be manufactured within **500 miles (800 km)** of Project site from aggregates[**and cementitious materials**] that have been extracted, harvested, or recovered, as well as manufactured, within **500 miles (800 km)** of Project site.
 - C. Regional Materials: Units shall be manufactured within **100 miles (160 km)** of Project site from aggregates[**and cementitious materials**] that have been extracted, harvested, or recovered, as well as manufactured, within **100 miles (160 km)** of Project site.
 - D. Indigenous Materials: Units shall be manufactured within **500 miles (800 km)** of Project site from aggregates[**and cementitious materials**] that have been extracted, harvested, or recovered, as well as manufactured, within **500 miles (800 km)** of Project site. If materials are transported by rail or water, the distance transported by rail or water shall be multiplied by 0.25 to determine the distance to Project site.
 - E. Regional Materials: Units shall be manufactured within **500 miles (800 km)** of Project site from aggregates[**and cementitious materials**] that have been extracted, harvested, or recovered, as well as manufactured, within **500 miles (800 km)** of Project site. If materials are transported by rail or water, the distance transported by rail or water shall be multiplied by 0.25 to determine the distance to Project site.
 - F. Color: [As indicated by manufacturer's designations][Match Architect's samples][As selected by Architect from manufacturer's full range].
 - G. Shape and Texture:
 1. Provide units with [machine-split textured][smooth], [flat exposed face][shaped exposed face with deeply beveled vertical edges].
 - a. Face Dimensions:
 - 1) [4 inches (100 mm)][6 inches (150 mm)][8 inches (200 mm)]<Insert dimension> high by [12 inches (300 mm)][16 inches (400 mm)][18 inches (460 mm)]<Insert dimension> long.
 - 2) Mix of sizes providing appearance of random range ashlar stone masonry.
 - 3) As indicated.
 2. Provide units matching basic shape, dimensions, and face texture of basis-of-design product.
 3. Provide units of any basic shape and dimensions that produce segmental retaining walls of dimensions and profiles indicated without interfering with other elements of the Work and with [machine-split textured][smooth], [flat exposed face][shaped exposed face with deeply beveled vertical edges].
 - H. Batter: Provide units that offset from course below to provide [at least][1:24][1:16][1:14][1:8][1:5] batter.

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- I. Cap Units: Provide cap units of **[shape indicated][same shape as other units]** with smooth, as-cast top surfaces without holes or lugs.
- J. Special Units: Provide corner units, end units, and other shapes as needed to produce segmental retaining walls of dimensions and profiles indicated and to provide texture on exposed surfaces **[matching face][as indicated]**.

2.3 INSTALLATION MATERIALS

- A. Pins: Product supplied by segmental retaining wall unit manufacturer for use with units provided, made from nondegrading polymer reinforced with glass fibers.
- B. Clips: Product supplied by segmental retaining wall unit manufacturer for use with units provided, made from nondegrading polymer reinforced with glass fibers.
- C. Cap Adhesive: Product supplied or recommended by segmental retaining wall unit manufacturer for adhering cap units to units below.
- D. Leveling Base: Comply with requirements in Section 312000 "Earth Moving" for **[base][drainage]** course.
 - 1. Leveling Course: Lean concrete with a compressive strength of not more than **500 psi (3.4 MPa)**.
- E. Drainage Fill: Comply with requirements in Section 312000 "Earth Moving" for drainage course.
- F. Reinforced Soil Fill:
 - 1. Comply with requirements in Section 312000 "Earth Moving" for satisfactory soils.
 - 2. ASTM D2487; GW, GP, SW, SP, and SM soil classification groups or a combination of these groups; free of debris, waste, frozen materials, vegetation, and other deleterious matter; complying with the following gradation in accordance with ASTM C136/C136M: 20 to 100 percent passing **No. 4 (4.75 mm)** sieve, zero to 60 percent passing **No. 40 (0.425 mm)** sieve, zero to 35 percent passing **No. 200 (0.075 mm)** sieve, and with fine fraction having a plasticity index of less than 20.
- G. Nonreinforced-Soil Fill: Comply with requirements in Section 312000 "Earth Moving" for satisfactory soils.
- H. Impervious Fill: Clayey gravel and sand mixture capable of compacting to a dense state.
- I. Drainage Geotextile: Nonwoven needle-punched geotextile, manufactured for subsurface drainage applications, made from polyolefins or polyesters; with elongation of greater than 50 percent.
 - 1. Apparent Opening Size: **No. 70 to 100 (0.212 to 0.150 mm)** sieve, maximum; ASTM D4751.
 - 2. Minimum Grab Tensile Strength: **110 lb (49.9 kg)**; ASTM D4632/D4632M.
 - 3. Minimum Weight: **4 oz./sq. yd. (132 g/sq. m)**.
- J. Soil Reinforcement: Product specifically manufactured for use as soil reinforcement and as follows:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- a. [Hanes Geo Components; Leggett & Platt Incorporated]
 - b. [Huesker International]
 - c. [Low & Bonar PLC]
 - d. [Luckenhaus Technical Textiles, Inc.]
 - e. [Propex Operating Company, LLC]
 - f. [Strata Systems, Inc]
 - g. [Synteen Technical Fabrics, Inc.]
 - h. [Tenax Corporation]
 - i. [TenCate Geosynthetics]
 - j. [Tensar International Corporation]
 - k. [Versa-Lok Retaining Wall Systems]
 - l. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Hanes Geo Components; Leggett & Platt Incorporated]
 - b. [Huesker International]
 - c. [Low & Bonar PLC]
 - d. [Luckenhaus Technical Textiles, Inc.]
 - e. [Propex Operating Company, LLC]
 - f. [Strata Systems, Inc]
 - g. [Synteen Technical Fabrics, Inc.]
 - h. [Tenax Corporation]
 - i. [TenCate Geosynthetics]
 - j. [Tensar International Corporation]
 - k. [Versa-Lok Retaining Wall Systems]
 - l. <Insert manufacturer's name>
3. Product Type: [Knitted or woven geogrid made from polyester yarns with a protective coating][Molded geogrid made from high-density polyethylene][Woven geotextile made from polyamides, polyesters, or polyolefins].

2.4 SOURCE QUALITY CONTROL

- A. Factory test and inspect each roll of soil reinforcement for minimum average roll values for geosynthetic index property tests, including the following:
 1. Weight.
 2. Grab or single-rib strength.
 3. Aperture opening.
 4. Rib or yarn size.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for excavation tolerances, condition of subgrades, and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF RETAINING WALLS

- A. General: Place units in accordance with NCMA's "Segmental Retaining Wall Installation Guide" and segmental retaining wall unit manufacturer's written instructions.
 - 1. Lay units in **[running bond][bond pattern indicated]**.
 - 2. Form corners and ends by **[using special units][cutting units with motor-driven saw][or][splitting units with mason's hammer and chisel]**.
- B. Do not use units with chips, cracks, or other defects that are visible at a distance of **20 feet (6 m)** where such defects are exposed in the completed Work.
- C. Leveling Base: Place and compact base material to thickness indicated and with not less than 95 percent maximum dry unit weight in accordance with ASTM D698.
 - 1. Leveling Course: **[At Contractor's option, unreinforced lean concrete may be substituted for upper 1 to 2 inches (25 to 50 mm) of base][Place unreinforced lean concrete over leveling base 1 to 2 inches (25 to 50 mm) thick]**. Compact and screed concrete to a smooth, level surface.
- D. First Course: Place first course of segmental retaining wall units for full length of wall. Place units in firm contact with each other, properly aligned and level.
 - 1. Tamp units into leveling base as necessary to bring tops of units into a level plane.
- E. Subsequent Courses: Remove excess fill and debris from tops of units in course below. Place units in firm contact, properly aligned, and directly on course below.
 - 1. For units with lugs designed to fit into holes in adjacent units, lay units so lugs are accurately aligned with holes, and bedding surfaces are firmly seated on beds of units below.
 - 2. For units with lips at front of units, slide units as far forward as possible for firm contact with lips of units below.
 - 3. For units with lips at bottom rear of units, slide units as far forward as possible for firm contact of lips with units below.
 - 4. For units with pins, install pins and align units.
 - 5. For units with clips, install clips and align units.
- F. Cap Units: Place cap units and secure with cap adhesive.

3.3 FILL PLACEMENT

- A. General: Comply with requirements in Section 312000 "Earth Moving," with NCMA's "Segmental Retaining Wall Installation Guide" and segmental retaining wall unit manufacturer's written instructions.
- B. Fill voids between and within units with drainage fill. Place fill as each course of units is laid.
- C. Place, spread, and compact drainage fill and soil fill in uniform lifts for full width and length of embankment as wall is laid. Place and compact fills without disturbing alignment of units. Where both sides of wall are indicated to be filled, place fills on both sides at same time. Begin at wall, and place and spread fills toward embankment.
 - 1. Use only hand-operated compaction equipment within **48 inches (1200 mm)** of wall or one-half of height above bottom of wall, whichever is greater.

2. Compact reinforced-soil fill to not less than 95 percent maximum dry unit weight in accordance with ASTM D698.
 - a. In areas where only hand-operated compaction equipment is allowed, compact fills to not less than 90 percent maximum dry unit weight in accordance with ASTM D698.
 - b. In areas where fill height exceeds **15 feet (4.5 m)**, compact reinforced-soil fill that will be more than **15 feet (4.5 m)** below finished grade to not less than 98 percent maximum dry unit weight in accordance with ASTM D698.
 - c. In areas where fill height exceeds **30 feet (9 m)**, compact reinforced-soil fill that will be more than **30 feet (9 m)** below finished grade to not less than 100 percent maximum dry unit weight in accordance with ASTM D698.
 3. Compact nonreinforced-soil fill to comply with Section 312000 "Earth Moving."
- D. Place drainage geotextile against back of wall, and place layer of drainage fill at least [**12 inches (300 mm)**][**6 inches (150 mm)**] wide behind drainage geotextile to within **12 inches (300 mm)** of finished grade. Place another layer of drainage geotextile between drainage fill and soil fill.
 - E. Place a layer of drainage fill at least [**12 inches (300 mm)**][**6 inches (150 mm)**] wide behind wall to within **12 inches (300 mm)** of finished grade. Place a layer of drainage geotextile between drainage fill and soil fill.
 - F. Wrap subdrainage pipe with filter fabric and place in drainage fill as indicated[, **sloped not less than 0.5 percent to drain**].
 - G. Place impervious fill over top edge of drainage fill layer.
 - H. Slope grade at top of wall away from wall unless otherwise indicated. Slope grade at wall base away from wall. Provide uniform slopes that prevent ponding.
 - I. Place soil reinforcement in horizontal joints of retaining wall where indicated and in accordance with soil-reinforcement manufacturer's written instructions. Embed reinforcement a minimum of **8 inches (200 mm)** into retaining wall and stretch tight over compacted backfill. Anchor soil reinforcement before placing fill.
 1. Place additional soil reinforcement at corners and curved walls to provide continuous reinforcement.
 2. Place geosynthetics with seams, if any, oriented perpendicularly to segmental retaining walls.
 3. Do not dump fill material directly from trucks onto geosynthetics.
 4. Place at least **6 inches (150 mm)** of fill over reinforcement before compacting with tracked vehicles or **4 inches (100 mm)** before compacting with rubber-tired vehicles.
 5. Do not turn vehicles on fill until first layer of fill is compacted and second layer is placed over each soil-reinforcement layer.
- 3.4 CONSTRUCTION TOLERANCES
- A. Variation from Level: For bed-joint lines along walls, do not exceed **1-1/4 inches in 10 feet (32 mm in 3 m)**, **3 inches (75 mm)** maximum.
 - B. Variation from Indicated Batter: For slope of wall face, do not vary from indicated slope by more than **1-1/4 inches in 10 feet (32 mm in 3 m)**.
 - C. Variation from Indicated Wall Line: For walls indicated as straight, do not vary from straight line by more than **1-1/4 inches in 10 feet (32 mm in 3 m)**.

- D. Maximum Gap between Units: **1/8 inch (3 mm)**.

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Comply with requirements in Section 312000 "Earth Moving" for field quality control.
- C. Tests and Inspections:
 - 1. In each compacted backfill layer, perform at least one field in-place compaction test for each **[150 feet (45 m)]<Insert dimension>** or less of segmental retaining wall length.
 - 2. In each compacted backfill layer, perform at least one field in-place compaction test for each **[24 inches (600 mm)]<Insert dimension>** of fill depth and each **[50 feet (15 m)]<Insert dimension>** or less of segmental retaining wall length.
 - 3. Segmental retaining wall system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

3.6 ADJUSTING

- A. Remove and replace segmental retaining wall construction of the following descriptions:
 - 1. Broken, chipped, stained, or otherwise damaged units. Units may be repaired if Architect approves methods and results.
 - 2. Segmental retaining walls that do not match approved Samples **[and mockups]**.
 - 3. Segmental retaining walls that do not comply with other requirements indicated.
- B. Replace units so segmental retaining wall matches approved Samples and mockups, complies with other requirements, and shows no evidence of replacement.

END OF SECTION 32 32 23 00



32 - Exterior Improvements

Task	Specification	Specification Description
32 32 23 13	32 32 23 00	Segmental Retaining Walls
32 32 26 00	32 32 23 00	Segmental Retaining Walls
32 32 29 00	32 32 23 00	Segmental Retaining Walls
32 32 53 00	32 32 23 00	Segmental Retaining Walls



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SECTION 32 33 00 00 - SITE FURNISHINGS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Seating.
2. Tables.
3. Bicycle racks.
4. Bicycle lockers.
5. Trash receptacles.
6. Ash receptacles.
7. Planters.
8. Bollards.

B. Related Requirements:

1. Section 033000 "Cast-in-Place Concrete" for **[installing pipe sleeves cast][installing anchor bolts cast][formed voids]** in concrete footings.
2. Section 312000 "Earth Moving" for excavation for installing concrete footings.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

1. Product Data: For recycled content, indicating postconsumer and preconsumer recycled content and cost.
2. Chain-of-Custody Certificates: For certified wood products. Include statement of costs.

C. Samples: For each exposed product and for each color and texture specified.

D. Samples for Initial Selection: For units with factory-applied finishes.

E. Samples for Verification: For each type of exposed finish, not less than **6-inch- (152-mm-)** long linear components and **4-inch- (102-mm-)** square sheet components.

1. Include full-size Samples of **[bench][table][bicycle rack][trash receptacle][ash receptacle]<Insert product>**. Approved samples may be incorporated into the Work.

F. Product Schedule: For site furnishings. **[Use same designations indicated on Drawings].**

1.3 INFORMATIONAL SUBMITTALS

A. Material Certificates: For site furnishings manufactured with preservative-treated wood.

1. Indicate type of preservative used and net amount of preservative retained. **[For products**

receiving a waterborne treatment, include statement that moisture content of treated materials was reduced to levels specified before shipment to Project site.]

1.4 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For site furnishings to include in maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Bench Replacement [**Slats**][**Planks**]: No fewer than [**two**]**<Insert number>** full-size units for each size indicated.
 2. Trash Receptacle Inner Containers: [**Five**]**<Insert number>** full-size units for each size indicated, but no fewer than [**two**]**<Insert number>** units.
 3. Anchors: **<Insert type and number>**.

PART 2 - PRODUCTS**2.1 SEATING**

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

1. [**4Topps Premium Seating**]
2. [**A&T Iron Works, Inc**]
3. [**BCI Burke Company, LLC**]
4. [**Bison, Inc.**]
5. [**brp by bison**]
6. [**Canterbury Design**]
7. [**Columbia Cascade Company**]
8. [**Country Casual**]
9. [**DuMor Inc.**]
10. [**Fibrex Group, Inc.**]
11. [**Forms+Surfaces**]
12. [**GameTime; a PlayCore Company**]
13. [**Gardenside, Ltd**]
14. [**Henderson Recreation Equipment Ltd**]
15. [**Huntco Supply, LLC**]
16. [**Kay Park Recreation**]
17. [**Keystone Ridge Designs, Inc**]
18. [**Kidstuff Playsystems, Inc.**]
19. [**Kingsley Bate**]
20. [**L.A. Steelcraft, a brand of Americana Outdoor**]
21. [**Landscape Forms**]
22. [**Landscape Structures Inc.**]
23. [**Madrax; Graber Manufacturing, Inc.**]
24. [**Maglin Site Furniture Inc.**]
25. [**Miracle Recreation Equipment Company**]

26. [Neenah Foundry Company]
27. [Petersen Manufacturing Co. Inc.]
28. [Playworld Systems, Inc.]
29. [Reliance Foundry Co. Ltd]
30. [RPI]
31. [Sitecraft]
32. [Smith & Hawken, Ltd.]
33. [SportsPlay Equipment, Inc]
34. [Thomas Steele; Graber Manufacturing, Inc.]
35. [Tournesol Siteworks LLC]
36. [Urban Accessories, Inc]
37. [Victor Stanley, Inc]
38. [Wausau Tile, Inc.]
39. [Weatherend Estate Furniture]
40. <Insert manufacturer's name>

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

1. [4Topps Premium Seating]
2. [A&T Iron Works, Inc]
3. [BCI Burke Company, LLC]
4. [Bison, Inc.]
5. [brp by bison]
6. [Canterbury Design]
7. [Columbia Cascade Company]
8. [Country Casual]
9. [DuMor Inc.]
10. [Fibrex Group, Inc.]
11. [Forms+Surfaces]
12. [GameTime; a PlayCore Company]
13. [Gardenside, Ltd]
14. [Henderson Recreation Equipment Ltd]
15. [Huntco Supply, LLC]
16. [Kay Park Recreation]
17. [Keystone Ridge Designs, Inc]
18. [Kidstuff Playsystems, Inc.]
19. [Kingsley Bate]
20. [L.A. Steelcraft, a brand of Americana Outdoor]
21. [Landscape Forms]
22. [Landscape Structures Inc.]
23. [Madrax; Graber Manufacturing, Inc.]
24. [Maglin Site Furniture Inc.]
25. [Miracle Recreation Equipment Company]
26. [Neenah Foundry Company]
27. [Petersen Manufacturing Co. Inc.]
28. [Playworld Systems, Inc.]
29. [Reliance Foundry Co. Ltd]
30. [RPI]
31. [Sitecraft]
32. [Smith & Hawken, Ltd.]
33. [SportsPlay Equipment, Inc]
34. [Thomas Steele; Graber Manufacturing, Inc.]
35. [Tournesol Siteworks LLC]
36. [Urban Accessories, Inc]
37. [Victor Stanley, Inc]

38. [Wausau Tile, Inc.]
 39. [Weatherend Estate Furniture]
 40. <Insert manufacturer's name>
- C. Frame: [Cast aluminum][Cast iron][Steel][Stainless steel][Wrought iron][Cedar][Teak]<Insert material>.
- D. Seat[and Back]:
1. Material:
 - a. Aluminum Sheet: [Perforated][Expanded] metal.
 - b. [Painted]Steel: [Perforated metal][Expanded metal][Evenly spaced, parallel flat straps or bars][Evenly woven, flat straps or bars][Edge framed, evenly spaced, parallel rods or rolled bars]<Insert description>.
 - c. Stainless Steel: [Perforated metal][Expanded metal][Evenly spaced, parallel flat straps or bars][Evenly woven, flat straps or bars][Edge framed, evenly spaced, parallel rods or rolled bars]<Insert description>.
 - d. Wood: [Douglas fir][Pine][Cedar][Redwood][Teak]<Insert species>; formed into [evenly spaced parallel slats][planks]<Insert description>.
 - e. [Recycled][Plastic][Fiberglass] Planks: [Evenly spaced, parallel]<Insert description>.
 - f. [Recycled][Plastic][Fiberglass] Sheet: [Solid][Perforated].
 2. Seat Height: [As indicated]<Insert dimension>.
 3. Seat Surface Shape: [Flat][Contoured or dished].
 4. Overall Height: [As indicated]<Insert dimension>.
 5. Overall Width: [As indicated]<Insert dimension>.
 6. Overall Depth: [As indicated]<Insert dimension>.
 7. Arms: [None][One, as indicated][Two, one at each end][Three, one at each end and in center]<Insert requirements>.
 - a. Arm Material: Match [frame][seat]<Insert component>.
 8. Weight: <Insert weight>.
 9. Seating Configuration: Multiple units[as indicated].
 - a. [Straight][Angled][Curved] shape.
 - b. Closed [hexagon][circle][shape indicated] around a [tree trunk][planter][light post]<Insert central element>.
- E. Aluminum Finish: [Mill finish][Color coated].
1. Color: [As indicated by manufacturer's designation][Match Architect's samples][As selected by Architect from manufacturer's full range][As indicated in a site furnishing schedule]<Insert color>.
- F. Steel Finish: [Galvanized and][color][PVC-color] coated.
1. Color: [As indicated by manufacturer's designation][Match Architect's samples][As selected by Architect from manufacturer's full range][As indicated in a site furnishing schedule]<Insert color>.
- G. Stainless Steel Finish: [ASTM A480/A480M, No. 6]<Insert description>.
- H. Wood Finish: [Unfinished][Factory-applied transparent finish][Factory-applied stain and

transparent finish][Factory-applied opaque finish][Manufacturer's standard finish].

1. Stain: [Manufacturer's standard]<Insert stain type and color>.

I. [Fiberglass][HDPE] Color: [As indicated by manufacturer's designation][Match Architect's samples][As selected by Architect from manufacturer's full range][As indicated in a site furnishing schedule]<Insert description>.

J. Graphics: [Surface-applied][Engraved][Attached brass plaque with engraved] copy, content, and style [according to manufacturer's standard][as indicated on Drawings].

2.2 TABLES

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

1. [4Topps Premium Seating]
2. [A&T Iron Works, Inc]
3. [BCI Burke Company, LLC]
4. [Bison, Inc.]
5. [Canterbury Design]
6. [Columbia Cascade Company]
7. [Country Casual]
8. [DuMor Inc.]
9. [Fibrex Group, Inc.]
10. [Forms+Surfaces]
11. [GameTime; a PlayCore Company]
12. [Gardenside, Ltd]
13. [Henderson Recreation Equipment Ltd]
14. [Huntco Supply, LLC]
15. [Kay Park Recreation]
16. [Keystone Ridge Designs, Inc]
17. [Kidstuff Playsystems, Inc.]
18. [Kingsley Bate]
19. [L.A. Steelcraft, a brand of Americana Outdoor]
20. [Landscape Forms]
21. [Landscape Structures Inc.]
22. [Madrax; Graber Manufacturing, Inc.]
23. [Maglin Site Furniture Inc.]
24. [Miracle Recreation Equipment Company]
25. [Neenah Foundry Company]
26. [Petersen Manufacturing Co. Inc.]
27. [Playworld Systems, Inc.]
28. [RPI]
29. [Sitecraft]
30. [Smith & Hawken, Ltd.]
31. [SportsPlay Equipment, Inc]
32. [Thomas Steele; Graber Manufacturing, Inc.]
33. [Tournesol Siteworks LLC]
34. [Urban Accessories, Inc]
35. [Victor Stanley, Inc]
36. [Wausau Tile, Inc.]
37. [Weatherend Estate Furniture]
38. <Insert manufacturer's name>

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

1. [4Topp's Premium Seating]
2. [A&T Iron Works, Inc]
3. [BCI Burke Company, LLC]
4. [Bison, Inc.]
5. [Canterbury Design]
6. [Columbia Cascade Company]
7. [Country Casual]
8. [DuMor Inc.]
9. [Fibrex Group, Inc.]
10. [Forms+Surfaces]
11. [GameTime; a PlayCore Company]
12. [Gardenside, Ltd]
13. [Henderson Recreation Equipment Ltd]
14. [Huntco Supply, LLC]
15. [Kay Park Recreation]
16. [Keystone Ridge Designs, Inc]
17. [Kidstuff Playsystems, Inc.]
18. [Kingsley Bate]
19. [L.A. Steelcraft, a brand of Americana Outdoor]
20. [Landscape Forms]
21. [Landscape Structures Inc.]
22. [Madrax; Graber Manufacturing, Inc.]
23. [Maglin Site Furniture Inc.]
24. [Miracle Recreation Equipment Company]
25. [Neenah Foundry Company]
26. [Petersen Manufacturing Co. Inc.]
27. [Playworld Systems, Inc.]
28. [RPI]
29. [Sitecraft]
30. [Smith & Hawken, Ltd.]
31. [SportsPlay Equipment, Inc]
32. [Thomas Steele; Graber Manufacturing, Inc.]
33. [Tournesol Siteworks LLC]
34. [Urban Accessories, Inc]
35. [Victor Stanley, Inc]
36. [Wausau Tile, Inc.]
37. [Weatherend Estate Furniture]
38. <Insert manufacturer's name>

C. Frame: [Cast aluminum][Cast iron][Steel][Stainless steel][Wrought iron][Cedar][Teak]<Insert material>.

D. Table Top:

1. Material:
 - a. Aluminum Sheet: [Perforated][Expanded] metal.
 - b. [Painted]Steel: [Perforated metal][Expanded metal][Evenly spaced, parallel flat straps or bars][Evenly woven, flat straps or bars][Edge framed, evenly spaced, parallel rods or rolled bars]<Insert description>.
 - c. Stainless Steel: [Perforated metal][Expanded metal][Evenly spaced, parallel flat straps or bars][Evenly woven, flat straps or bars][Edge framed, evenly spaced, parallel rods

- or rolled bars]<Insert description>.
 - d. Wood: [Douglas fir][Pine][Cedar][Redwood][Teak]<Insert species>; formed into [evenly spaced parallel slats][planks]<Insert description>.
 - e. [Recycled][Plastic][Fiberglass] Planks: [Evenly spaced, parallel]<Insert description>.
 - f. [Recycled][Plastic][Fiberglass] Sheet: [Solid][Perforated].
 2. Surface Shape: [Round][Hexagon][Shape indicated]<Insert shape>.
 3. Feature: [Center umbrella hole]<Insert feature>.
 - E. Aluminum Finish: [Mill finish][Color coated].
 1. Color: [As indicated by manufacturer's designation][Match Architect's samples][As selected by Architect from manufacturer's full range][As indicated in a site furnishing schedule]<Insert color>.
 - F. Steel Finish: [Galvanized and][color][PVC-color] coated.
 1. Color: [As indicated by manufacturer's designation][Match Architect's samples][As selected by Architect from manufacturer's full range][As indicated in a site furnishing schedule]<Insert color>.
 - G. Stainless Steel Finish: [ASTM A480/480M, No. 6]<Insert description>.
 - H. Wood Finish: [Unfinished][Factory-applied transparent finish][Factory-applied stain and transparent finish][Factory-applied opaque finish][Manufacturer's standard finish].
 1. Stain: [Manufacturer's standard]<Insert stain type and color>.
 - I. [Fiberglass][HDPE] Color: [As indicated by manufacturer's designation][Match Architect's samples][As selected by Architect from manufacturer's full range][As indicated in a site furnishing schedule]<Insert description>.
 - J. Graphics: [Surface-applied][Engraved][Attached brass plaque with engraved] copy, content, and style [per manufacturer's standard][as indicated on Drawings].
- 2.3 BICYCLE RACKS
- A. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 1. [A A A Ribbon Rack Co., Inc.; a division of Brandir]
 2. [American Bicycle Security Company]
 3. [BCI Burke Company, LLC]
 4. [Bison, Inc.]
 5. [brp by bison]
 6. [Canterbury Design]
 7. [Columbia Cascade Company]
 8. [Cora Bike Rack]
 9. [CycleSafe, Inc.]
 10. [DuMor Inc.]
 11. [GameTime; a PlayCore Company]
 12. [Ground Control Systems]
 13. [Henderson Recreation Equipment Ltd]
 14. [Huntco Supply, LLC]

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15. [Kay Park Recreation]
16. [Keystone Ridge Designs, Inc]
17. [Kidstuff Playsystems, Inc.]
18. [L.A. Steelcraft, a brand of Americana Outdoor]
19. [Landscape Forms]
20. [Landscape Structures Inc.]
21. [Madrax; Graber Manufacturing, Inc.]
22. [Maglin Site Furniture Inc.]
23. [Miracle Recreation Equipment Company]
24. [Neenah Foundry Company]
25. [Playworld Systems, Inc.]
26. [RPI]
27. [Saris Infrastructure]
28. [SportsPlay Equipment, Inc]
29. [Tournesol Siteworks LLC]
30. [Urban Accessories, Inc]
31. [Victor Stanley, Inc]
32. [Wausau Tile, Inc.]
33. <Insert manufacturer's name>

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

1. [A A A Ribbon Rack Co., Inc.; a division of Brandir]
2. [American Bicycle Security Company]
3. [BCI Burke Company, LLC]
4. [Bison, Inc.]
5. [brp by bison]
6. [Canterbury Design]
7. [Columbia Cascade Company]
8. [Cora Bike Rack]
9. [CycleSafe, Inc.]
10. [DuMor Inc.]
11. [GameTime; a PlayCore Company]
12. [Ground Control Systems]
13. [Henderson Recreation Equipment Ltd]
14. [Huntco Supply, LLC]
15. [Kay Park Recreation]
16. [Keystone Ridge Designs, Inc]
17. [Kidstuff Playsystems, Inc.]
18. [L.A. Steelcraft, a brand of Americana Outdoor]
19. [Landscape Forms]
20. [Landscape Structures Inc.]
21. [Madrax; Graber Manufacturing, Inc.]
22. [Maglin Site Furniture Inc.]
23. [Miracle Recreation Equipment Company]
24. [Neenah Foundry Company]
25. [Playworld Systems, Inc.]
26. [RPI]
27. [Saris Infrastructure]
28. [SportsPlay Equipment, Inc]
29. [Tournesol Siteworks LLC]
30. [Urban Accessories, Inc]
31. [Victor Stanley, Inc]
32. [Wausau Tile, Inc.]

33. <Insert manufacturer's name>

C. Bicycle Rack Construction:

1. Frame: [Aluminum][Steel][Galvanized steel][Stainless steel][Steel and redwood][Steel and pine]<Insert description>.
 - a. [Pipe][Tubing] OD: Not less than [1-5/8 inches (41 mm)][2-3/8 inches (60 mm)][2-7/8 inches (73 mm)][4-1/2 inches (115 mm)]<Insert dimension>.
 - b. Locking Bars: Solid round bar, not less than [3/4 inch (19 mm)][1 inch (25 mm)] in diameter.
2. Style: [Single-side parking][Double-side parking][Bollard][As indicated]<Insert description>.
 - a. Overall Height: [As indicated]<Insert dimension>.
 - b. Overall Width: [As indicated]<Insert dimension>.
 - c. Overall Depth: [As indicated]<Insert dimension>.
 - d. Capacity: Designed to accommodate no fewer than [two][three][four]<Insert number> bicycles.
3. Security: Designed to lock [wheel][and][frame].
4. Accessories: [Base covers for each pipe and tubing anchored end][Wheel stops]<Insert accessory>.
5. Installation Method: [Freestanding][Surface flange anchored at finished grade to substrate indicated][Surface flange anchored below finished grade to substrate indicated][Cast in concrete][Bolted to cast-in anchor bolts][Wall mounted][As indicated].

D. Aluminum Finish: [Mill finish][Color coated].

1. Color: [As indicated by manufacturer's designation][Match Architect's samples][As selected by Architect from manufacturer's full range][As indicated in a site furnishing schedule]<Insert description>.

E. Steel Finish: [Galvanized][Color coated].

1. Color: [As indicated by manufacturer's designation][Match Architect's samples][As selected by Architect from manufacturer's full range][As indicated in a site furnishing schedule]<Insert color>.

F. Stainless Steel Finish: [ASTM A480/A480M, No. 4]<Insert description>.

G. Wood Finish: [Unfinished][Manufacturer's standard finish].

2.4 BICYCLE LOCKERS

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

1. [American Bicycle Security Company]
2. [Columbia Cascade Company]
3. [Cora Bike Rack]
4. [CycleSafe, Inc.]
5. [Ground Control Systems]
6. [Huntco Supply, LLC]

7. [Madrax; Graber Manufacturing, Inc.]
8. <Insert manufacturer's name>

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

1. [American Bicycle Security Company]
2. [Columbia Cascade Company]
3. [Cora Bike Rack]
4. [CycleSafe, Inc.]
5. [Ground Control Systems]
6. [Huntco Supply, LLC]
7. [Madrax; Graber Manufacturing, Inc.]
8. <Insert manufacturer's name>

C. Bicycle Locker Construction:

1. Locker: [Molded one-piece fiberglass][Steel sheet, 0.053 inch (1.4 mm) thick][Steel sheet, 0.053 inch (1.4 mm) thick, with perforated metal sides][with welded tubular steel frame]<Insert material>.
2. Door: [Molded one-piece fiberglass][Steel sheet, 0.053 inch (1.4 mm) thick][with tubular steel frame][Match locker]<Insert material>.
3. View [Window][Grille]: [Lexan, 12 inches (305 mm) square][Perforated metal].
4. Lock: [Manufacturer's standard][Key lock with internal locking bar][Coin/token lock]<Insert description>.
- a. Provide [four]<Insert number> keys.
5. Overall Height: [As indicated]<Insert dimension>.
6. Overall Width: [As indicated]<Insert dimension>.
7. Overall Depth: [As indicated]<Insert dimension>.
8. Capacity: Designed to accommodate [one][two] bicycle(s).
9. Installation Method: [Locker anchored at finished grade to substrate indicated][Locker anchored below finished grade to substrate indicated][As indicated].
10. Locker Configuration: [Multiple][Four]<Insert number> units[as indicated], in [straight row][curved shape][shape indicated]<Insert description>.

D. Steel Finish: Color coated.

1. Color: [As indicated by manufacturer's designation][Match Architect's samples][As selected by Architect from manufacturer's full range][As indicated in a site furnishing schedule]<Insert description>.

E. Fiberglass Color: [As indicated by manufacturer's designation][Match Architect's samples][As selected by Architect from manufacturer's full range][As indicated in a site furnishing schedule]<Insert description>.

2.5 TRASH RECEPTACLES

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

1. [A&T Iron Works, Inc]

2. [BCI Burke Company, LLC]
3. [Bison, Inc.]
4. [brp by bison]
5. [Canterbury Design]
6. [Columbia Cascade Company]
7. [Country Casual]
8. [DuMor Inc.]
9. [Fiberglass Engineering Company]
10. [Fibrex Group, Inc.]
11. [Forms+Surfaces]
12. [GameTime; a PlayCore Company]
13. [Gardenside, Ltd]
14. [Henderson Recreation Equipment Ltd]
15. [Huntco Supply, LLC]
16. [Kay Park Recreation]
17. [Keystone Ridge Designs, Inc]
18. [Kidstuff Playsystems, Inc.]
19. [L.A. Steelcraft, a brand of Americana Outdoor]
20. [Landscape Forms]
21. [Landscape Structures Inc.]
22. [Maglin Site Furniture Inc.]
23. [Miracle Recreation Equipment Company]
24. [Petersen Manufacturing Co. Inc.]
25. [Playworld Systems, Inc.]
26. [RPI]
27. [Sitecraft]
28. [Smith & Hawken, Ltd.]
29. [Thomas Steele; Graber Manufacturing, Inc.]
30. [Tournesol Siteworks LLC]
31. [Urban Accessories, Inc]
32. [Victor Stanley, Inc]
33. [Wausau Tile, Inc.]
34. [Weatherend Estate Furniture]
35. <Insert manufacturer's name>

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

1. [A&T Iron Works, Inc]
2. [BCI Burke Company, LLC]
3. [Bison, Inc.]
4. [brp by bison]
5. [Canterbury Design]
6. [Columbia Cascade Company]
7. [Country Casual]
8. [DuMor Inc.]
9. [Fiberglass Engineering Company]
10. [Fibrex Group, Inc.]
11. [Forms+Surfaces]
12. [GameTime; a PlayCore Company]
13. [Gardenside, Ltd]
14. [Henderson Recreation Equipment Ltd]
15. [Huntco Supply, LLC]
16. [Kay Park Recreation]
17. [Keystone Ridge Designs, Inc]
18. [Kidstuff Playsystems, Inc.]

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19. [L.A. Steelcraft, a brand of Americana Outdoor]
 20. [Landscape Forms]
 21. [Landscape Structures Inc.]
 22. [Maglin Site Furniture Inc.]
 23. [Miracle Recreation Equipment Company]
 24. [Petersen Manufacturing Co. Inc.]
 25. [Playworld Systems, Inc.]
 26. [RPI]
 27. [Sitecraft]
 28. [Smith & Hawken, Ltd.]
 29. [Thomas Steele; Graber Manufacturing, Inc.]
 30. [Tournesol Siteworks LLC]
 31. [Urban Accessories, Inc]
 32. [Victor Stanley, Inc]
 33. [Wausau Tile, Inc.]
 34. [Weatherend Estate Furniture]
 35. <Insert manufacturer's name>
- C. Aluminum Facing Surrounds: [Aluminum sheet][Perforated aluminum sheet][Grid in tubular frame][Evenly patterned, parallel flat aluminum straps, bars, or tubular shapes][Match benches]<Insert material and description>.
- D. Steel Facing Surrounds: [Steel sheet][Perforated-steel sheet][Evenly patterned, parallel flat steel straps, bars, or tubular shapes][Evenly patterned, parallel round steel rods, bars, or tubular shapes][Grid in tubular frame][Match benches]<Insert material and description>.
- E. Stainless Steel Facing Surrounds: [Steel sheet][Perforated-steel sheet][Evenly patterned, parallel flat steel straps, bars, or tubular shapes][Evenly patterned, parallel round steel rods, bars, or tubular shapes][Grid in tubular frame][Match benches]<Insert material and description>.
- F. Wood Facing Surrounds: [Evenly spaced, Douglas fir slats][Evenly spaced pine slats][Evenly spaced cedar slats][Redwood panels][Evenly spaced redwood slats][Teak panels][Evenly spaced teak slats][Match benches]<Insert wood type and description>.
- G. Fiberglass Facing Surrounds: Molded fiberglass shape.
- H. Plastic Facing Surrounds: [Molded HDPE shape][Evenly spaced HDPE slats][Evenly spaced, recycled HDPE slats][Match benches]<Insert plastic type and description>.
- I. Support Frames: [Steel][Galvanized steel]; welded.
- J. Trash Receptacles:
1. Receptacle Shape and Form: [Round cylinder][Round cylinder with tapered funnel top][Round, tapered column][Square column][Rectangular column][As indicated]<Insert shape and form>; with opening for depositing trash in [lid or top][side of lid or top][receptacle side].
 2. Lids and Tops: [Matching facing panels][Aluminum][Steel][HDPE][Recycled HDPE]<Insert material and description> secured by cable or chain, hinged, swiveled, or permanently secured.
 - a. Description: [Flat rim ring lid with center opening][Dome top][Arched top][Elevated flat or shallow dome rain-cap lid][Combination ash sand pan and rim lid][Combination ash sand pan and dome top][Combination ash sand pan and elevated flat or shallow dome rain-cap lid]<Insert description>.
 - b. Opening for depositing trash covered by [self-closing, spring-loaded-hinged, push-

in][rotating] weather flap.

3. Receptacle Height: [As indicated]<Insert dimension>.
4. Overall Width: [As indicated]<Insert dimension>.
5. Weight: <Insert weight>.
6. Inner Container: [Aluminum][Galvanized-steel sheet][Perforated-metal][Fiberglass][Rigid plastic] container with [drain holes][lift-out handles]; designed to be removable and reusable.
7. Disposable Liners: Provide receptacle designed to accommodate disposable liners.
8. Capacity: Not less than [22 gal. (83 L)][28 gal. (106 L)][30 gal. (114 L)][32 gal. (121 L)][40 gal. (151 L)][55 gal. (208 L)]<Insert value>.
9. Service Access: [Removable lid or top][Fixed lid or top, side access]; inner container and disposable liner lift or slide-out for emptying[; lockable with padlock hasps][; keyed lock with two keys per receptacle][; self-latching hinge].
10. Post Mount: [Color-coated steel pipe; color to match receptacle][Galvanized-steel pipe][Wood]; for mounting [one][two][three] receptacle(s).

K. Aluminum Finish: [Mill finish][Color coated].

1. Color: [As indicated by manufacturer's designation][Match Architect's samples][As selected by Architect from manufacturer's full range][As indicated in a site furnishing schedule]<Insert description>.

L. Steel Finish: [Galvanized and][color][PVC-color] coated.

1. Color: [As indicated by manufacturer's designation][Match Architect's samples][As selected by Architect from manufacturer's full range][As indicated in a site furnishing schedule]<Insert description>.

M. Stainless Steel Finish: [ASTM A480/A480M, No. 6]<Insert description>.

N. Wood Finish: [Unfinished][Factory-applied transparent finish][Factory-applied stain and transparent finish][Factory-applied opaque finish][Manufacturer's standard finish].

1. Stain: [Manufacturer's standard]<Insert stain type and color>.

O. [Fiberglass][HDPE] Color: [As indicated by manufacturer's designation][Match Architect's samples][As selected by Architect from manufacturer's full range][As indicated in a site furnishing schedule]<Insert description>.

P. Graphics: [Surface-applied][Engraved][Attached brass plaque with engraved] copy, content, and style [according to manufacturer's standard][as indicated on Drawings].

1. Copy: [Litter][Trash][Waste][Recycle]<Insert term>.

2.6 ASH RECEPTACLES

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

1. [A&T Iron Works, Inc]
2. [BCI Burke Company, LLC]
3. [Canterbury Design]
4. [Columbia Cascade Company]
5. [Country Casual]

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6. [DuMor Inc.]
7. [Fiberglass Engineering Company]
8. [Fibrex Group, Inc.]
9. [Forms+Surfaces]
10. [GameTime; a PlayCore Company]
11. [Gardenside, Ltd]
12. [Henderson Recreation Equipment Ltd]
13. [Huntco Supply, LLC]
14. [Kay Park Recreation]
15. [Kidstuff Playsystems, Inc.]
16. [L.A. Steelcraft, a brand of Americana Outdoor]
17. [Landscape Forms]
18. [Landscape Structures Inc.]
19. [Maglin Site Furniture Inc.]
20. [Miracle Recreation Equipment Company]
21. [Playworld Systems, Inc.]
22. [RPI]
23. [Sitecraft]
24. [Smith & Hawken, Ltd.]
25. [Thomas Steele; Graber Manufacturing, Inc.]
26. [Tournesol Siteworks LLC]
27. [Urban Accessories, Inc]
28. [Victor Stanley, Inc]
29. [Wausau Tile, Inc.]
30. [Weatherend Estate Furniture]
31. <Insert manufacturer's name>

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

1. [A&T Iron Works, Inc]
2. [BCI Burke Company, LLC]
3. [Canterbury Design]
4. [Columbia Cascade Company]
5. [Country Casual]
6. [DuMor Inc.]
7. [Fiberglass Engineering Company]
8. [Fibrex Group, Inc.]
9. [Forms+Surfaces]
10. [GameTime; a PlayCore Company]
11. [Gardenside, Ltd]
12. [Henderson Recreation Equipment Ltd]
13. [Huntco Supply, LLC]
14. [Kay Park Recreation]
15. [Kidstuff Playsystems, Inc.]
16. [L.A. Steelcraft, a brand of Americana Outdoor]
17. [Landscape Forms]
18. [Landscape Structures Inc.]
19. [Maglin Site Furniture Inc.]
20. [Miracle Recreation Equipment Company]
21. [Playworld Systems, Inc.]
22. [RPI]
23. [Sitecraft]
24. [Smith & Hawken, Ltd.]
25. [Thomas Steele; Graber Manufacturing, Inc.]

26. [Tournesol Siteworks LLC]
 27. [Urban Accessories, Inc]
 28. [Victor Stanley, Inc]
 29. [Wausau Tile, Inc.]
 30. [Weatherend Estate Furniture]
 31. <Insert manufacturer's name>
- C. Aluminum Facing Surrounds: [Aluminum sheet][Perforated aluminum sheet][Grid in tubular frame][Evenly patterned, parallel flat aluminum straps, bars, or tubular shapes][Match benches]<Insert material and description>.
- D. Steel Facing Surrounds: [Steel sheet][Perforated-steel sheet][Evenly patterned, parallel flat steel straps, bars, or tubular shapes][Evenly patterned, parallel round steel rods, bars, or tubular shapes][Grid in tubular frame][Match benches]<Insert material and description>.
- E. Stainless Steel Facing Surrounds: [Steel sheet][Perforated-steel sheet][Evenly patterned, parallel flat steel straps, bars, or tubular shapes][Evenly patterned, parallel round steel rods, bars, or tubular shapes][Grid in tubular frame][Match benches]<Insert material and description>.
- F. Fiberglass Facing Surrounds: Molded fiberglass shape.
- G. Support Frames: [Steel][Galvanized steel]; welded.
- H. Ash Receptacles:
1. Receptacle Shape and Form: [Round cylinder][Round cylinder with tapered funnel top][Round, tapered column][Square column][Rectangular column][As indicated]<Insert shape and form>; with opening for depositing trash in [lid or top][side of lid or top][receptacle side].
 2. Function: [Uncovered receptacle with sand pan][Uncovered receptacle with bowl and funnel][Covered receptacle with sand pan][Covered receptacle with bowl and screen][Covered receptacle with slots][Uncovered receptacle with sand pan attaching to side of trash receptacle]<Insert description and accessories> for depositing cigarette butts; fire-proof design; bowl and pan removable for cleaning.
 3. Lids and Tops: [Matching facing panels][Aluminum][Steel][HDPE][Recycled HDPE]<Insert material and description> secured by cable or chain, hinged, swiveled, or permanently secured.
 - a. Description: [Flat rim ring lid with center opening][Dome top][Arched top][Elevated flat or shallow dome rain-cap lid][Combination ash sand pan and rim lid][Combination ash sand pan and dome top][Combination ash sand pan and elevated flat or shallow dome rain-cap lid]<Insert description>.
 4. Receptacle Height: [As indicated]<Insert dimension>.
 5. Overall Width: [As indicated]<Insert dimension>.
 6. Weight: <Insert weight>.
 7. Post Mount: [Color-coated steel pipe; color to match receptacle][Galvanized-steel pipe][Wood]; for mounting [one][two][three] receptacle(s).
 8. Accessories: [Sand sifter][Butt stub-out]<Insert accessory>.
- I. Aluminum Finish: [Mill finish][Color coated].
1. Color: [As indicated by manufacturer's designation][Match Architect's samples][As selected by Architect from manufacturer's full range][As indicated in a site furnishing schedule]<Insert description>.
- J. Steel Finish: [Galvanized and][color][PVC-color] coated.

1. Color: [As indicated by manufacturer's designation][Match Architect's samples][As selected by Architect from manufacturer's full range][As indicated in a site furnishing schedule]<Insert description>.

K. Stainless Steel Finish: [ASTM A480/A480M, No. 6]<Insert description>.

L. [Fiberglass][HDPE] Color: [As indicated by manufacturer's designation][Match Architect's samples][As selected by Architect from manufacturer's full range][As indicated in a site furnishing schedule]<Insert description>.

2.7 PLANTERS

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

1. [Bison Innovative Products, United Construction Products, Inc.]
2. [Country Casual]
3. [DuMor Inc.]
4. [Fiberglass Engineering Company]
5. [Fibrex Group, Inc.]
6. [Gardenside, Ltd]
7. [Kay Park Recreation]
8. [Kingsley Bate]
9. [Maglin Site Furniture Inc.]
10. [Omni Ecosystems]
11. [Petersen Manufacturing Co. Inc.]
12. [RPI]
13. [Sitecraft]
14. [Thomas Steele; Graber Manufacturing, Inc.]
15. [Tournesol Siteworks LLC]
16. [Victor Stanley, Inc]
17. [Wausau Tile, Inc.]
18. [Weatherend Estate Furniture]
19. <Insert manufacturer's name>

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

1. [Bison Innovative Products, United Construction Products, Inc.]
2. [Country Casual]
3. [DuMor Inc.]
4. [Fiberglass Engineering Company]
5. [Fibrex Group, Inc.]
6. [Gardenside, Ltd]
7. [Kay Park Recreation]
8. [Kingsley Bate]
9. [Maglin Site Furniture Inc.]
10. [Omni Ecosystems]
11. [Petersen Manufacturing Co. Inc.]
12. [RPI]
13. [Sitecraft]
14. [Thomas Steele; Graber Manufacturing, Inc.]
15. [Tournesol Siteworks LLC]

16. [Victor Stanley, Inc]
 17. [Wausau Tile, Inc.]
 18. [Weatherend Estate Furniture]
 19. <Insert manufacturer's name>
- C. Aluminum Facing Surrounds: [Aluminum sheet][Perforated aluminum sheet][Grid in tubular frame][Evenly patterned, parallel flat aluminum straps, bars, or tubular shapes][Match benches]<Insert material and description>.
 - D. Steel Facing Surrounds: [Steel sheet][Perforated-steel sheet][Evenly patterned, parallel flat steel straps, bars, or tubular shapes][Evenly patterned, parallel round steel rods, bars, or tubular shapes][Grid in tubular frame][Match benches]<Insert material and description>.
 - E. Stainless Steel Facing Surrounds: [Steel sheet][Perforated-steel sheet][Evenly patterned, parallel flat steel straps, bars, or tubular shapes][Evenly patterned, parallel round steel rods, bars, or tubular shapes][Grid in tubular frame][Match benches]<Insert material and description>.
 - F. Wood Facing Surrounds: [Evenly spaced, Douglas fir slats][Evenly spaced pine slats][Evenly spaced cedar slats][Redwood panels][Evenly spaced redwood slats][Teak panels][Evenly spaced teak slats][Match benches]<Insert wood type and description>.
 - G. Fiberglass Facing Surrounds: Molded fiberglass shape.
 - H. Plastic Facing Surrounds: [Molded HDPE shape][Evenly spaced HDPE slats][Evenly spaced, recycled HDPE slats][Match benches]<Insert plastic type and description>.
 - I. Support Frames: [Steel][Galvanized steel]; welded.
 - J. Planter Shape and Form: [Round cylinder][Round cylinder with tapered funnel top][Round, tapered column][Square column][Rectangular column][As indicated]<Insert shape and form>.
 - K. Style: [To match benches][As indicated by manufacturer's designation].
 - L. Overall Height: [As indicated]<Insert dimension>.
 - M. Overall [Diameter][Width]: [As indicated]<Insert dimension>.
 - N. Overall Depth: [As indicated]<Insert dimension>.
 - O. Weight: <Insert weight>.
 - P. Inner Container: [Aluminum][Galvanized-steel sheet][Fiberglass][Rigid plastic] container[with drain holes].
 - Q. Capacity: Not less than [22 gal. (83 L)][28 gal. (106 L)][30 gal. (114 L)][32 gal. (121 L)][40 gal. (151 L)][55 gal. (208 L)]<Insert value>.
 - R. Installation Method: [Freestanding][Freestanding with weighted base][Anchored to substrate indicated on Drawings][Wall mounted][Post mounted][Mounted on elevated leg angles anchored at finished grade to substrate indicated on Drawings][Mounted on elevated leg angles anchored below finished grade to substrate indicated on Drawings][As indicated on Drawings].
 1. Post Mount: [Color-coated steel pipe; color to match receptacle][Galvanized-steel pipe][Wood]; for mounting [one][two][three] planter(s).

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- S. Aluminum Finish: Color coated.
 - 1. Color: **[As indicated by manufacturer's designation][Match Architect's samples][As selected by Architect from manufacturer's full range][As indicated in a site furnishing schedule]<Insert description>.**
- T. Steel Finish: **[Galvanized and][color][PVC-color]** coated.
 - 1. Color: **[As indicated by manufacturer's designation][Match Architect's samples][As selected by Architect from manufacturer's full range][As indicated in a site furnishing schedule]<Insert description>.**
- U. Stainless Steel Finish: **[ASTM A480/A480M, No. 6]<Insert description>.**
- V. Wood Finish: **[Unfinished][Factory-applied transparent finish][Factory-applied stained and transparent finish].**
 - 1. Stain: **<Insert stain type and color>.**
- W. **[Fiberglass][HDPE]** Color: **[As indicated by manufacturer's designation][Match Architect's samples][As selected by Architect from manufacturer's full range][As indicated in a site furnishing schedule]<Insert description>.**
 - 1. Finish: **[Smooth][Textured].**

2.8 BOLLARDS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1. **[1-800-Bollards]**
 - 2. **[brp by bison]**
 - 3. **[CAME Americas Automation LLC]**
 - 4. **[Canterbury Design]**
 - 5. **[Columbia Cascade Company]**
 - 6. **[Dero; a PlayCore company]**
 - 7. **[DuMor Inc.]**
 - 8. **[Huntco Supply, LLC]**
 - 9. **[L.A. Steelcraft, a brand of Americana Outdoor]**
 - 10. **[Maglin Site Furniture Inc.]**
 - 11. **[Neenah Foundry Company]**
 - 12. **[Petersen Manufacturing Co. Inc.]**
 - 13. **[Reliance Foundry Co. Ltd]**
 - 14. **[Thomas Steele; Graber Manufacturing, Inc.]**
 - 15. **[Tournesol Siteworks LLC]**
 - 16. **[Urban Accessories, Inc]**
 - 17. **[Victor Stanley, Inc]**
 - 18. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[1-800-Bollards]**

2. [brp by bison]
3. [CAME Americas Automation LLC]
4. [Canterbury Design]
5. [Columbia Cascade Company]
6. [Dero; a PlayCore company]
7. [DuMor Inc.]
8. [Huntco Supply, LLC]
9. [L.A. Steelcraft, a brand of Americana Outdoor]
10. [Maglin Site Furniture Inc.]
11. [Neenah Foundry Company]
12. [Petersen Manufacturing Co. Inc.]
13. [Reliance Foundry Co. Ltd]
14. [Thomas Steele; Graber Manufacturing, Inc.]
15. [Tournesol Siteworks LLC]
16. [Urban Accessories, Inc]
17. [Victor Stanley, Inc]
18. <Insert manufacturer's name>

C. Bollard Construction:

1. [Pipe][Tubing][Cast Iron] OD: Not less than [4-1/2 inches (115 mm)]<Insert dimension>[, fluted].
 - a. Steel: [Schedule 40][Schedule 80] pipe.
 - b. Aluminum: [Extruded pipe and tubes][Castings].
 - c. Stainless Steel: [Tubes][Pipe].
 - d. Cast Iron: [Tapered][As indicated].
2. [Round][Square] Wood: [Cedar]<Insert material>, [8 inches (203 mm) square][10 inches (254 mm) in diameter].
3. Style: [Manufacturer's standard][Chamfered top][Dome top][Ornamental cap][As indicated]<Insert description>.
4. Overall Height: [As indicated]<Insert dimension>.
5. Overall Width: [As indicated]<Insert dimension>.
6. Overall Depth: [As indicated]<Insert dimension>.
7. Accessories: [Eye bolts]<Insert accessory>.
8. Installation Method: [Surface flange anchored at finished grade to substrate indicated][Surface flange anchored below finished grade to substrate indicated][Cast in concrete][Bolted to cast-in anchor bolts][As indicated].

D. Aluminum Finish: [Mill finish][Color coated].

1. Color: [As indicated by manufacturer's designation][Match Architect's samples][As selected by Architect from manufacturer's full range][As indicated in a site furnishing schedule]<Insert description>.

E. Steel Finish: [Galvanized][Color coated].

1. Color: [As indicated by manufacturer's designation][Match Architect's samples][As selected by Architect from manufacturer's full range][As indicated in a site furnishing schedule]<Insert description>.

F. Cast-Iron Finish: [Manufacturer's standard][Galvanized][Color coated].

1. Color: [As indicated by manufacturer's designation][Match Architect's samples][As selected by Architect from manufacturer's full range][As indicated in a site furnishing schedule]<Insert description>.

schedule]<Insert description>.

G. Stainless Steel Finish: **[ASTM A480/A480M, No. 4]<Insert description>.**

H. Wood Finish: **[Unfinished][Manufacturer's standard finish].**

2.9 MATERIALS

A. Aluminum: Alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated; free of surface blemishes and complying with the following:

1. Rolled or Cold-Finished Bars, Rods, and Wire: **ASTM B211 (ASTM B211M).**
2. Extruded Bars, Rods, Wire, Profiles, and Tubes: **ASTM B221 (ASTM B221M).**
3. Structural Pipe and Tube: ASTM B429/B429M.
4. Sheet and Plate: **ASTM B209 (ASTM B209M).**
5. Castings: ASTM B26/B26M.

B. Steel and Iron: Free of surface blemishes and complying with the following:

1. Plates, Shapes, and Bars: ASTM A36/A36M.
2. Steel Pipe: Standard-weight steel pipe complying with ASTM A53/A53M, or electric-resistance-welded pipe complying with ASTM A135/A135M.
3. Tubing: Cold-formed steel tubing complying with ASTM A500/A500M.
4. Mechanical Tubing: Cold-rolled, electric-resistance-welded carbon or alloy steel tubing complying with ASTM A513/A513M, or steel tubing fabricated from steel complying with ASTM A1011/A1011M and complying with dimensional tolerances in ASTM A500/A500M; zinc coated internally and externally.
5. Sheet: Commercial steel sheet complying with ASTM A1011/A1011M.
6. Perforated Metal: From steel sheet not less than **[0.075-inch (1.9-mm)][0.090-inch (2.3-mm)][0.120-inch (3.0-mm)]<Insert dimension>** nominal thickness; manufacturer's standard perforation pattern.
7. Expanded Metal: Carbon-steel sheets, deburred after expansion, and complying with ASTM F1267.
8. Malleable-Iron Castings: ASTM A47/A47M, grade as recommended by fabricator for type of use intended.
9. Gray-Iron Castings: ASTM A48/A48M, Class 200.

C. Stainless Steel: Free of surface blemishes and complying with the following:

1. Sheet, Strip, Plate, and Flat Bars: ASTM A240/A240M or ASTM A666.
2. Pipe: Schedule 40 steel pipe complying with ASTM A312/A312M.
3. Tubing: ASTM A554.

D. Wood: Surfaced smooth on four sides with eased edges; kiln dried, free of knots, solid stock of species indicated.

1. Wood Species: **[Manufacturer's standard.]**
 - a. Douglas Fir: Clear Grade, vertical grain.
 - b. Pine: Southern pine; No. 2 or better; **preservative treated, kiln dried after treatment].**
 - c. **[Eastern White][Red][Yellow]** Cedar: Select Grade or better.
 - d. Redwood: **[Clear all heart][Construction heart or better]**, free-of-heart center.
 - e. Teak (Tectona Grandis): Clear Grade.
 - f. **<Insert wood species>: <Insert grade, if applicable, and other requirements>.**

- E. Certified Wood: Wood products shall be certified as "FSC Pure"[or "**FSC Mixed Credit**"] according to FSC STD-01-00 and FSC STD-40-004.
- F. Certified Wood: Wood products shall be certified as "FSC Pure"[or "**FSC Mixed Credit**"] according to FSC STD-01-001 and FSC STD-40-004.
- G. Certified Wood: Wood products shall be labeled according to the AFPA's Sustainable Forestry Initiative, be certified as "FSC Pure" according to FSC STD-01-001 and FSC STD-40-004, or be certified and labeled according to the standards of the Programme for Endorsement of Forest Certification.
- H. Certified Wood: Wood products shall **[contain not less than 60 percent][be made from]** certified wood tracked through a chain-of-custody process. Certified wood documentation shall be provided by sources certified through a forest certification system with principles, criteria, and standards developed using ISO/IEC Guide 59 or the World Trade Organization's "Technical Barriers to Trade."
- I. Certified Wood: Wood products shall be certified according to the American Tree Farm System's "AFF Standard," the AFPA's Sustainable Forestry Initiative, FSC STD-01-001 and FSC STD-40-004, or the standards of the Programme for Endorsement of Forest Certification.
 - 1. Finish: Manufacturer's standard **[stain][and][transparent sealer][transparent wood-preservative treatment and sealer]<Insert treatment or finish>**.
- J. Fiberglass: Multiple laminations of glass-fiber-reinforced polyester resin with UV-light stable, colorfast, nonfading, weather- and stain-resistant, colored polyester gel coat, and with manufacturer's standard finish.
- K. Plastic: Color impregnated, color and UV-light stabilized, and mold resistant.
 - 1. Polyethylene: Fabricated from virgin plastic HDPE resin.
 - 2. Polyethylene with Recycled Content: Fabricated from HDPE and other resins with postconsumer recycled content plus one-half of preconsumer recycled content not less than **<Insert number>** percent.
- L. Anchors, Fasteners, Fittings, and Hardware: **[Stainless steel][Brass][Galvanized steel][Zinc-plated steel][Manufacturer's standard, corrosion-resistant-coated or noncorrodible materials];** commercial quality[, **tamperproof, vandal and theft resistant**][, **concealed, recessed, and capped or plugged**].
 - 1. Angle Anchors: For inconspicuously bolting legs of site furnishings to **[on][below]-**grade substrate; **[one per leg][extent as indicated]<Insert extent>**.
 - 2. Antitheft Hold-Down Brackets: For securing site furnishings to substrate; **[two per unit][extent as indicated on Drawings]<Insert extent>**.
- M. Nonshrink, Nonmetallic Grout: Premixed, factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C1107/C1107M; recommended in writing by manufacturer, for exterior applications.
- N. Erosion-Resistant Anchoring Cement: Factory-packaged, nonshrink, nonstaining, hydraulic-controlled expansion cement formulation for mixing with potable water at Project site to create pourable anchoring, patching, and grouting compound; resistant to erosion from water exposure without needing protection by a sealer or waterproof coating; recommended in writing by manufacturer, for exterior applications.
- O. Galvanizing: Where indicated for steel and iron components, provide the following protective zinc coating applied to components after fabrication:
 - 1. Zinc-Coated Tubing: External, zinc with organic overcoat, consisting of a minimum of **0.9 oz./sq.**

ft. (0.27 kg/sq. m) of zinc after welding, a chromate conversion coating, and a clear, polymer film. Internal, same as external or consisting of 81 percent zinc pigmented coating, not less than 0.3 mil (0.0076 mm) thick.

2. Hot-Dip Galvanizing: According to ASTM A123/A123M, ASTM A153/A153M, or ASTM A924/A924M.

2.10 WOOD-PRESERVATIVE-TREATED MATERIALS

- A. Preservative Treatment: Pressure-treat wood according to AWWA U1, Use Category UC3b, and the following:
 1. Use preservative chemicals acceptable to authorities having jurisdiction and containing no arsenic or chromium. Use chemical formulations that do not bleed through or otherwise adversely affect finishes. Do not use colorants to distinguish treated materials from untreated materials.
 2. Kiln-dry lumber and plywood after treatment to a maximum moisture content, respectively, of 19 and 15 percent. Do not use materials that are warped or do not comply with requirements for untreated materials.

2.11 FABRICATION

- A. Metal Components: Form to required shapes and sizes with true, consistent curves, lines, and angles. Separate metals from dissimilar materials to prevent electrolytic action.
- B. Welded Connections: Weld connections continuously. Weld solid members with full-length, full-penetration welds and hollow members with full-circumference welds. At exposed connections, finish surfaces smooth and blended, so no roughness or unevenness shows after finishing and welded surface matches contours of adjoining surfaces.
- C. Pipes and Tubes: Form simple and compound curves by bending members in jigs to produce uniform curvature for each repetitive configuration required; maintain cylindrical cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of handrail and railing components.
- D. Preservative-Treated Wood Components: Complete fabrication of treated items before treatment if possible. If cut after treatment, apply field treatment complying with AWWA M4 to cut surfaces.
- E. Exposed Surfaces: Polished, sanded, or otherwise finished; all surfaces smooth, free of burrs, barbs, splinters, and sharpness; all edges and ends rolled, rounded, or capped.
- F. Factory Assembly: Factory assemble components to greatest extent possible to minimize field assembly. Clearly mark units for assembly in the field.

2.12 GENERAL FINISH REQUIREMENTS

- A. Appearance of Finished Work: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.13 ALUMINUM FINISHES

- A. Powder-Coat Finish: Manufacturer's standard polyester powder-coat finish complying with finish manufacturer's written instructions for surface preparation, including pretreatment, application, baking, and minimum dry film thickness.

2.14 STEEL AND GALVANIZED-STEEL FINISHES

- A. Powder-Coat Finish: Manufacturer's standard polyester, powder-coat finish complying with finish manufacturer's written instructions for surface preparation, including pretreatment, application, baking, and minimum dry film thickness.
- B. PVC Finish: Manufacturer's standard, UV-light stabilized, mold-resistant, slip-resistant, matte-textured, dipped or sprayed-on, PVC-plastisol finish, with flame retardant added; complying with coating manufacturer's written instructions for pretreatment, application, and minimum dry film thickness.

2.15 IRON FINISHES

- A. Powder-Coat Finish: Manufacturer's standard polyester powder-coat finish complying with finish manufacturer's written instructions for surface preparation, including pretreatment, application, baking, and minimum dry film thickness.

2.16 STAINLESS STEEL FINISHES

- A. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.
- B. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.
 - 1. Run directional finishes with long dimension of each piece.
 - 2. Directional Satin Finish: ASTM A480/A480M, No 4.
 - 3. Dull Satin Finish: ASTM A480/A480M, No. 6.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for correct and level finished grade, mounting surfaces, installation tolerances, and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Comply with manufacturer's written installation instructions unless more stringent requirements are indicated. Complete field assembly of site furnishings where required.
- B. Unless otherwise indicated, install site furnishings after landscaping and paving have been completed.



- C. Install site furnishings level, plumb, true, and **[securely anchored][positioned]** at locations indicated on Drawings.
- D. Post Setting: Set cast-in support posts in concrete footing with smooth top, shaped to shed water. Protect portion of posts above footing from concrete splatter. Verify that posts are set plumb or at correct angle and are aligned and at correct height and spacing. Hold posts in position during placement and finishing operations until concrete is sufficiently cured.
- E. Posts Set into Voids in Concrete: Form or core-drill holes for installing posts in concrete to depth recommended in writing by manufacturer of site furnishings and **3/4 inch (19 mm)** larger than OD of post. Clean holes of loose material, insert posts, and fill annular space between post and concrete with **[nonshrink, nonmetallic grout][or][anchoring cement]**, mixed and placed to comply with anchoring material manufacturer's written instructions, with top smoothed and shaped to shed water.
- F. Pipe Sleeves: Use steel pipe sleeves preset and anchored into concrete for installing posts. After posts have been inserted into sleeves, fill annular space between post and sleeve with **[nonshrink, nonmetallic grout][or][anchoring cement]**, mixed and placed to comply with anchoring material manufacturer's written instructions, with top smoothed and shaped to shed water.

END OF SECTION 32 33 00 00



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Task	Specification	Specification Description
32 33 13 00	32 33 00 00	Site Furnishings
32 33 23 00	32 33 00 00	Site Furnishings
32 33 33 00	32 33 00 00	Site Furnishings
32 33 43 00	32 33 00 00	Site Furnishings
32 33 43 13	32 33 00 00	Site Furnishings
32 33 43 53	32 33 00 00	Site Furnishings
32 33 53 00	32 33 00 00	Site Furnishings
32 33 63 00	32 33 00 00	Site Furnishings



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SECTION 32 84 00 00 - PLANTING IRRIGATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipes, tubes, and fittings.
2. Encasement for piping.
3. Manual valves.
4. Pressure-reducing valves.
5. Automatic control valves.
6. Automatic drain valves.
7. Transition fittings.
8. Dielectric fittings.
9. Miscellaneous piping specialties.
10. Sprinklers.
11. Quick couplers.
12. Drip irrigation specialties.
13. Controllers.
14. Boxes for automatic control valves.

B. Related Requirements:

1. Section 220500 "Common Work Results for Plumbing" for water metering requirements.
2. Section 230923.14 "Flow Instruments" for water metering equipment.

1.2 DEFINITIONS

- A. Circuit Piping:** Downstream from control valves to sprinklers, specialties, and drain valves. Piping is under pressure during flow.
- B. Drain Piping:** Downstream from circuit-piping drain valves. Piping is not under pressure.
- C. ET Controllers:** EvapoTranspiration Controllers. Irrigation controllers, which use some method of weather-based adjustment of irrigation. These adjusting methods include use of historical monthly averages of ET, broadcasting of ET measurements, or use of on-site sensors to track ET.
- D. Main Piping:** Downstream from point of connection to water distribution piping to, and including, control valves. Piping is under water-distribution-system pressure.
- E. Low Voltage:** As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

1.3 ACTION SUBMITTALS

A. Product Data:

1. Pipes, tubes, and fittings.

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2. Encasement for piping.
3. Manual valves.
4. Pressure-reducing valves.
5. Automatic control valves.
6. Automatic drain valves.
7. Transition fittings.
8. Dielectric fittings.
9. Miscellaneous piping specialties.
10. Sprinklers.
11. Quick couplers.
12. Drip irrigation specialties.
13. Controllers.
14. Boxes for automatic control valves.
15. Include rated capacities, operating characteristics, **[electrical characteristics,]** and furnished specialties and accessories.

- B. Wiring Diagrams: For power, signal, and control wiring.
- C. Delegated Design Submittals: For irrigation systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
- D. Sustainable Design Submittals:
1. Product Data: For irrigation control system.
 2. Product Data: For irrigation submetering.
 3. Irrigation Submetering: Provide manufacturer cut sheets for irrigation metering equipment.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Irrigation systems, drawn to scale, on which components are indicated and coordinated with each other, using input from Installers of the items involved. Also include adjustments necessary to avoid plantings and obstructions, such as signs and light standards.
- B. Zoning Chart: Indicate each irrigation zone and its control valve.
- C. Controller Timing Schedule: Indicate timing settings for each automatic controller zone.
- D. Field Quality-Control Submittals:
1. Field quality-control reports.
- E. Qualification Statements: For **[Installer]<Insert entity or specialist>**.
- F. Delegated design engineer qualifications.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For **[sprinklers][controllers][and][automatic control valves]** to include in operation and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Extra Stock Material: Furnish extra materials to Owner that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Impact Sprinklers: Equal to **<Insert number>** percent of amount installed for each type and size indicated, but no fewer than **<Insert number>** units.
 2. Spray Sprinklers: Equal to **<Insert number>** percent of amount installed for each type and size indicated, but no fewer than **<Insert number>** units.
 3. Bubblers: Equal to **<Insert number>** percent of amount installed for each type indicated, but no fewer than **<Insert number>** units.
 4. Emitters: Equal to **<Insert number>** percent of amount installed for each type indicated, but no fewer than **<Insert number>** units.
 5. Drip-Tube System Tubing: Equal to **<Insert number>** percent of total length installed for each type and size indicated, but not less than **[100 ft. (30 m)][500 ft. (152 m)]<Insert value>**.
 6. Soaker Tubes: Equal to **<Insert number>** percent of total length installed for each type and size indicated, but not less than **[50 ft. (15.2 m)][100 ft. (30 m)]<Insert value>**.
- B. Schedule of maintenance material items.

1.7 QUALITY ASSURANCE

- A. Qualifications:
1. Installers: Entity that employs a **[Certified Irrigation Designer - Landscape qualified by the Irrigation Association][Professional Class member of the American Society of Irrigation Consultants][Professional Technical Class member of the American Society of Irrigation Consultants]<Insert qualifications>**.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Deliver piping with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe-end damage and entrance of dirt, debris, and moisture.
- B. Store plastic piping protected from direct sunlight. Support piping to prevent sagging and bending.

1.9 FIELD CONDITIONS

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

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Irrigation Zone Control: **[Automatic operation with controller and automatic control][Manual operation with manual]** valves.
- B. Location of Sprinklers and Specialties: Design location is approximate. Make minor adjustments necessary to avoid plantings and obstructions, such as signs and light standards. Maintain 100 percent irrigation coverage of areas indicated.
- C. Delegated Design: Design 100 percent coverage irrigation system, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
 - 1. Available land records indicate the following soil conditions:
 - a. Type: **[Coarse][Medium][Fine]<Insert type>**.
 - b. Texture:
 - 1) Sand: **<Insert number>** percent.
 - 2) Silt: **<Insert number>** percent.
 - 3) Clay: **<Insert number>** percent.
 - c. Particle Size:
 - 1) Sand: **<Insert number>** mm.
 - 2) Silt: **<Insert number>** mm.
 - 3) Clay: **<Insert number>** mm.
 - d. Structure: **[Single grained][Granular][Platy][Blocky]<Insert structure>**.
 - e. Density: **<Insert lb/cu. ft. (kg./cu. m)>**.
 - f. Moisture Content: **<Insert number>** percent.
 - g. Infiltration Rate: **<Insert gph (L/s)>**.
- D. Minimum Working Pressures: The following are minimum pressure requirements for piping, valves, and specialties unless otherwise indicated:
 - 1. Irrigation Main Piping: **[200 psig (1380 kPa)]<Insert value>**.
 - 2. Circuit Piping: **[150 psig (1035 kPa)]<Insert value>**.

2.2 PIPES, TUBES, AND FITTINGS

- A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, and fitting materials, and for joining methods for specific services, service locations, and pipe sizes.
- B. Galvanized-Steel Pipe: ASTM A53/A53M, Standard Weight, Type E, Grade B.
 - 1. Galvanized-Steel Pipe Nipples: ASTM A733, made of ASTM A53/A53M or ASTM A106/A106M, Standard Weight, seamless-steel pipe with threaded ends.
 - 2. Galvanized, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.
 - 3. Malleable-Iron Unions: ASME B16.39, Class 150, hexagonal-stock body with ball-and-socket,

- metal-to-metal, bronze seating surface, and female threaded ends.
4. Cast-Iron Flanges: ASME B16.1, Class 125.
- C. Ductile-Iron Pipe with Mechanical Joints: AWWA C151, with mechanical-joint bell and spigot ends.
 1. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
 - a. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.
- D. Ductile-Iron Pipe with Push-on Joint: AWWA C151, with push-on-joint bell and spigot ends.
 1. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
 - a. Gaskets: AWWA C111 rubber.
- E. Soft Copper Tube: **ASTM B88, Type L (ASTM B88M, Type B)**, water tube, annealed temper.
 1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper solder-joint fittings. Furnish wrought-copper fittings if indicated.
 2. Bronze Flanges: ASME B16.24, Class 150, with solder-joint end.
 3. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces and solder-joint or threaded ends.
- F. Hard Copper Tube: **[ASTM B88, Type L (ASTM B88M, Type B),][and][ASTM B88, Type M (ASTM B88M, Type C),]** water tube, drawn temper.
 1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper solder-joint fittings. Furnish wrought-copper fittings if indicated.
 2. Bronze Flanges: ASME B16.24, Class 150, with solder-joint end.
 3. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces and solder-joint or threaded ends.
- G. PE Pipe with Controlled ID: ASTM D2239, PE 3408 compound; **[SIDR 11.5][and][SIDR 15]**.
 1. Insert Fittings for PE Pipe: ASTM D2609, nylon or propylene plastic with barbed ends. Include bands or other fasteners.
- H. PE Pipe with Controlled OD: ASTM D3035, PE 3408 compound, SIDR 11.
 1. PE Butt, Heat-Fusion Fittings: ASTM D3261.
 2. PE Socket-Type Fittings: ASTM D2683.
- I. PE Pressure Pipe: AWWA C906, with DR of 7.3, 9, or 9.3 and PE compound number required to give pressure rating of not less than **[160 psig (1100 kPa)][200 psig (1380 kPa)]**.
 1. PE Butt, Heat-Fusion Fittings: ASTM D3261.
 2. PE Socket-Type Fittings: ASTM D2683.
- J. PVC Pipe: ASTM D1785, PVC 1120 compound, **[Schedule 40][Schedule 80][Schedules 40 and 80]**.
 1. PVC Socket Fittings: ASTM D2466, **[Schedule 40][Schedule 80][Schedules 40 and 80]**.
 2. PVC Threaded Fittings: ASTM D2464, Schedule 80.

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3. PVC Socket Unions: Construction similar to that of MSS SP-107, except both headpiece and tailpiece shall be PVC with socket ends.

K. PVC Pipe, Pressure Rated: ASTM D2241, PVC 1120 compound, **[SDR 21][and][SDR 26]**.

1. PVC Socket Fittings: ASTM D2467, Schedule 80.
2. PVC Socket Unions: Construction similar to that of MSS SP-107, except both headpiece and tailpiece shall be PVC with socket or threaded ends.

2.3 PIPING JOINING MATERIALS

- A. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, **1/8 inch (3 mm)** thick unless otherwise indicated; full-face or ring type unless otherwise indicated.
- B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
- C. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.
- D. Solder Filler Metals: ASTM B32, lead-free alloys. Include water-flushable flux in accordance with ASTM B813.
- E. Solvent Cements for Joining PVC Piping: ASTM D2564. Include primer in accordance with ASTM F656.
- F. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

2.4 ENCASEMENT FOR PIPING

- A. Standard: ASTM A674 or AWWA C105.
- B. Form: **[Sheet][Sheet or tube][Tube]**.
- C. Material: **[LLDPE film of 0.008-inch (0.20-mm)][LLDPE film of 0.008-inch (0.20-mm) minimum thickness or high-density, cross-laminated PE film of 0.004-inch (0.10-mm)][High-density, cross-laminated PE film of 0.004-inch (0.10-mm)]** minimum thickness.
- D. Color: **[Black][or][Natural]<Insert color>**.

2.5 MANUAL VALVES

- A. Curb Valves:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[A.Y. McDonald Mfg. Co.]**
 - b. **[Amcast Industrial Corporation]**
 - c. **[Ford Meter Box Company, Inc. (The)]**

- d. [James Jones Company, LLC, Mueller Water Products, Inc.]
 - e. [Mueller Co. LLC; Mueller Water Products, Inc.]
 - f. [Red Hed Manufacturing Company; a division of Everett J. Prescott, Inc.]
 - g. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [A.Y. McDonald Mfg. Co.]
 - b. [Amcast Industrial Corporation]
 - c. [Ford Meter Box Company, Inc. (The)]
 - d. [James Jones Company, LLC, Mueller Water Products, Inc.]
 - e. [Mueller Co. LLC; Mueller Water Products, Inc.]
 - f. [Red Hed Manufacturing Company; a division of Everett J. Prescott, Inc.]
 - g. <Insert manufacturer's name>
 3. Description:
 - a. Standard: AWWA C800.
 - b. NPS 1 (DN 25) and Smaller Pressure Rating: [100 psig (690 kPa) minimum][150 psig (1035 kPa)].
 - c. NPS 1-1/4 to NPS 2 (DN 32 to DN 50) Pressure Rating: [80 psig (550 kPa) minimum][150 psig (1035 kPa)].
 - d. Body Material: Brass or bronze with ball or ground-key plug.
 - e. End Connections: Matching piping.
 - f. Stem: With wide-tee head.
- B. Curb-Valve Casing:
1. Standard: Similar to AWWA M44 for cast-iron valve casings.
 2. Top Section: Telescoping, of length required for depth of burial of curb valve.
 3. Barrel: Approximately 3-inch (75-mm) diameter.
 4. Plug: With lettering "WATER."
 5. Bottom Section: With base of size to fit over valve.
 6. Base Support: Concrete collar[or wood frame].
- C. Shutoff Rods for Curb-Valve Casings: Furnish [one][two]<Insert number> steel, tee-handle shutoff rod(s) with one pointed end, stem of length to operate deepest buried valve, and slotted end matching curb valve for Project.
- D. Brass Ball Valves:
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Crane Fluid Systems; Crane Co.]
 - b. [DynaQuip Controls]
 - c. [Flow-Tek; a subsidiary of Bray International]
 - d. [Hammond Valve]
 - e. [Jomar Valve]
 - f. [KITZ Corporation]
 - g. [Marwin Valve; Richards Industries]
 - h. [Milwaukee Valve Company]

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- i. [Neles Corporation]
 - j. [NIBCO INC.]
 - k. [Red-White Valve Corp.]
 - l. [RuB Inc]
 - m. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Crane Fluid Systems; Crane Co.]
 - b. [DynaQuip Controls]
 - c. [Flow-Tek; a subsidiary of Bray International]
 - d. [Hammond Valve]
 - e. [Jomar Valve]
 - f. [KITZ Corporation]
 - g. [Marwin Valve; Richards Industries]
 - h. [Milwaukee Valve Company]
 - i. [Neles Corporation]
 - j. [NIBCO INC.]
 - k. [Red-White Valve Corp.]
 - l. [RuB Inc]
 - m. <Insert manufacturer's name>
3. Description:
 - a. Standard: MSS SP-110.
 - b. SWP Rating: **150 psig (1035 kPa)**.
 - c. CWP Rating: **600 psig (4140 kPa)**.
 - d. Body Design: Two piece.
 - e. Body Material: Forged brass.
 - f. Ends: Threaded or solder joint if indicated.
 - g. Seats: PTFE or TFE.
 - h. Stem: Brass.
 - i. Ball: Chrome-plated brass.
 - j. Port: Full[**or regular, but not reduced**].

E. Bronze Ball Valves:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [American Valve, Inc]
 - b. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - c. [Crane Fluid Systems; Crane Co.]
 - d. [Hammond Valve]
 - e. [Lance Valves]
 - f. [Milwaukee Valve Company]
 - g. [NIBCO INC.]
 - h. [Red-White Valve Corp.]
 - i. [WATTS; A Watts Water Technologies Company]
 - j. [Zurn Industries, LLC]
 - k. <Insert manufacturer's name>

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Valve, Inc]**
 - b. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - c. **[Crane Fluid Systems; Crane Co.]**
 - d. **[Hammond Valve]**
 - e. **[Lance Valves]**
 - f. **[Milwaukee Valve Company]**
 - g. **[NIBCO INC.]**
 - h. **[Red-White Valve Corp.]**
 - i. **[WATTS; A Watts Water Technologies Company]**
 - j. **[Zurn Industries, LLC]**
 - k. **<Insert manufacturer's name>**
3. Description:
 - a. Standard: MSS SP-110.
 - b. SWP Rating: **150 psig (1035 kPa)**.
 - c. CWP Rating: **600 psig (4140 kPa)**.
 - d. Body Design: Two piece.
 - e. Body Material: Bronze.
 - f. Ends: Threaded or solder joint if indicated.
 - g. Seats: PTFE or TFE.
 - h. Stem: Bronze.
 - i. Ball: Chrome-plated brass.
 - j. Port: Full[**or regular, but not reduced**].

F. Iron Ball Valves:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[American Valve, Inc]**
 - b. **[KITZ Corporation]**
 - c. **[Sure Flow Equipment Inc]**
 - d. **[WATTS; A Watts Water Technologies Company]**
 - e. **[Zurn Industries, LLC]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Valve, Inc]**
 - b. **[KITZ Corporation]**
 - c. **[Sure Flow Equipment Inc]**
 - d. **[WATTS; A Watts Water Technologies Company]**
 - e. **[Zurn Industries, LLC]**
 - f. **<Insert manufacturer's name>**

3. Description:

- a. Standard: MSS SP-72.
- b. CWP Rating: **200 psig (1380 kPa)**.
- c. Body Design: Split body.
- d. Body Material: ASTM A126, gray iron.
- e. Ends: Flanged.
- f. Seats: PTFE or TFE.
- g. Stem: Stainless steel.
- h. Ball: Stainless steel.
- i. Port: Full.

G. Plastic Ball Valves:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[American Valve, Inc]**
 - b. **[Asahi/America]**
 - c. **[Colonial Engineering, Inc.]**
 - d. **[GF Piping Systems: Georg Fischer LLC]**
 - e. **[Hayward Flow Control; Hayward Industries, Inc.]**
 - f. **[IPEX USA LLC]**
 - g. **[Jomar Valve]**
 - h. **[NIBCO INC.]**
 - i. **[Spears Manufacturing Company]**
 - j. **[Thermoplastic Valves, Inc]**
 - k. **[WATTS; A Watts Water Technologies Company]**
 - l. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Valve, Inc]**
 - b. **[Asahi/America]**
 - c. **[Colonial Engineering, Inc.]**
 - d. **[GF Piping Systems: Georg Fischer LLC]**
 - e. **[Hayward Flow Control; Hayward Industries, Inc.]**
 - f. **[IPEX USA LLC]**
 - g. **[Jomar Valve]**
 - h. **[NIBCO INC.]**
 - i. **[Spears Manufacturing Company]**
 - j. **[Thermoplastic Valves, Inc]**
 - k. **[WATTS; A Watts Water Technologies Company]**
 - l. **<Insert manufacturer's name>**
3. Description:
 - a. Standard: MSS SP-122.
 - b. Pressure Rating: **[125 psig (860 kPa) minimum][150 psig (1035 kPa)]**.
 - c. Body Material: PVC.
 - d. Type: Union.
 - e. End Connections: Socket or threaded.
 - f. Port: Full.

H. Bronze Gate Valves:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[American Valve, Inc]**
 - b. **[Crane Fluid Systems; Crane Co.]**
 - c. **[Hammond Valve]**
 - d. **[Jenkins Valves; a Crane Co. brand]**
 - e. **[KITZ Corporation]**
 - f. **[Milwaukee Valve Company]**
 - g. **[NIBCO INC.]**
 - h. **[Powell Valves]**
 - i. **[WATTS; A Watts Water Technologies Company]**
 - j. **[Zurn Industries, LLC]**
 - k. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American Valve, Inc]**
 - b. **[Crane Fluid Systems; Crane Co.]**
 - c. **[Hammond Valve]**
 - d. **[Jenkins Valves; a Crane Co. brand]**
 - e. **[KITZ Corporation]**
 - f. **[Milwaukee Valve Company]**
 - g. **[NIBCO INC.]**
 - h. **[Powell Valves]**
 - i. **[WATTS; A Watts Water Technologies Company]**
 - j. **[Zurn Industries, LLC]**
 - k. **<Insert manufacturer's name>**
3. Description:
 - a. Standard: MSS SP-80, Type 2.
 - b. Class: 125.
 - c. CWP Rating: **200 psig (1380 kPa)**.
 - d. Body Material: ASTM B62 bronze with integral seat and screw-in bonnet.
 - e. Ends: Threaded or solder joint.
 - f. Stem: Bronze, nonrising.
 - g. Disc: Solid wedge; bronze.
 - h. Packing: Asbestos free.
 - i. Handwheel: Malleable iron, bronze, or aluminum.

I. Iron Gate Valves, Resilient Seated:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[American AVK Co.]**
 - b. **[American Cast Iron Pipe Company]**

- c. [Clow Valve Company; a subsidiary of McWane, Inc.]
- d. [Kennedy Valve Company; a division of McWane, Inc.]
- e. [M & H Valve Company; a division of McWane, Inc.]
- f. [Mueller Co. LLC; Mueller Water Products, Inc.]
- g. [NIBCO INC.]
- h. [U.S. Pipe]
- i. [Zurn Industries, LLC]
- j. <Insert manufacturer's name>

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

- a. [American AVK Co.]
- b. [American Cast Iron Pipe Company]
- c. [Clow Valve Company; a subsidiary of McWane, Inc.]
- d. [Kennedy Valve Company; a division of McWane, Inc.]
- e. [M & H Valve Company; a division of McWane, Inc.]
- f. [Mueller Co. LLC; Mueller Water Products, Inc.]
- g. [NIBCO INC.]
- h. [U.S. Pipe]
- i. [Zurn Industries, LLC]
- j. <Insert manufacturer's name>

3. Description:

- a. Standard: AWWA C509.
- b. Pressure Rating: [200 psig (1380 kPa)][250 psig (1725 kPa)] minimum.
- c. Body Material: Ductile or gray iron with bronze trim.
- d. End Connections: Mechanical joint or push-on joint.
- e. Interior Coating: Comply with AWWA C550.
- f. Body Design: Nonrising stem.
- g. Operator: Stem nut.
- h. Disc: Solid wedge with resilient coating.

J. Iron Gate Valve Casings:

- 1. Standard: AWWA M44 for cast-iron valve casings.
- 2. Top Section: Adjustable extension of length required for depth of burial of valve.
- 3. Barrel: Approximately **5-inch (125-mm)** diameter.
- 4. Plug: With lettering "WATER."
- 5. Bottom Section: With base of size to fit over valve.
- 6. Base Support: Concrete collar[**or wood frame**].

- K. Operating Wrenches for Iron Gate Valve Casings: Furnish [one][two]<Insert number> steel, tee-handle operating wrench(es) with one pointed end, stem of length to operate deepest buried valve, and socket matching valve operating nut for Project.

L. Iron Gate Valves, NRS:

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

- a. [Crane Fluid Systems; Crane Co.]
 - b. [Flo Fab Inc]
 - c. [Hammond Valve]
 - d. [KITZ Corporation]
 - e. [Milwaukee Valve Company]
 - f. [NIBCO INC.]
 - g. [Powell Valves]
 - h. [Red-White Valve Corp.]
 - i. [WATTS; A Watts Water Technologies Company]
 - j. [Zurn Industries, LLC]
 - k. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Crane Fluid Systems; Crane Co.]
 - b. [Flo Fab Inc]
 - c. [Hammond Valve]
 - d. [KITZ Corporation]
 - e. [Milwaukee Valve Company]
 - f. [NIBCO INC.]
 - g. [Powell Valves]
 - h. [Red-White Valve Corp.]
 - i. [WATTS; A Watts Water Technologies Company]
 - j. [Zurn Industries, LLC]
 - k. <Insert manufacturer's name>
3. Description:
 - a. Standard: MSS SP-70, Type I.
 - b. CWP Rating: **200 psig (1380 kPa)**.
 - c. Body Material: ASTM A126, gray iron with bolted bonnet.
 - d. Ends: Flanged.
 - e. Trim: All bronze.
 - f. Disc: Solid wedge.
 - g. Packing and Gasket: Asbestos free.

M. Iron Gate Valves, OS&Y:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Crane Fluid Systems; Crane Co.]
 - b. [Flo Fab Inc]
 - c. [Hammond Valve]
 - d. [KITZ Corporation]
 - e. [Milwaukee Valve Company]
 - f. [NIBCO INC.]
 - g. [Powell Valves]
 - h. [Red-White Valve Corp.]
 - i. [WATTS; A Watts Water Technologies Company]
 - j. [Zurn Industries, LLC]
 - k. <Insert manufacturer's name>

32 - Exterior Improvements

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Crane Fluid Systems; Crane Co.]**
 - b. **[Flo Fab Inc]**
 - c. **[Hammond Valve]**
 - d. **[KITZ Corporation]**
 - e. **[Milwaukee Valve Company]**
 - f. **[NIBCO INC.]**
 - g. **[Powell Valves]**
 - h. **[Red-White Valve Corp.]**
 - i. **[WATTS; A Watts Water Technologies Company]**
 - j. **[Zurn Industries, LLC]**
 - k. **<Insert manufacturer's name>**
3. Description:
 - a. Standard: MSS SP-70, Type I.
 - b. CWP Rating: **200 psig (1380 kPa)**.
 - c. Body Material: ASTM A126, gray iron with bolted bonnet.
 - d. Ends: Flanged.
 - e. Trim: All bronze.
 - f. Disc: Solid wedge.
 - g. Packing and Gasket: Asbestos free.

2.6 PRESSURE-REDUCING VALVES

A. Water Regulators:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Cash Acme Plumbing Products; an RWC brand]**
 - b. **[Honeywell International Inc.]**
 - c. **[WATTS; A Watts Water Technologies Company]**
 - d. **[Zurn Industries, LLC]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Cash Acme Plumbing Products; an RWC brand]**
 - b. **[Honeywell International Inc.]**
 - c. **[WATTS; A Watts Water Technologies Company]**
 - d. **[Zurn Industries, LLC]**
 - e. **<Insert manufacturer's name>**
3. Description:
 - a. Standard: ASSE 1003.

- b. Body Material: Bronze for **NPS 2 (DN 50)** and smaller; cast iron[**with interior lining complying with AWWA C550 or that is FDA approved**] for **NPS 2-1/2** and **NPS 3 (DN 65 and DN 80)**.
 - c. Pressure Rating: Initial pressure of **150 psig (1035 kPa)**.
 - d. End Connections: Threaded for **NPS 2 (DN 50)** and smaller; flanged for **NPS 2-1/2** and **NPS 3 (DN 65 and DN 80)**.
 - 4. Capacities and Characteristics:
 - a. Size: **<Insert NPS (DN)>**.
 - b. Design Flow Rate: **<Insert gpm (L/s)>**.
 - c. Design Inlet Pressure: **<Insert psig (kPa)>**.
 - d. Design Outlet Pressure Setting: **<Insert psig (kPa)>**.
- B. Water-Control Valves:
 - 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. **[CLA-VAL]**
 - b. **[Flomatic Valves; Flomatic Corporation]**
 - c. **[OCV Control Valves]**
 - d. **[WATTS; A Watts Water Technologies Company]**
 - e. **[Zurn Industries, LLC]**
 - f. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[CLA-VAL]**
 - b. **[Flomatic Valves; Flomatic Corporation]**
 - c. **[OCV Control Valves]**
 - d. **[WATTS; A Watts Water Technologies Company]**
 - e. **[Zurn Industries, LLC]**
 - f. **<Insert manufacturer's name>**
 - 3. Description: Pilot-operation, diaphragm-type, single-seated main water-control valve. Include small pilot control valve, restrictor device, specialty fittings, and sensor piping.
 - a. Main Valve Body: Cast- or ductile-iron body with AWWA C550 or FDA-approved, interior epoxy coating; or stainless steel body.
 - b. Pattern: **[Angle][Globe]**-valve design.
 - c. Trim: Stainless steel.
 - d. Pressure Rating: Initial pressure of **150 psig (1035 kPa)** minimum.
 - e. End Connections: Threaded for **NPS 2 (DN 50)** and smaller; **[flanged]<Insert type>** for **NPS 2-1/2 (DN 65)** and larger.
 - 4. Capacities and Characteristics:
 - a. Size: **<Insert NPS (DN)>**.
 - b. Design Flow Rate: **<Insert gpm (L/s)>**.
 - c. Design Inlet Pressure: **<Insert psig (kPa)>**.
 - d. Design Outlet Pressure Setting: **<Insert psig (kPa)>**.

2.7 AUTOMATIC CONTROL VALVES

A. Bronze, Automatic Control Valves:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Buckner Superior; Storm Industries, Inc.]**
 - b. **[Champion-Arrowhead]**
 - c. **[Netafim USA]**
 - d. **[Rain Bird Corporation]**
 - e. **[Toro Company (The)]**
 - f. **[Weathermatic]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Buckner Superior; Storm Industries, Inc.]**
 - b. **[Champion-Arrowhead]**
 - c. **[Netafim USA]**
 - d. **[Rain Bird Corporation]**
 - e. **[Toro Company (The)]**
 - f. **[Weathermatic]**
 - g. **<Insert manufacturer's name>**
3. Description: Cast-bronze body, normally closed, diaphragm type with manual-flow adjustment, and operated by 24 V ac solenoid.

B. Plastic, Automatic Control Valves:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Buckner Superior; Storm Industries, Inc.]**
 - b. **[Champion-Arrowhead]**
 - c. **[Dig Corporation]**
 - d. **[Evoqua Water Technologies, LLC]**
 - e. **[Greenlawn Sprinkler Company]**
 - f. **[Hit Products Corporation]**
 - g. **[Hunter Industries Incorporated]**
 - h. **[Irritrol Systems]**
 - i. **[Nelson; Fiskars Brands, Inc.]**
 - j. **[Netafim USA]**
 - k. **[Orbit Irrigation Products, LLC]**
 - l. **[Rain Bird Corporation]**
 - m. **[Toro Company (The)]**
 - n. **[Weathermatic]**
 - o. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Buckner Superior; Storm Industries, Inc.]**
 - b. **[Champion-Arrowhead]**
 - c. **[Dig Corporation]**
 - d. **[Evoqua Water Technologies, LLC]**
 - e. **[Greenlawn Sprinkler Company]**
 - f. **[Hit Products Corporation]**
 - g. **[Hunter Industries Incorporated]**
 - h. **[Irritrol Systems]**
 - i. **[Nelson; Fiskars Brands, Inc.]**
 - j. **[Netafim USA]**
 - k. **[Orbit Irrigation Products, LLC]**
 - l. **[Rain Bird Corporation]**
 - m. **[Toro Company (The)]**
 - n. **[Weathermatic]**
 - o. **<Insert manufacturer's name>**
3. Description: Molded-plastic body, normally closed, diaphragm type with manual-flow adjustment, and operated by 24 V ac solenoid.

2.8 AUTOMATIC DRAIN VALVES

- A. Description: Spring-loaded-ball type of corrosion-resistant construction and designed to open for drainage if line pressure drops below **2-1/2 to 3 psig (17 to 20 kPa)**.

2.9 TRANSITION FITTINGS

- A. General Requirements: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.
- B. Transition Couplings:
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Cascade Waterworks Mfg. Co.]**
 - b. **[Dresser Utility Solutions]**
 - c. **[Ford Meter Box Company, Inc. (The)]**
 - d. **[JCM Industries, Inc]**
 - e. **[Smith-Blair, a Xylem brand.]**
 - f. **[Viking Johnson]**
 - g. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Cascade Waterworks Mfg. Co.]**
 - b. **[Dresser Utility Solutions]**

- c. [Ford Meter Box Company, Inc. (The)]
- d. [JCM Industries, Inc]
- e. [Smith-Blair, a Xylem brand.]
- f. [Viking Johnson]
- g. <Insert manufacturer's name>

3. Description: AWWA C219, metal sleeve-type coupling for underground pressure piping.

C. Plastic-to-Metal Transition Fittings:

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

- a. [Harvel Plastics, Inc.]
- b. [Spears Manufacturing Company]
- c. <Insert manufacturer's name>

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

- a. [Harvel Plastics, Inc.]
- b. [Spears Manufacturing Company]
- c. <Insert manufacturer's name>

3. Description: PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert and one solvent-cement-socket[**or threaded**] end.

D. Plastic-to-Metal Transition Unions:

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

- a. [Colonial Engineering, Inc.]
- b. [NIBCO INC.]
- c. [Spears Manufacturing Company]
- d. <Insert manufacturer's name>

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

- a. [Colonial Engineering, Inc.]
- b. [NIBCO INC.]
- c. [Spears Manufacturing Company]
- d. <Insert manufacturer's name>

3. Description: MSS SP-107, PVC four-part union. Include one brass[**or stainless steel**] threaded end, one solvent-cement-joint[**or threaded**] plastic end, rubber O-ring, and union nut.

2.10 DIELECTRIC FITTINGS

- A. General Requirements: Assembly of copper alloy and ferrous materials or ferrous material body with separating nonconductive insulating material suitable for system fluid, pressure, and temperature.
- B. Dielectric Unions:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Capitol Manufacturing Company]**
 - b. **[GF Piping Systems: Georg Fischer LLC]**
 - c. **[HART Industrial Unions, LLC]**
 - d. **[WATTS; A Watts Water Technologies Company]**
 - e. **[Zurn Industries, LLC]**
 - f. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Capitol Manufacturing Company]**
 - b. **[GF Piping Systems: Georg Fischer LLC]**
 - c. **[HART Industrial Unions, LLC]**
 - d. **[WATTS; A Watts Water Technologies Company]**
 - e. **[Zurn Industries, LLC]**
 - f. **<Insert manufacturer's name>**
 3. Description: Factory-fabricated union, **NPS 2 (DN 50)** and smaller.
 - a. Pressure Rating: **[150 psig (1035 kPa) minimum][250 psig (1725 kPa)]** at 180 deg F (82 deg C).
 - b. End Connections: Solder-joint copper alloy and threaded ferrous; threaded ferrous.
- C. Dielectric Flanges:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Capitol Manufacturing Company]**
 - b. **[GF Piping Systems: Georg Fischer LLC]**
 - c. **[WATTS; A Watts Water Technologies Company]**
 - d. **[Zurn Industries, LLC]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Capitol Manufacturing Company]**
 - b. **[GF Piping Systems: Georg Fischer LLC]**
 - c. **[WATTS; A Watts Water Technologies Company]**

- d. **[Zurn Industries, LLC]**
- e. **<Insert manufacturer's name>**

- 3. Description: Factory-fabricated, bolted, companion-flange assembly, **NPS 2-1/2 to NPS 4 (DN 65 to DN 100)** and larger.

- a. Pressure Rating: **[150 psig (1035 kPa) minimum][175 psig (1200 kPa) minimum][300 psig (2070 kPa)]**.
- b. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Kits:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Advance Products & Systems, LLC]**
 - b. **[CALPICO, Inc.]**
 - c. **[GF Piping Systems: Georg Fischer LLC]**
 - d. **[GPT; a division of EnPRO Industries]**
 - e. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Advance Products & Systems, LLC]**
 - b. **[CALPICO, Inc.]**
 - c. **[GF Piping Systems: Georg Fischer LLC]**
 - d. **[GPT; a division of EnPRO Industries]**
 - e. **<Insert manufacturer's name>**
- 3. Description: Nonconducting materials for field assembly of companion flanges, **NPS 2-1/2 (DN 65)** and larger.
 - a. Pressure Rating: **[150 psig (1035 kPa) minimum]<Insert value>**.
 - b. Gasket: Neoprene or phenolic.
 - c. Bolt Sleeves: Phenolic or polyethylene.
 - d. Washers: Phenolic with steel backing washers.

E. Dielectric Couplings:

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

following:

- a. [CALPICO, Inc.]
- b. [Lochinvar, LLC]
- c. <Insert manufacturer's name>

3. Description: Galvanized-steel coupling.

- a. Pressure Rating: **300 psig (2070 kPa) at 225 deg F (107 deg C)**.
- b. End Connections: Female threaded.
- c. Lining: Inert and noncorrosive, thermoplastic lining.

F. Dielectric Nipples:

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

- a. [Elster Perfection; Honeywell]
- b. [Precision Plumbing Products]
- c. [Victaulic Company]
- d. <Insert manufacturer's name>

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

- a. [Elster Perfection; Honeywell]
- b. [Precision Plumbing Products]
- c. [Victaulic Company]
- d. <Insert manufacturer's name>

3. Description: Electroplated steel nipple complying with ASTM F1545.

- a. Pressure Rating: **[300 psig (2070 kPa) at 225 deg F (107 deg C)]<Insert values>**.
- b. End Connections: Male threaded or grooved.
- c. Lining: Inert and noncorrosive, propylene.

2.11 MISCELLANEOUS PIPING SPECIALTIES

- A. Water Hammer Arresters: ASSE 1010 or PDI WH 201, with bellows or piston-type pressurized cushioning chamber and in sizes complying with PDI WH 201, Sizes A to F.
- B. Pressure Gages: ASME B40.1. Include **4-1/2-inch- (115-mm-)** diameter dial, dial range of two times system operating pressure, and bottom outlet.

2.12 SPRINKLERS

- A. General Requirements: Designed for uniform coverage over entire spray area indicated at available water pressure.
- B. Metal, Exposed, Impact-Drive Rotary Sprinklers:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Buckner Superior; Storm Industries, Inc.]**
 - b. **[Champion-Arrowhead]**
 - c. **[Orbit Irrigation Products, LLC]**
 - d. **[Rain Bird Corporation]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Buckner Superior; Storm Industries, Inc.]**
 - b. **[Champion-Arrowhead]**
 - c. **[Orbit Irrigation Products, LLC]**
 - d. **[Rain Bird Corporation]**
 - e. **<Insert manufacturer's name>**
3. Description:
 - a. Construction: Brass and other corrosion-resistant metals.
 - b. Mounting: Aboveground, exposed on riser.
4. Capacities and Characteristics:
 - a. Flow: **<Insert gpm (L/s)>**.
 - b. Arc: **[Full][Half][Quarter]<Insert arc>** circle.
 - c. Radius: **<Insert feet (m)>**.
 - d. Inlet: **[NPS 1/2 (DN 15)][NPS 1/2 or NPS 3/4 (DN 15 or DN 20)][NPS 3/4 (DN 20)]<Insert value>**.

C. Plastic, Exposed, Impact-Drive Rotary Sprinklers:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Champion-Arrowhead]**
 - b. **[K-RAIN Manufacturing Corporation]**
 - c. **[Nelson; Fiskars Brands, Inc.]**
 - d. **[Orbit Irrigation Products, LLC]**
 - e. **[Senninger Irrigation, Inc]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Champion-Arrowhead]**
 - b. **[K-RAIN Manufacturing Corporation]**
 - c. **[Nelson; Fiskars Brands, Inc.]**

- d. [Orbit Irrigation Products, LLC]
 - e. [Senninger Irrigation, Inc]
 - f. <Insert manufacturer's name>
3. Description:
- a. Construction: ABS and corrosion-resistant metals.
 - b. Mounting: Aboveground, exposed on riser.
4. Capacities and Characteristics:
- a. Flow: <Insert gpm (L/s)>.
 - b. Arc: [Full][Half][Quarter]<Insert arc> circle.
 - c. Radius: <Insert feet (m)>.
 - d. Inlet: [NPS 1/2 (DN 15)][NPS 1/2 or NPS 3/4 (DN 15 or DN 20)][NPS 3/4 (DN 20)]<Insert size>.
- D. Plastic, Pop-up, Gear-Drive Rotary Sprinklers:
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
- a. [Buckner Superior; Storm Industries, Inc.]
 - b. [Champion-Arrowhead]
 - c. [Hunter Industries Incorporated]
 - d. [Irritrol Systems]
 - e. [K-RAIN Manufacturing Corporation]
 - f. [Nelson; Fiskars Brands, Inc.]
 - g. [Rain Bird Corporation]
 - h. [Toro Company (The)]
 - i. [Weathermatic]
 - j. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Buckner Superior; Storm Industries, Inc.]
 - b. [Champion-Arrowhead]
 - c. [Hunter Industries Incorporated]
 - d. [Irritrol Systems]
 - e. [K-RAIN Manufacturing Corporation]
 - f. [Nelson; Fiskars Brands, Inc.]
 - g. [Rain Bird Corporation]
 - h. [Toro Company (The)]
 - i. [Weathermatic]
 - j. <Insert manufacturer's name>
3. Description:
- a. Body Material: ABS.
 - b. Nozzle: [ABS][Brass].
 - c. Retraction Spring: Stainless steel.
 - d. Internal Parts: Corrosion resistant.

4. Capacities and Characteristics:

- a. Flow: **<Insert gpm (L/s)>**.
- b. Pop-up Height: **[4 inches (100 mm)]<Insert inches (mm)>** aboveground to nozzle.
- c. Arc: **[Full][Half][Quarter]<Insert arc>** circle.
- d. Radius: **<Insert feet (m)>**.
- e. Inlet: **[NPS 1/2 (DN 15)][NPS 1/2 or NPS 3/4 (DN 15 or DN 20)][NPS 3/4 (DN 20)]**.

E. Metal, Pop-up, Impact-Drive Rotary Sprinklers:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Buckner Superior; Storm Industries, Inc.]**
 - b. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Buckner Superior; Storm Industries, Inc.]**
 - b. **<Insert manufacturer's name>**
- 3. Description:
 - a. Case: Brass.
 - b. Body Material: Brass.
 - c. Pop-up Height: **[4 inches (100 mm)][Approximately 3 inches (75 mm)]<Insert value>** aboveground to nozzle.
 - d. Sprinkler Construction: Brass and other corrosion-resistant metals.
- 4. Capacities and Characteristics:
 - a. Flow: **<Insert gpm (L/s)>**.
 - b. Arc: **[Full][Half][Quarter]<Insert arc>** circle.
 - c. Radius: **<Insert feet (m)>**.
 - d. Inlet: **[NPS 3/4 (DN 20)][NPS 1-1/4 (DN 32)]**.

F. Plastic, Pop-up, Impact-Drive Rotary Sprinklers:

- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Buckner Superior; Storm Industries, Inc.]**
 - b. **[Champion-Arrowhead]**
 - c. **[Nelson; Fiskars Brands, Inc.]**
 - d. **[Rain Bird Corporation]**
 - e. **[Toro Company (The)]**
 - f. **<Insert manufacturer's name>**
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert**

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

- a. **[Buckner Superior; Storm Industries, Inc.]**
- b. **[Champion-Arrowhead]**
- c. **[Nelson; Fiskars Brands, Inc.]**
- d. **[Rain Bird Corporation]**
- e. **[Toro Company (The)]**
- f. **<Insert manufacturer's name>**

3. Description:

- a. Case: ABS.
- b. Pop-up Height: **[4 inches (100 mm)][Approximately 3 inches (75 mm)]<Insert value>** aboveground to nozzle.
- c. Sprinkler Construction: ABS and other corrosion-resistant metals.

4. Capacities and Characteristics:

- a. Nozzle: **[ABS][Brass]**.
- b. Flow: **<Insert gpm (L/s)>**.
- c. Arc: **[Full][Half][Quarter]<Insert arc>** circle.
- d. Radius: **<Insert feet (m)>**.
- e. Inlet: **[NPS 3/4 (DN 20)][NPS 1-1/4 (DN 32)]**.

G. Metal, Surface Spray Sprinklers:

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

- a. **[Champion-Arrowhead]**
- b. **[Rain Bird Corporation]**
- c. **<Insert manufacturer's name>**

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

- a. **[Champion-Arrowhead]**
- b. **[Rain Bird Corporation]**
- c. **<Insert manufacturer's name>**

3. Description:

- a. Body Material and Flange: Brass.
- b. Nozzle: Brass.
- c. Pattern: Fixed, with flow adjustment.

4. Capacities and Characteristics:

- a. Flow: **<Insert gpm (L/s)>**.
- b. Arc: **[Full][Half][Quarter]<Insert arc>** circle.
- c. Radius: **<Insert feet (m)>**.
- d. Inlet: **[NPS 1/2 (DN 15)][NPS 1/2 or NPS 3/4 (DN 15 or DN 20)][NPS 3/4 (DN 20)]**.

H. Plastic, Surface Spray Sprinklers:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Champion-Arrowhead]**
 - b. **[Hit Products Corporation]**
 - c. **[Rain Bird Corporation]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Champion-Arrowhead]**
 - b. **[Hit Products Corporation]**
 - c. **[Rain Bird Corporation]**
 - d. **<Insert manufacturer's name>**
3. Description:
 - a. Body Material and Flange: ABS.
 - b. Pattern: Fixed, with flow adjustment.
4. Capacities and Characteristics:
 - a. Nozzle: **[ABS][Brass]**.
 - b. Flow: **<Insert gpm (L/s)>**.
 - c. Arc: **[Full][Half][Quarter]<Insert arc>** circle.
 - d. Radius: **<Insert feet (m)>**.
 - e. Inlet: **[NPS 1/2 (DN 15)][NPS 1/2 or NPS 3/4 (DN 15 or DN 20)][NPS 3/4 (DN 20)]**.

I. Metal, Surface, Pop-up Spray Sprinklers:

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

3. Description:

- a. Body Material and Flange: Brass.
- b. Nozzle: Brass.
- c. Pattern: Fixed, with flow adjustment.

4. Capacities and Characteristics:

- a. Pop-up Height: [4 inches (100 mm)][1-1/4 or 1-1/2 inches (32 or 38 mm)][1-3/4 or 2 inches (44 or 50 mm)]<Insert value>.
- b. Flow: <Insert gpm (L/s)>.
- c. Arc: [Full][Half][Quarter]<Insert arc> circle.
- d. Radius: <Insert feet (m)>.
- e. Inlet: [NPS 1/2 (DN 15)][NPS 1/2 or NPS 3/4 (DN 15 or DN 20)][NPS 3/4 (DN 20)].

J. Plastic, Surface, Pop-up Spray Sprinklers:

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

- a. [Champion-Arrowhead]
- b. [Hit Products Corporation]
- c. [Rain Bird Corporation]
- d. <Insert manufacturer's name>

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

- a. [Champion-Arrowhead]
- b. [Hit Products Corporation]
- c. [Rain Bird Corporation]
- d. <Insert manufacturer's name>

3. Description:

- a. Body Material and Flange: ABS.
- b. Pattern: Fixed, with flow adjustment.

4. Capacities and Characteristics:

- a. Pop-up Height: [4 inches (100 mm)][1-1/4 or 1-1/2 inches (32 or 38 mm)][1-3/4 or 2 inches (44 or 50 mm)]<Insert value>.
- b. Nozzle: [ABS][Brass].
- c. Flow: <Insert gpm (L/s)>.
- d. Arc: [Full][Half][Quarter]<Insert arc> circle.
- e. Radius: <Insert feet (m)>.
- f. Inlet: [NPS 1/2 (DN 15)][NPS 1/2 or NPS 3/4 (DN 15 or DN 20)][NPS 3/4 (DN 20)].

K. Plastic, Pop-up Spray Sprinklers:

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

following]:

- a. [Buckner Superior; Storm Industries, Inc.]
- b. [Champion-Arrowhead]
- c. [Hit Products Corporation]
- d. [Hunter Industries Incorporated]
- e. [K-RAIN Manufacturing Corporation]
- f. [Nelson; Fiskars Brands, Inc.]
- g. [Orbit Irrigation Products, LLC]
- h. [Rain Bird Corporation]
- i. [Toro Company (The)]
- j. [Weathermatic]
- k. <Insert manufacturer's name>

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

- a. [Buckner Superior; Storm Industries, Inc.]
- b. [Champion-Arrowhead]
- c. [Hit Products Corporation]
- d. [Hunter Industries Incorporated]
- e. [K-RAIN Manufacturing Corporation]
- f. [Nelson; Fiskars Brands, Inc.]
- g. [Orbit Irrigation Products, LLC]
- h. [Rain Bird Corporation]
- i. [Toro Company (The)]
- j. [Weathermatic]
- k. <Insert manufacturer's name>

3. Description:

- a. Body Material: ABS.
- b. Nozzle: [ABS][Brass].
- c. Retraction Spring: Stainless steel.
- d. Internal Parts: Corrosion resistant.
- e. Pattern: Fixed, with flow adjustment.

4. Capacities and Characteristics:

- a. Nozzle: [ABS][Brass].
- b. Flow: <Insert gpm (L/s)>.
- c. Pop-up Height: [4 inches (100 mm)]<Insert inches (mm)> aboveground to nozzle.
- d. Arc: [Full][Half][Quarter]<Insert arc> circle.
- e. Radius: <Insert feet (m)>.
- f. Inlet: [NPS 1/2 (DN 15)][NPS 1/2 or NPS 3/4 (DN 15 or DN 20)][NPS 3/4 (DN 20)].

L. Metal Shrub Sprinklers:

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

- b. [Champion-Arrowhead]
 - c. [Orbit Irrigation Products, LLC]
 - d. [Rain Bird Corporation]
 - e. [Weathermatic]
 - f. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Buckner Superior; Storm Industries, Inc.]
 - b. [Champion-Arrowhead]
 - c. [Orbit Irrigation Products, LLC]
 - d. [Rain Bird Corporation]
 - e. [Weathermatic]
 - f. <Insert manufacturer's name>
3. Description:
 - a. Body Material: Brass.
 - b. Nozzle: Brass.
 - c. Pattern: Fixed, with flow adjustment.
4. Capacities and Characteristics:
 - a. Configuration: <Insert description>.
 - b. Flow: <Insert gpm (L/s)>.
 - c. Arc: [Full][Half][Quarter]<Insert arc> circle.
 - d. Radius: <Insert feet (m)>.
 - e. Mounting Height: <Insert inches (mm)> aboveground to nozzle.
 - f. Inlet: [NPS 1/2 (DN 15)][NPS 1/2 or NPS 3/4 (DN 15 or DN 20)][NPS 3/4 (DN 20)].

M. Plastic Shrub Sprinklers:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Buckner Superior; Storm Industries, Inc.]
 - b. [Champion-Arrowhead]
 - c. [Dig Corporation]
 - d. [Hunter Industries Incorporated]
 - e. [Orbit Irrigation Products, LLC]
 - f. [Rain Bird Corporation]
 - g. [Senninger Irrigation, Inc.]
 - h. [Toro Company (The)]
 - i. [Weathermatic]
 - j. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Buckner Superior; Storm Industries, Inc.]
 - b. [Champion-Arrowhead]

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- c. [Dig Corporation]
- d. [Hunter Industries Incorporated]
- e. [Orbit Irrigation Products, LLC]
- f. [Rain Bird Corporation]
- g. [Senninger Irrigation, Inc]
- h. [Toro Company (The)]
- i. [Weathermatic]
- j. <Insert manufacturer's name>

3. Description:

- a. Body Material: ABS or other plastic.
- b. Pattern: Fixed, with flow adjustment.

4. Capacities and Characteristics:

- a. Configuration: <Insert description>.
- b. Flow: <Insert gpm (L/s)>.
- c. Arc: [Full][Half][Quarter]<Insert arc> circle.
- d. Radius: <Insert feet (m)>.
- e. Mounting Height: <Insert inches (mm)> aboveground to nozzle.
- f. Inlet: [NPS 1/2 (DN 15)][NPS 1/2 or NPS 3/4 (DN 15 or DN 20)][NPS 3/4 (DN 20)].

2.13 QUICK COUPLERS

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

- 1. [Buckner Superior; Storm Industries, Inc.]
- 2. [Champion-Arrowhead]
- 3. [Hunter Industries Incorporated]
- 4. [Nelson; Fiskars Brands, Inc.]
- 5. [Rain Bird Corporation]
- 6. [Toro Company (The)]
- 7. [Weathermatic]
- 8. <Insert manufacturer's name>

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

- 1. [Buckner Superior; Storm Industries, Inc.]
- 2. [Champion-Arrowhead]
- 3. [Hunter Industries Incorporated]
- 4. [Nelson; Fiskars Brands, Inc.]
- 5. [Rain Bird Corporation]
- 6. [Toro Company (The)]
- 7. [Weathermatic]
- 8. <Insert manufacturer's name>

- C. Description: Factory-fabricated, bronze or brass, two-piece assembly. Include coupler water-seal valve; removable upper body with spring-loaded or weighted, rubber-covered cap; hose swivel with ASME B1.20.7, 3/4-11.5NH threads for garden hose on outlet; and operating key.

1. Locking-Top Option: Vandal-resistant locking feature. Include [one][two]<Insert number> matching key(s).

2.14 DRIP IRRIGATION SPECIALTIES

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

1. [Buckner Superior; Storm Industries, Inc.]
2. [Dig Corporation]
3. [Evoqua Water Technologies, LLC]
4. [Geoflow, Inc.]
5. [Hendrickson Bros.]
6. [Hit Products Corporation]
7. [Irritrol Systems]
8. [Jain Irrigation, Inc.]
9. [Maxijet, Inc.]
10. [NDS Inc]
11. [Netafim USA]
12. [Orbit Irrigation Products, LLC]
13. [Rain Bird Corporation]
14. [Roberts Irrigation Products, Inc.]
15. [Salco Products]
16. [Toro Company (The)]
17. <Insert manufacturer's name>

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

1. [Buckner Superior; Storm Industries, Inc.]
2. [Dig Corporation]
3. [Evoqua Water Technologies, LLC]
4. [Geoflow, Inc.]
5. [Hendrickson Bros.]
6. [Hit Products Corporation]
7. [Irritrol Systems]
8. [Jain Irrigation, Inc.]
9. [Maxijet, Inc.]
10. [NDS Inc]
11. [Netafim USA]
12. [Orbit Irrigation Products, LLC]
13. [Rain Bird Corporation]
14. [Roberts Irrigation Products, Inc.]
15. [Salco Products]
16. [Toro Company (The)]
17. <Insert manufacturer's name>

- C. Freestanding Emitters: Device to deliver water at approximately 20 psig (138 kPa).

1. Body Material: PE or vinyl, with flow control.
2. Riser to Emitter: PE or PVC flexible tubing.
3. Capacities and Characteristics:

- a. Flow: [1/2 gph (1.9 L/h)][1 gph (3.8 L/h)][2 gph (7.6 L/h)]<Insert value> at approximately

20 psig (138 kPa).

- b. Tubing: PE or PVC; **1/8-inch (3-mm)** minimum ID.
- c. Mounting Height: **<Insert dimension>** aboveground to nozzle.

D. Manifold Emitter Systems: Manifold with tubing and emitters.

- 1. Manifold: With multiple outlets to deliver water to emitters.
 - a. Body Material: Plastic.
 - b. Outlet Caps: Plastic, for outlets without installed tubing.
 - c. Operation: Automatic pressure compensating.
- 2. Tubing: PE or PVC; **1/8-inch (3-mm)** minimum ID.
- 3. Emitter: Device to deliver water at approximately **20 psig (138 kPa)**.
 - a. Body Material: PE or vinyl, with flow control.
- 4. Capacities and Characteristics:
 - a. Manifold:
 - 1) Design Flow: **<Insert gph (L/h)>**.
 - 2) Number of Outlets: **[Four][Six]<Insert number>**.
 - b. Emitter No.: **<Insert number>**.
 - 1) Flow: **[1/2 gph (1.9 L/h)][1 gph (3.8 L/h)][2 gph (7.6 L/h)]<Insert value>** at approximately **20 psig (138 kPa)**.
 - 2) Mounting Height: **[At ground][As indicated]<Insert dimension>**.

E. Multiple-Outlet Emitter Systems: Emitter with tubing and button-type outlets.

- 1. Emitter: With multiple outlets to deliver water to remote outlets.
 - a. Body Material: Plastic, with flow control.
 - b. Outlet Caps: Plastic, for outlets without installed tubing.
 - c. Operation: Automatic pressure compensating.
 - d. Emitters: Devices to deliver water at approximately **20 psig (138 kPa)**.
- 2. Tubing: PE or PVC; **1/8-inch (3-mm)** minimum ID.
- 3. Capacities and Characteristics:
 - a. Emitter:
 - 1) Flow: **[1/2 gph (1.9 L/h)][1 gph (3.8 L/h)][2 gph (7.6 L/h)]<Insert value>**.
 - 2) Number of Outlets: **[Four][Six]<Insert number>**.
 - b. Button-Type Outlet No.: **<Insert number>**.
 - 1) Mounting Height: **[At ground][As indicated]<Insert dimension>**.

F. Drip Tubes with Direct-Attached Emitters:

- 1. Tubing: Flexible PE or PVC with plugged end.

2. Emitters: Devices to deliver water at approximately **20 psig (138 kPa)**.
 - a. Body Material: PE or vinyl, with flow control.
 - b. Mounting: Inserted into tubing at set intervals.
3. Capacities and Characteristics:
 - a. Tubing Size: **[NPS 1/2 (DN 15)][NPS 3/4 (DN 20)][NPS 1 (DN 25)]<Insert value>**.
 - b. Length: **<Insert inches (mm)>**.
 - c. Emitter Spacing: **<Insert inches (mm)>**.
 - d. Emitter Flow: **[1/2 gph (1.9 L/h)][1 gph (3.8 L/h)][2 gph (7.6 L/h)]<Insert value>**.

G. Drip Tubes with Remote Discharge:

1. Tubing: Flexible PE or PVC with plugged end.
2. Emitters: Devices to deliver water at approximately **20 psig (138 kPa)**.
 - a. Body Material: PE or vinyl, with flow control.
 - b. Mounting: Inserted into tubing at set intervals.
3. Capacities and Characteristics:
 - a. Tubing Size: **[NPS 1/2 (DN 15)][NPS 3/4 (DN 20)][NPS 1 (DN 25)]<Insert value>**.
 - b. Length: **<Insert inches (mm)>**.
 - c. Emitter Spacing: **<Insert inches (mm)>**.
 - d. Emitter Flow: **[1/2 gph (1.9 L/h)][1 gph (3.8 L/h)][2 gph (7.6 L/h)]<Insert value>**.
 - e. Branch Tubing Size: **[NPS 1/4 (DN 8)]<Insert value>** with button-type outlet.
 - f. Branch Tubing Length: **<Insert inches (mm)>**.

H. Off-Ground Supports: Plastic stakes.

I. Application Pressure Regulators: Brass or plastic housing, **NPS 3/4 (DN 20)**, with corrosion-resistant internal parts; capable of controlling outlet pressure to approximately **20 psig (138 kPa)**.

J. Filter Units: Brass or plastic housing, with corrosion-resistant internal parts; of size and capacity required for devices downstream from unit.

K. Air Relief Valves: Brass or plastic housing, with corrosion-resistant internal parts.

L. Vacuum Relief Valves: Brass or plastic housing, with corrosion-resistant internal parts.

2.15 CONTROLLERS

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

1. **[Buckner Superior; Storm Industries, Inc.]**
2. **[Champion-Arrowhead]**
3. **[Hit Products Corporation]**
4. **[Hunter Industries Incorporated]**
5. **[Irritrol Systems]**
6. **[K-RAIN Manufacturing Corporation]**
7. **[Nelson; Fiskars Brands, Inc.]**

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8. [Netafim USA]
9. [Orbit Irrigation Products, LLC]
10. [Rain Bird Corporation]
11. [Toro Company (The)]
12. [Weathermatic]
13. <Insert manufacturer's name>

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

1. [Buckner Superior; Storm Industries, Inc.]
2. [Champion-Arrowhead]
3. [Hit Products Corporation]
4. [Hunter Industries Incorporated]
5. [Irritrol Systems]
6. [K-RAIN Manufacturing Corporation]
7. [Nelson; Fiskars Brands, Inc.]
8. [Netafim USA]
9. [Orbit Irrigation Products, LLC]
10. [Rain Bird Corporation]
11. [Toro Company (The)]
12. [Weathermatic]
13. <Insert manufacturer's name>

C. Description:

1. Controller Stations for Automatic Control Valves: Each station is variable from approximately [5 to 60]<Insert numbers> minutes. Include switch for manual or automatic operation of each station.
2. Exterior Control Enclosures: NEMA 250, Type 4, weatherproof, with locking cover and [two]<Insert number> matching keys; include provision for grounding.
 - a. Body Material: [Enameled-steel sheet metal][Stainless steel sheet metal][Molded plastic].
 - b. Mounting: [Freestanding type for concrete base][Surface type for wall].
3. Interior Control Enclosures: NEMA 250, Type 12, dripproof, with locking cover and [two]<Insert number> matching keys.
 - a. Body Material: [Enameled-steel sheet metal][Stainless steel sheet metal][Molded plastic].
 - b. Mounting: [Freestanding type for concrete base][Surface type for wall].
4. Control Transformer: 24 V secondary, with primary fuse.
5. Timing Device: Adjustable, 24-hour, 14-day clock, with automatic operations to skip operation any day in timer period, to operate every other day, or to operate two or more times daily.
 - a. Manual or Semiautomatic Operation: Allows this mode without disturbing preset automatic operation.
 - b. Nickel-Cadmium Battery and Trickle Charger: Automatically powers timing device during power outages.
 - c. Surge Protection: Metal-oxide-varistor type on each station and primary power.
6. Moisture Sensor: Adjustable from one to seven days, to shut off water flow during rain.
7. Smart Controllers: Use ET, tested in accordance with IA SWAT Climatological Based Controllers 8th Draft Testing Protocol and compliant with ASHRAE 189.1.

8. Wiring: UL 493, Type UF multiconductor, with solid-copper conductors; insulated cable; suitable for direct burial.
 - a. Feeder-Circuit Cables: No. 12 AWG minimum, between building and controllers.
 - b. Low-Voltage, Branch-Circuit Cables: No. 14 AWG minimum, between controllers and automatic control valves; color-coded different from feeder-circuit-cable jacket color; with jackets of different colors for multiple-cable installation in same trench.
 - c. Splicing Materials: Manufacturer's packaged kit consisting of insulating, spring-type connector or crimped joint and epoxy resin moisture seal; suitable for direct burial.
9. Concrete Base: Reinforced precast concrete not less than **36 by 24 by 4 inches (900 by 600 by 100 mm)** thick, and **6 inches (150 mm)** greater in each direction than overall dimensions of controller. Include opening for wiring.

2.16 BOXES FOR AUTOMATIC CONTROL VALVES

A. Plastic Boxes:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Armorcast Products Company; brand of Hubbell Utility Solutions; Hubbell Incorporated]**
 - b. **[Nationwide Plastics, Inc.]**
 - c. **[NewBasis]**
 - d. **[Oldcastle Infrastructure Inc.; CRH Americas]**
 - e. **[Orbit Irrigation Products, LLC]**
 - f. **[USFilter/Plymouth Products, Inc.]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Armorcast Products Company; brand of Hubbell Utility Solutions; Hubbell Incorporated]**
 - b. **[Nationwide Plastics, Inc.]**
 - c. **[NewBasis]**
 - d. **[Oldcastle Infrastructure Inc.; CRH Americas]**
 - e. **[Orbit Irrigation Products, LLC]**
 - f. **[USFilter/Plymouth Products, Inc.]**
 - g. **<Insert manufacturer's name>**
3. Description: Box and cover, with open bottom and openings for piping; designed for installing flush with grade.
 - a. Size: As required for valves and service.
 - b. Shape: **[Round][Square][Rectangular]**.
 - c. Sidewall Material: **[PE][PE, ABS, or FRP]<Insert material>**.
 - d. Cover Material: **[PE][PE, ABS, or FRP]<Insert material>**.
 - 1) Lettering: **"[VALVE BOX][IRRIGATION]<Insert lettering>."**

B. Polymer-Concrete Boxes:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Armorcast Products Company; brand of Hubbell Utility Solutions; Hubbell Incorporated]
 - b. [NewBasis]
 - c. [Oldcastle Infrastructure Inc.; CRH Americas]
 - d. [Quazite; brand of Hubbell Utility Solutions; Hubbell Incorporated]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Armorcast Products Company; brand of Hubbell Utility Solutions; Hubbell Incorporated]
 - b. [NewBasis]
 - c. [Oldcastle Infrastructure Inc.; CRH Americas]
 - d. [Quazite; brand of Hubbell Utility Solutions; Hubbell Incorporated]
 - e. <Insert manufacturer's name>
3. Description: Box and cover, with open bottom and openings for piping; designed for installing flush with grade.
 - a. Size: As required for valves and service.
 - b. Shape: [Round][Square][Rectangular].
 - c. Sidewall Material: Polymer concrete with lateral and vertical sidewall design loading of [5000 lb (2268 kg)][10,000 lb (4536 kg)][15,000 lb (6800 kg)] minimum over 10 by 10 inches (254 by 254 mm) square.
 - d. Cover Material: [Polymer concrete][Reinforced polymer concrete]<Insert material> with cover design loading of [5000 lb (2268 kg)][10,000 lb (4536 kg)][15,000 lb (6800 kg)] minimum over 10 by 10 inches (254 by 254 mm) square.
 - 1) Lettering: "[VALVE BOX][IRRIGATION]<Insert lettering>."

- C. Drainage Backfill: Cleaned gravel or crushed stone, graded from 3/4 inch (19 mm) minimum to 3 inches (75 mm) maximum.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Excavating, trenching, and backfilling are specified in Section 312000 "Earth Moving."
- B. Install warning tape directly above pressure piping, [12 inches (300 mm)]<Insert value> below finished grades, except 6 inches (150 mm) below subgrade under pavement and slabs.
- C. Drain Pockets: Excavate to sizes indicated. Backfill with cleaned gravel or crushed stone, graded from [3/4 to 3 inches (19 to 75 mm)]<Insert value>, to [12 inches (300 mm)]<Insert value> below grade.

Cover gravel or crushed stone with sheet of asphalt-saturated felt and backfill remainder with excavated material.

- D. Provide minimum cover over top of underground piping according to the following:
1. Irrigation Main Piping: Minimum depth of **[36 inches (900 mm)]<Insert value>** below finished grade, or not less than **[18 inches (450 mm)]<Insert value>** below average local frost depth, whichever is deeper.
 2. Circuit Piping: **[12 inches (300 mm)]<Insert value>**.
 3. Drain Piping: **[12 inches (300 mm)]<Insert value>**.
 4. Sleeves: **[24 inches (600 mm)]<Insert value>**.

3.2 PREPARATION

- A. Set stakes to identify locations of proposed irrigation system. Obtain Architect's approval before excavation.

3.3 INSTALLATION OF PIPING

- A. Location and Arrangement: Drawings indicate location and arrangement of piping systems. Install piping as indicated unless deviations are approved on Coordination Drawings.
- B. Install piping at minimum uniform slope of 0.5 percent down toward drain valves.
- C. Install piping free of sags and bends.
- D. Install groups of pipes parallel to each other, spaced to permit valve servicing.
- E. Install fittings for changes in direction and branch connections.
- F. Install unions adjacent to valves and to final connections to other components with **NPS 2 (DN 50)** or smaller pipe connection.
- G. Install flanges adjacent to valves and to final connections to other components with **NPS 2-1/2 (DN 65)** or larger pipe connection.
- H. Install underground thermoplastic piping in accordance with ASTM D2774[**and ASTM**].
- I. Install expansion loops in control-valve boxes for plastic piping.
- J. Lay piping on solid subbase, uniformly sloped without humps or depressions.
- K. Install ductile-iron piping in accordance with AWWA C600.
- L. Install PVC piping in dry weather when temperature is above **40 deg F (5 deg C)**. Allow joints to cure at least 24 hours at temperatures above **40 deg F (5 deg C)** before testing.
- M. Install water regulators with shutoff valve and strainer on inlet and pressure gage on outlet. Install shutoff valve on outlet. Install aboveground or in control-valve boxes.
- N. Water Hammer Arresters: Install between connection to building main and circuit valves aboveground or in control-valve boxes.

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- O. Install piping in sleeves under parking lots, roadways, and sidewalks.
- P. Install sleeves made of [**Schedule 40**][**Schedule 80**], PVC pipe and socket fittings, and solvent-cemented joints.
- Q. Install transition fittings for plastic-to-metal pipe connections according to the following:
 - 1. Underground Piping:
 - a. **NPS 1-1/2 (DN 40)** and Smaller: Plastic-to-metal transition fittings.
 - b. **NPS 2 (DN 50)** and Larger: AWWA transition couplings.
 - 2. Aboveground Piping:
 - a. **NPS 2 (DN 50)** and Smaller: Plastic-to-metal transition [**fittings**][**unions**].
 - b. **NPS 2 (DN 50)** and Larger: Use dielectric flange kits with one plastic flange.
- R. Install dielectric fittings for dissimilar-metal pipe connections according to the following:
 - 1. Underground Piping:
 - a. **NPS 2 (DN 50)** and Smaller: Dielectric coupling or dielectric nipple.
 - b. **NPS 2-1/2 (DN 65)** and Larger: Prohibited except in control-valve box.
 - 2. Aboveground Piping:
 - a. **NPS 2 (DN 50)** and Smaller: Dielectric union.
 - b. **NPS 2-1/2 to NPS 4 (DN 65 to DN 100)**: Dielectric flange.
 - c. **NPS 5 (DN 125)** and Larger: Dielectric flange kit.
 - 3. Piping in Control-Valve Boxes:
 - a. **NPS 2 (DN 50)** and Smaller: Dielectric union.
 - b. **NPS 2-1/2 to NPS 4 (DN 65 to DN 100)**: Dielectric flange.
 - c. **NPS 5 (DN 125)** and Larger: Dielectric flange kit.

3.4 JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Threaded Joints: Thread pipe with tapered pipe threads in accordance with ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- D. Flanged Joints: Select rubber gasket material of size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

- E. Ductile-Iron Piping Gasketed Joints: Comply with AWWA C600 and AWWA M41.
- F. Copper-Tubing Brazed Joints: Construct joints in accordance with CDA's "Copper Tube Handbook," using copper-phosphorus brazing filler metal.
- G. Copper-Tubing Soldered Joints: Apply ASTM B813 water-flushable flux to tube end unless otherwise indicated. Construct joints in accordance with ASTM B828 or CDA's "Copper Tube Handbook," using lead-free solder alloy (0.20 percent maximum lead content) complying with ASTM B32.
- H. PE Piping Fastener Joints: Join with insert fittings and bands or fasteners in accordance with piping manufacturer's written instructions.
- I. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join in accordance with ASTM D2657.
 - 1. Plain-End PE Pipe and Fittings: Use butt fusion.
 - 2. Plain-End PE Pipe and Socket Fittings: Use socket fusion.
- J. PVC Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings in accordance with the following:
 - 1. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements.
 - 2. PVC Pressure Piping: Join schedule number, ASTM D1785, PVC pipe and PVC socket fittings in accordance with ASTM D2672. Join other-than-schedule-number PVC pipe and socket fittings in accordance with ASTM D2855.
 - 3. PVC Nonpressure Piping: Join in accordance with ASTM D2855.

3.5 INSTALLATION OF VALVES

- A. Underground Curb Valves: Install in curb-valve casings with tops flush with grade.
- B. Underground Iron Gate Valves, Resilient Seat: Comply with AWWA C600 and AWWA M44. Install in valve casing with top flush with grade.
 - 1. Install valves and PVC pipe with restrained, gasketed joints.
- C. Aboveground Valves: Install as components of connected piping system.
- D. Pressure-Reducing Valves: Install in boxes for automatic control valves or aboveground between shutoff valves. [**Install full-size valved bypass.**]
- E. Throttling Valves: Install in underground piping in boxes for automatic control valves.
- F. Drain Valves: Install in underground piping in boxes for automatic control valves.

3.6 INSTALLATION OF SPRINKLERS

- A. Install sprinklers after hydrostatic test is completed.
- B. Install sprinklers at manufacturer's recommended heights.
- C. Locate part-circle sprinklers to maintain a minimum distance of **4 inches (100 mm)** from walls and **2 inches (50 mm)** from other boundaries unless otherwise indicated.

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3.7 INSTALLATION OF DRIP IRRIGATION SPECIALTIES

- A. Install freestanding emitters on pipe riser to mounting height indicated.
- B. Install manifold emitter systems with tubing to emitters. Plug unused manifold outlets. Install emitters on off-ground supports at height indicated.
- C. Install multiple-outlet emitter systems with tubing to outlets. Plug unused emitter outlets. Install outlets on off-ground supports at height indicated.
- D. Install drip tubes with direct-attached emitters on ground.
- E. Install drip tubes with remote discharge on ground with outlets on off-ground supports at height indicated.
- F. Install off-ground supports of length required for indicated mounted height of device.
- G. Install **[application pressure regulators][and][filter units]** in piping near device being protected, and **[aboveground][in control-valve boxes]**.
- H. Install **[air relief valves][and][vacuum relief valves]** in piping, and **[aboveground][in control-valve boxes]**.

3.8 INSTALLATION OF AUTOMATIC IRRIGATION CONTROL SYSTEM

- A. Equipment Mounting, Interior: Install controllers on interior **[floor][concrete bases][wall]**.
 - 1. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
- B. Equipment Mounting, Exterior: Install exterior freestanding controllers on precast concrete bases.
 - 1. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
- C. Install control cable in same trench as irrigation piping and at least **2 inches (50 mm)** below **[or beside]** piping. Provide conductors of size not smaller than recommended by controller manufacturer. Install cable in separate sleeve under paved areas.

3.9 CONNECTIONS

- A. Comply with requirements for piping specified in Section 331415 "Site Water Distribution Piping" for water supply from exterior water service piping, water meters, protective enclosures, and backflow preventers. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment, valves, and devices to allow service and maintenance.
- C. Connect wiring between controllers and automatic control valves.

3.10 IDENTIFICATION

- A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."
- B. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplates and signs on each automatic controller.
 - 1. Text: In addition to identifying unit, distinguish between multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.
- C. Warning Tapes: Arrange for installation of continuous, underground, detectable warning tapes over underground piping during backfilling of trenches. See Section 312000 "Earth Moving" for warning tapes.

3.11 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- B. Perform tests and inspections.
 - 1. Manufacturer's Field Service with Test Assistance: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- C. Tests and Inspections:
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Operational Test: After electrical circuitry has been energized, operate controllers and automatic control valves to confirm proper system operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 4. Irrigation system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

3.12 STARTUP SERVICE

- A. **[Engage a factory-authorized service representative to perform][Perform]** startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 - 2. Verify that controllers are installed and connected in accordance with the Contract Documents.
 - 3. Verify that electrical wiring installation complies with manufacturer's submittal.

3.13 ADJUSTING

- A. Adjust settings of controllers.
- B. Adjust automatic control valves to provide flow rate at rated operating pressure required for each

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sprinkler circuit.

- C. Adjust sprinklers and devices, except those intended to be mounted aboveground, so they will be flush with, or not more than **[1/2 inch (13 mm)]<Insert value>** above, finish grade.

3.14 CLEANING

- A. Flush dirt and debris from piping before installing sprinklers and other devices.

3.15 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train][Train]** Owner's maintenance personnel to adjust, operate, and maintain **[automatic control valves][and][controllers]**.

3.16 PIPING SCHEDULE

- A. Install components having pressure rating equal to or greater than system operating pressure.
- B. Piping in control-valve boxes and aboveground may be joined with flanges or unions instead of joints indicated.

- C. Aboveground Irrigation Main Piping:

- 1. **NPS 4 (DN 100)** and Smaller:

- a. Galvanized-steel pipe and galvanized-steel pipe nipples; galvanized, gray-iron threaded fittings; and threaded joints.
- b. **[Type L (Type B)][Type M (Type C)]** hard copper tube, wrought- or cast-copper fittings, and **[brazed][soldered]** joints.
- c. **[Schedule 40][Schedule 80]**, PVC pipe; socket-type PVC fittings; and solvent-cemented joints.
- d. Schedule 80, PVC pipe; Schedule 80, threaded PVC fittings; and threaded joints.

- 2. **NPS 5 (DN 125)** and Larger:

- a. Galvanized-steel pipe and galvanized-steel pipe nipples; galvanized, gray-iron threaded fittings; and threaded joints.
- b. **[Schedule 40][Schedule 80]**, PVC pipe and socket fittings; and solvent-cemented joints.
- c. Schedule 80, PVC pipe; Schedule 80, threaded PVC fittings; and threaded joints.

- D. Underground Irrigation Main Piping:

- 1. **NPS 4 (DN 100)** and Smaller:

- a. **NPS 3 and NPS 4 (DN 80 and DN 100)** ductile-iron, mechanical-joint pipe; ductile-iron, mechanical-joint fittings, glands, bolts, and nuts; and gasketed joints.
- b. **NPS 3 and NPS 4 (DN 80 and DN 100)** ductile-iron, push-on-joint pipe; ductile-iron, push-on-joint fittings and gaskets; and gasketed joints.
- c. **Type L (Type B)** soft copper tube, wrought-copper fittings, and brazed joints.
- d. **NPS 4 (DN 100)** PE pressure pipe; PE butt, heat-fusion or socket-type fittings; and heat-fusion joints.

- e. **[Schedule 40][Schedule 80]**, PVC pipe and socket fittings, and solvent-cemented joints.
 - f. Schedule 80, PVC pipe; Schedule 80, threaded PVC fittings; and threaded joints.
 - g. SDR 21, PVC, pressure-rated pipe; Schedule 80, PVC socket fittings; and solvent-cemented joints.
- 2. **NPS 5 (DN 125) and Larger:**
 - a. **NPS 6 (DN 150)** and larger ductile-iron, mechanical-joint pipe; ductile-iron, mechanical-joint fittings, glands, bolts, and nuts; and gasketed joints.
 - b. **NPS 6 (DN 150)** and larger ductile-iron, push-on-joint pipe; ductile-iron, push-on-joint fittings and gaskets; and gasketed joints.
 - c. PE pressure pipe; PE butt, heat-fusion fittings; and heat-fusion joints.
 - d. **[Schedule 40][Schedule 80]**, PVC pipe and socket fittings; and solvent-cemented joints.
 - e. SDR 21, PVC, pressure-rated pipe; Schedule 80, PVC socket fittings; and solvent-cemented joints.
- E. Circuit Piping:
 - 1. **NPS 2 (DN 50) and Smaller:**
 - a. **[SIDR 7][SIDR 9]**, PE, controlled ID pipe; insert fittings for PE pipe; and fastener joints.
 - b. **[DR 9][DR 11]**, PE, controlled OD pipe; PE butt, heat-fusion, or PE socket-type fittings; and heat-fusion joints.
 - c. Schedule 40, PVC pipe and socket fittings; and solvent-cemented joints.
 - d. SDR 26, PVC, pressure-rated pipe; Schedule 40, PVC socket fittings; and solvent-cemented joints.
 - 2. **NPS 2-1/2 to NPS 4 (DN 65 to DN 100):**
 - a. **[SIDR 7][SIDR 9]**, PE, controlled ID pipe; insert fittings for PE pipe; and banded or fastener joints.
 - b. **[DR 9][DR 11]**, PE, controlled OD pipe; PE socket or butt-fusion fittings; and heat-fusion joints. **NPS 3 (DN 80)** pipe and fittings if **NPS 2-1/2 (DN 65)** pipe and fittings are not available.
 - c. Schedule 40, PVC pipe and socket fittings; and solvent-cemented joints.
 - d. SDR 26, PVC, pressure-rated pipe; Schedule 40, PVC socket fittings; and solvent-cemented joints.
- F. Underground Branches and Offsets at Sprinklers and Devices: Schedule 80, PVC pipe; threaded PVC fittings; and threaded joints.
 - 1. Option: Plastic swing-joint assemblies, with offsets for flexible joints, manufactured for this application.
- G. Risers to Aboveground Sprinklers and Specialties:
 - 1. **[Type L (Type B)][Type M (Type C)]** hard copper tube, wrought-copper fittings, and **[brazed][soldered]** joints.
 - 2. Schedule 80, PVC pipe and socket fittings; and solvent-cemented joints.
- H. Drain piping shall be **[one of]** the following:
 - 1. SIDR 9, 11.5, or 15; PE, controlled ID pipe; insert fittings for PE pipe; and banded or fastener joints.
 - 2. Schedule 40, PVC pipe and socket fittings; and solvent-cemented joints.
 - 3. SDR 21, 26, or 32.5; PVC, pressure-rated pipe; Schedule 40, PVC socket fittings; and solvent-

cemented joints.

3.17 VALVE SCHEDULE

A. Underground, Shutoff-Duty Valves: Use the following:

1. **NPS 2 (DN 50)** and Smaller: Curb valve, curb-valve casing, and shutoff rod.
2. **NPS 3 (DN 80)** and Larger: Iron gate valve, resilient seated; iron gate valve casing; and operating wrench(es).

B. Aboveground, Shutoff-Duty Valves:

1. **NPS 2 (DN 50)** and Smaller:
 - a. **[Brass][Brass or bronze][Bronze][Plastic]** ball valve.
 - b. Bronze gate valve.
2. **NPS 2-1/2 (DN 65)** and Larger:
 - a. Iron ball valve.
 - b. Iron gate valve, **[NRS][OS&Y]**.

C. Throttling-Duty Valves:

1. **NPS 2 (DN 50)** and Smaller:
 - a. **[Bronze][Plastic]** automatic control valve.
 - b. **[Brass][Brass or bronze][Bronze][Plastic]** ball valve.
2. **NPS 2-1/2 and NPS 3 (DN 65 and DN 80):**
3. **[Bronze][Plastic]** automatic control valve.
4. Iron ball valve.

D. Drain Valves:

1. **NPS 1/2 and NPS 3/4 (DN 15 and DN 20):**
 - a. Automatic drain valve.
 - b. **[Brass][Brass or bronze][Bronze][Plastic]** ball valve.
 - c. Bronze gate valve.
2. **NPS 1 to NPS 2 (DN 25 to DN 50):**
 - a. **[Brass][Brass or bronze][Bronze][Plastic]** ball valve.
 - b. Bronze gate valve.

END OF SECTION 32 84 00 00



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Task	Specification	Specification Description
32 84 13 00	32 84 00 00	Planting Irrigation
32 84 23 00	21 05 00 00	Common Work Results for Fire Suppression
32 84 23 00	22 05 00 00	Common Work Results for Plumbing
32 84 23 00	23 05 00 00	Common Work Results for HVAC
32 84 23 00	32 84 00 00	Planting Irrigation



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SECTION 32 91 13 00 - SOIL PREPARATION

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes planting soils[**and layered soil assemblies**] specified by composition of the mixes.
- B. Related Requirements:
 - 1. Section 077273 "Vegetated Roof Systems" for growing media (soil).
 - 2. Section 129200 "Interior Planters and Artificial Plants" for placing planting soil in planters for live interior plants.
 - 3. Section 323300 "Site Furnishings" for placing planting soil in exterior unit planters.
 - 4. Section 311000 "Site Clearing" for topsoil stripping and stockpiling.
 - 5. Section 321443 "Porous Unit Paving" for placing planting-soil fill in porous paving.
 - 6. Section 329200 "Turf and Grasses" for placing planting soil for turf and grasses.
 - 7. Section 329300 "Plants" for placing planting soil for plantings.
 - 8. Section 329600 "Transplanting" for placing planting soil in tree planting pits.

1.2 ALLOWANCES

- A. **[Preconstruction][and][field quality-control]** testing **[is][are]** part of testing and inspecting allowance.

1.3 UNIT PRICES

- A. Work of this Section is affected by **[unit prices specified in Section 012200 "Unit Prices."]<Insert name of unit price.>**

1.4 DEFINITIONS

- A. AAPFCO: Association of American Plant Food Control Officials.
- B. Backfill: The earth used to replace or the act of replacing earth in an excavation. This can be amended or unamended soil as indicated.
- C. CEC: Cation exchange capacity.
- D. Compost: The product resulting from the controlled biological decomposition of organic material that has been sanitized through the generation of heat and stabilized to the point that it is beneficial to plant growth.
- E. Duff Layer: A surface layer of soil, typical of forested areas, that is composed of mostly decayed leaves, twigs, and detritus.
- F. Imported Soil: Soil that is transported to Project site for use.
- G. Layered Soil Assembly: A designed series of planting soils, layered on each other, that together produce an environment for plant growth.

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- H. **Manufactured Soil:** Soil produced by blending soils, sand, stabilized organic soil amendments, and other materials to produce planting soil.
- I. **NAPT:** North American Proficiency Testing Program. An SSSA program to assist soil-, plant-, and water-testing laboratories through interlaboratory sample exchanges and statistical evaluation of analytical data.
- J. **Organic Matter:** The total of organic materials in soil exclusive of undecayed plant and animal tissues, their partial decomposition products, and the soil biomass; also called "humus" or "soil organic matter."
- K. **Planting Soil:** Existing, on-site soil; imported soil; or manufactured soil that has been modified as specified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.
- L. **RCRA Metals:** Hazardous metals identified by the EPA under the Resource Conservation and Recovery Act.
- M. **SSSA:** Soil Science Society of America.
- N. **Subgrade:** Surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.
- O. **Subsoil:** Soil beneath the level of subgrade; soil beneath the topsoil layers of a naturally occurring soil profile, typified by less than 1 percent organic matter and few soil organisms.
- P. **Surface Soil:** Soil that is present at the top layer of the existing soil profile. In undisturbed areas, surface soil is typically called "topsoil"; but in disturbed areas such as urban environments, the surface soil can be subsoil.
- Q. **USCC:** U.S. Composting Council.

1.5 PREINSTALLATION MEETINGS

- A. **Preinstallation Conference:** Conduct conference at **[Project site]<Insert location>**.

1.6 ACTION SUBMITTALS

- A. **Product Data:** For each type of product.
 - 1. Include recommendations for application and use.
 - 2. Include test data substantiating that products comply with requirements.
 - 3. Include sieve analyses for aggregate materials.
 - 4. **Material Certificates:** For each type of **[imported soil][and][soil amendment and fertilizer]<Insert item>** before delivery to the site, according to the following:
 - a. Manufacturer's qualified testing agency's certified analysis of standard products.
 - b. Analysis of fertilizers, by a qualified testing agency, made according to AAPFCO methods for testing and labeling and according to AAPFCO's SUIP #25.
 - c. Analysis of nonstandard materials, by a qualified testing agency, made according to SSSA methods, where applicable.
- B. **Sustainable Design Submittals:**

1. Product Certificates: For regional materials, indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project and cost for each regional material.
 2. Environmental Product Declaration (EPD): For each product.
 3. Product Certificates: For indigenous materials, indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project, means of transportation, and cost for each indigenous material.
 4. Environmental Product Declaration: For each product.
 5. Product Certificates: For regional materials, indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project, means of transportation, and cost for each regional material.
 6. Environmental Product Declaration: For each product.
 7. Environmental Product Declaration: For each product.
 8. Third-Party Certifications: For each product.
 9. Third-Party Certified Life Cycle Assessment: For each product.
- C. Samples: For each bulk-supplied material, [1-quart (1-L)][1-gal. (4-L)]<Insert value> volume of each in sealed containers labeled with content, source, and date obtained. Each Sample shall be typical of the lot of material to be furnished; provide an accurate representation of composition, color, and texture.

1.7 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For each testing agency.
- B. Preconstruction Test Reports: For preconstruction soil analyses specified in "Preconstruction Testing" Article.
- C. Field quality-control reports.

1.8 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent, state-operated, or university-operated laboratory; experienced in soil science, soil testing, and plant nutrition; with the experience and capability to conduct the testing indicated; and that specializes in types of tests to be performed.
 1. Laboratories: Subject to compliance with requirements, [provide testing by the following][provide testing by one of the following]:
 - a. <Insert laboratory's name and address>.
 2. Multiple Laboratories: At Contractor's option, work may be divided among qualified testing laboratories specializing in physical testing, chemical testing, and fertility testing.

1.9 PRECONSTRUCTION TESTING

- A. Preconstruction Testing Service: [Owner will engage][Engage] a qualified testing agency to perform preconstruction soil analyses on [existing, on-site soil][imported soil]<Insert item>.
 1. Notify Architect [seven]<Insert number> days in advance of the dates and times when laboratory samples will be taken.
- B. Preconstruction Soil Analyses: For each unamended soil type, perform testing on soil samples and

furnish soil analysis and a written report containing soil-amendment and fertilizer recommendations by a qualified testing agency performing the testing according to "Soil-Sampling Requirements" and "Testing Requirements" articles.

1. Have testing agency identify and label samples and test reports according to sample collection and labeling requirements.

1.10 SOIL-SAMPLING REQUIREMENTS

- A. General: Extract soil samples according to requirements in this article.
- B. Sample Collection and Labeling: Have samples taken and labeled by **[Owner][Contractor in presence of Architect][soil scientist (CPSS) certified by SSSA][soil classifier (CPSC) certified by SSSA][soil scientist (RPSS) registered by the National Society of Consulting Soil Scientists][or][state-certified, -licensed, or -registered soil scientist]<Insert requirement>** under the direction of the testing agency.
 1. Number and Location of Samples: Minimum of **[three][eight]<Insert number>** representative soil samples **[from varied locations][where indicated on Drawings][where directed by Architect]<Insert requirement>** for each soil to be used or amended for landscaping purposes.
 2. Procedures and Depth of Samples: **[According to USDA-NRCS's "Field Book for Describing and Sampling Soils."][As directed by Architect.]<Insert requirement.>**
 3. Division of Samples: Split each sample into two, equal parts. Send half to the testing agency and half to Owner for its records.
 4. Labeling: Label each sample with the date, location keyed to a site plan or other location system, visible soil condition, and sampling depth.

1.11 TESTING REQUIREMENTS

- A. General: Perform tests on soil samples according to requirements in this article.
- B. Physical Testing:
 1. Soil Texture: Soil-particle, size-distribution analysis by **[one of]** the following methods according to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods":
 - a. Sieving Method: Report sand-gradation percentages for very coarse, coarse, medium, fine, and very fine sand; and fragment-gradation (gravel) percentages for fine, medium, and coarse fragments; according to USDA sand and fragment sizes.
 - b. Hydrometer Method: Report percentages of sand, silt, and clay.
 2. Total Porosity: Calculate using particle density and bulk density according to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods."
 3. Water Retention: According to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods."
 4. Saturated Hydraulic Conductivity: According to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods"; at 85% compaction according to ASTM D698 (Standard Proctor).
- C. Chemical Testing:
 1. CEC: Analysis by sodium saturation at pH 7 according to SSSA's "Methods of Soil Analysis - Part 3- Chemical Methods."

2. Clay Mineralogy: Analysis and estimated percentage of expandable clay minerals using CEC by ammonium saturation at pH 7 according to SSSA's "Methods of Soil Analysis - Part 1- Physical and Mineralogical Methods."
 3. Metals Hazardous to Human Health: Test for presence and quantities of RCRA metals including aluminum, arsenic, barium, copper, cadmium, chromium, cobalt, lead, lithium, and vanadium. If RCRA metals are present, include recommendations for corrective action.
 4. Phytotoxicity: Test for plant-available concentrations of phytotoxic minerals including aluminum, arsenic, barium, cadmium, chlorides, chromium, cobalt, copper, lead, lithium, mercury, nickel, selenium, silver, sodium, strontium, tin, titanium, vanadium, and zinc.
- D. Fertility Testing: Soil-fertility analysis according to standard laboratory protocol of **[SSSA NAPT NCR-13][SSSA NAPT NEC-67][SSSA NAPT SERA-6][SSSA NAPT WERA-103]**, including the following:
1. Percentage of organic matter.
 2. CEC, calcium percent of CEC, and magnesium percent of CEC.
 3. Soil reaction (acidity/alkalinity pH value).
 4. Buffered acidity or alkalinity.
 5. Nitrogen ppm.
 6. Phosphorous ppm.
 7. Potassium ppm.
 8. Manganese ppm.
 9. Manganese-availability ppm.
 10. Zinc ppm.
 11. Zinc availability ppm.
 12. Copper ppm.
 13. Sodium ppm[**and sodium absorption ratio**].
 14. Soluble-salts ppm.
 15. Presence and quantities of problem materials including salts and metals cited in the Standard protocol. If such problem materials are present, provide additional recommendations for corrective action.
 16. Other deleterious materials, including their characteristics and content of each.
- E. Organic-Matter Content: Analysis using loss-by-ignition method according to SSSA's "Methods of Soil Analysis - Part 3- Chemical Methods."
- F. Recommendations: Based on the test results, state recommendations for soil treatments and soil amendments to be incorporated to produce satisfactory planting soil suitable for healthy, viable plants indicated. Include, at a minimum, recommendations for nitrogen, phosphorous, and potassium fertilization, and for micronutrients.
1. Fertilizers and Soil Amendment Rates: State recommendations in weight **[per 1000 sq. ft. (100 sq. m) for 6-inch (150-mm)depth of soil]<Insert requirement>**.
 2. Soil Reaction: State the recommended liming rates for raising pH or sulfur for lowering pH according to the buffered acidity or buffered alkalinity in weight **[per 1000 sq. ft. (100 sq. m) for 6-inch (150-mm)depth of soil]<Insert requirement>**.
- 1.12 DELIVERY, STORAGE, AND HANDLING
- A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and compliance with state and Federal laws if applicable.
- B. Bulk Materials:
1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on

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- existing turf areas or plants.
2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
3. Do not move or handle materials when they are wet or frozen.
4. Accompany each delivery of bulk fertilizers and soil amendments with appropriate certificates.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Regional Materials: **[Imported soil][manufactured planting soil][and][soil amendments and fertilizers]** shall be manufactured within **500 miles (800 km)** of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within **500 miles (800 km)** of Project site.
- B. Regional Materials: **[Imported soil][manufactured planting soil][and][soil amendments and fertilizers]** shall be manufactured within **100 miles (160 km)** of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within **100 miles (160 km)** of Project site.
- C. Indigenous Materials: **[Imported soil][manufactured planting soil][and][soil amendments and fertilizers]** shall be manufactured within **500 miles (800 km)** of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within **500 miles (800 km)** of Project site. If materials are transported by rail or water, the distance transported by rail or water shall be multiplied by 0.25 to determine the distance to Project site.
- D. Regional Materials: **[Imported soil][manufactured planting soil][and][soil amendments and fertilizers]** shall be manufactured within **500 miles (800 km)** of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within **500 miles (800 km)** of Project site. If materials are transported by rail or water, the distance transported by rail or water shall be multiplied by 0.25 to determine the distance to Project site.

2.2 PLANTING SOILS SPECIFIED BY COMPOSITION

- A. General: Soil amendments, fertilizers, and rates of application specified in this article are guidelines that may need revision based on testing laboratory's recommendations after preconstruction soil analyses are performed.
- B. Planting-Soil Type **<Insert drawing designation>**: Existing, on-site surface soil, with the duff layer, if any, retained; **and stockpiled on-site**; modified to produce viable planting soil. Blend existing, on-site surface soil with the following soil amendments and fertilizers in the following quantities to produce planting soil:
 1. Ratio of Loose Compost to Soil: **[1:4][1:3][1:2]<Insert ratio>** by volume.
 2. Ratio of Loose **[Sphagnum][Muck]** Peat to Soil: **<Insert ratio>** by volume.
 3. Ratio of Loose Wood Derivatives Soil: **<Insert ratio>** by volume.
 4. Weight of Lime: **<Insert weight>** per **[1000 sq. ft. (100 sq. m)]<Insert area>** per **[6 inches (150 mm)]<Insert dimension>** of soil depth.
 5. Weight of **[Sulfur][Iron Sulfate]**: **<Insert weight>** per **[1000 sq. ft. (100 sq. m)]<Insert area>** per **[6 inches (150 mm)]<Insert dimension>** of soil depth.
 6. Weight of Agricultural Gypsum: **<Insert weight>** per **[1000 sq. ft. (100 sq. m)]<Insert area>** per

7. [6 inches (150 mm)]<Insert dimension> of soil depth. Weight of Superphosphate: <Insert weight> per [1000 sq. ft. (100 sq. m)]<Insert area> per [6 inches (150 mm)]<Insert dimension> of soil depth.
 8. Weight of Commercial Fertilizer: <Insert weight> per [1000 sq. ft. (100 sq. m)]<Insert area> per [6 inches (150 mm)]<Insert dimension> of soil depth.
 9. Weight of Slow-Release Fertilizer: <Insert weight> per [1000 sq. ft. (100 sq. m)]<Insert area> per [6 inches (150 mm)]<Insert dimension> of soil depth.
- C. Planting-Soil Type <Insert drawing designation>: Imported, naturally formed soil from off-site sources and consisting of [sandy loam][loam][silt loam][loamy sand][or][sand] soil <Insert soil texture> according to USDA textures; and modified to produce viable planting soil.
1. Sources: Take imported, unamended soil from sources that are naturally well-drained sites where topsoil occurs at least **4 inches (100 mm)** deep, not from [agricultural land], bogs, or marshes; and that do not contain undesirable organisms; disease-causing plant pathogens; or obnoxious weeds and invasive plants including, but not limited to, quackgrass, Johnsongrass, poison ivy, nutsedge, nimblewill, Canada thistle, bindweed, bentgrass, wild garlic, ground ivy, perennial sorrel, and brome grass.
 2. Additional Properties of Imported Soil before Amending: Soil reaction of [pH 6 to 7]<Insert range> and minimum of [2][4][6]<Insert number> percent organic-matter content, friable, and with sufficient structure to give good tilth and aeration.
 3. Unacceptable Properties: Clean soil of the following:
 - a. Unacceptable Materials: Concrete slurry, concrete layers or chunks, cement, plaster, building debris, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, acid, and other extraneous materials that are harmful to plant growth.
 - b. Unsuitable Materials: Stones, roots, plants, sod, clay lumps, and pockets of coarse sand that exceed a combined maximum of [8]<Insert number> percent by dry weight of the imported soil.
 - c. Large Materials: Stones, clods, roots, clay lumps, and pockets of coarse sand exceeding [2 inches (50 mm)][3 inches (75 mm)]<Insert dimension> in any dimension.
 4. Amended Soil Composition: Blend imported, unamended soil with the following soil amendments and fertilizers in the following quantities to produce planting soil:
 - a. Ratio of Loose Compost to Soil: [1:4][1:3][1:2]<Insert ratio> by volume.
 - b. Ratio of Loose [Sphagnum][Muck] Peat to Soil: <Insert ratio> by volume.
 - c. Ratio of Loose Wood Derivatives to Soil: <Insert ratio> by volume.
 - d. Weight of Lime: <Insert weight> per [1000 sq. ft. (100 sq. m)]<Insert area> per [6 inches (150 mm)]<Insert dimension> of soil depth.
 - e. Weight of [Sulfur][Iron Sulfate]: <Insert weight> per [1000 sq. ft. (100 sq. m)]<Insert area> per [6 inches (150 mm)]<Insert dimension> of soil depth.
 - f. Weight of Agricultural Gypsum: <Insert weight> per [1000 sq. ft. (100 sq. m)]<Insert area> per [6 inches (150 mm)]<Insert dimension> of soil depth.
 - g. Weight of Superphosphate: <Insert weight> per [1000 sq. ft. (100 sq. m)]<Insert area> per [6 inches (150 mm)]<Insert dimension> of soil depth.
 - h. Weight of Commercial Fertilizer: <Insert weight> per [1000 sq. ft. (100 sq. m)]<Insert area> per [6 inches (150 mm)]<Insert dimension> of soil depth.
 - i. Weight of Slow-Release Fertilizer: <Insert weight> per [1000 sq. ft. (100 sq. m)]<Insert area> per [6 inches (150 mm)]<Insert dimension> of soil depth.
- D. Planting-Soil Type <Insert drawing designation>: Manufactured soil consisting of manufacturer's basic [topsoil,][sandy loam according to USDA textures,]<Insert soil texture or manufacturer's base-soil designation> blended in a manufacturing facility with sand, stabilized organic soil amendments, and other materials to produce viable planting soil.

1. Additional Properties of Manufacturer's Basic Soil before Amending: Soil reaction of [pH 6 to 7]<Insert range> and minimum of [2][4][6]<Insert number> percent organic-matter content, friable, and with sufficient structure to give good tilth and aeration.
2. Unacceptable Properties: Manufactured soil shall not contain the following:
 - a. Unacceptable Materials: Concrete slurry, concrete layers or chunks, cement, plaster, building debris, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, acid, and other extraneous materials that are harmful to plant growth.
 - b. Unsuitable Materials: Stones, roots, plants, sod, clay lumps, and pockets of coarse sand that exceed a combined maximum of [5]<Insert number> percent by dry weight of the manufactured soil.
 - c. Large Materials: Stones, clods, roots, clay lumps, and pockets of coarse sand exceeding [1-1/2 inches (38 mm)][2 inches (50 mm)]<Insert dimension> in any dimension.
3. Blend manufacturer's basic soil with the following soil amendments and fertilizers in the following quantities to produce planting soil:
 - a. Ratio of Loose Compost to Soil: [1:4][1:3][1:2]<Insert ratio> by volume.
 - b. Ratio of Loose [Sphagnum][Muck] Peat to Soil: <Insert ratio> by volume.
 - c. Ratio of Loose Wood Derivatives Soil: <Insert ratio> by volume.
 - d. Volume of Sand: <Insert volume> per [cu. yd. (cu. m)]<Insert value>.
 - e. Volume of Perlite: <Insert volume> per [cu. yd. (cu. m)]<Insert value>.
 - f. Weight of Lime: <Insert weight> per [cu. yd. (cu. m)]<Insert value>.
 - g. Weight of [Sulfur][Iron Sulfate]: <Insert weight> per [cu. yd. (cu. m)]<Insert value>.
 - h. Weight of Agricultural Gypsum: <Insert weight> per [cu. yd. (cu. m)]<Insert value>.
 - i. Weight of Superphosphate: <Insert weight> per [cu. yd. (cu. m)]<Insert value>.
 - j. Weight of Commercial Fertilizer: <Insert weight> per [cu. yd. (cu. m)]<Insert value>.
 - k. Weight of Slow-Release Fertilizer: <Insert weight> per [cu. yd. (cu. m)]<Insert value>.

2.3 INORGANIC SOIL AMENDMENTS

- A. Lime: ASTM C602, agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent and as follows:
 1. Class: T, with a minimum of 99 percent passing through a **No. 8 (2.36-mm)** sieve and a minimum of 75 percent passing through a **No. 60 (0.25-mm)** sieve.
 2. Class: O, with a minimum of 95 percent passing through a **No. 8 (2.36-mm)** sieve and a minimum of 55 percent passing through a **No. 60 (0.25-mm)** sieve.
 3. Form: Provide lime in form of ground [dolomitic limestone][calcitic limestone][mollusk shells]<Insert material>.
- B. Sulfur: Granular, biodegradable, and containing a minimum of 90 percent elemental sulfur, with a minimum of 99 percent passing through a **No. 6 (3.35-mm)** sieve and a maximum of 10 percent passing through a **No. 40 (0.425-mm)** sieve.
- C. Iron Sulfate: Granulated ferrous sulfate containing a minimum of 20 percent iron and 10 percent sulfur.
- D. Perlite: Horticultural perlite, soil amendment grade.
- E. Agricultural Gypsum: Minimum 90 percent calcium sulfate, finely ground with 90 percent passing through a **No. 50 (0.30-mm)** sieve.
- F. Sand: Clean, washed, natural or manufactured, free of toxic materials, and according to [ASTM C33/C33M]<Insert requirement>.

2.4 ORGANIC SOIL AMENDMENTS

- A. Compost: Well-composted, stable, and weed-free organic matter produced by composting feedstock, and bearing USCC's "Seal of Testing Assurance," and as follows:
 1. Feedstock: **[Limited to leaves][May include sewage sludge][May include animal waste]<Insert requirement>**.
 2. Reaction: **[pH of 5.5 to 8]<Insert range>**.
 3. Soluble-Salt Concentration: Less than **[4]<Insert value>** dS/m.
 4. Moisture Content: **[35 to 55]<Insert number range>** percent by weight.
 5. Organic-Matter Content: **[30 to 40][50 to 60]<Insert number range>** percent of dry weight.
 6. Particle Size: Minimum of 98 percent passing through a **[4-inch (100-mm)][2-inch (50-mm)][1-inch (25-mm)][1/2-inch (13-mm)]** sieve.
- B. Sphagnum Peat: Partially decomposed sphagnum peat moss, finely divided or of granular texture with 100 percent passing through a **[1/2-inch (13-mm)]<Insert dimension>** sieve, a pH of 3.4 to 4.8, and a soluble-salt content measured by electrical conductivity of **[maximum 5]<Insert value or range>** dS/m.
- C. Muck Peat: Partially decomposed moss peat, native peat, or reed-sedge peat, finely divided or of granular texture with 100 percent passing through a **[1/2-inch (13-mm)]<Insert dimension>** sieve, a pH of 6 to 7.5, a soluble-salt content measured by electrical conductivity of **[maximum 5]<Insert value or range>** dS/m, having a water-absorbing capacity of 1100 to 2000 percent, and containing no sand.
- D. Wood Derivatives: Shredded and composted, nitrogen-treated sawdust, ground bark, or wood waste; of uniform texture and free of chips, stones, sticks, soil, or toxic materials.
 1. Partially Decomposed Wood Derivatives: In lieu of shredded and composted wood derivatives, mix shredded and partially decomposed wood derivatives with ammonium nitrate at a minimum rate of **[0.15 lb/cu. ft. (2.4 kg/cu. m)]<Insert value>** of loose sawdust or ground bark, or with ammonium sulfate at a minimum rate of **[0.25 lb/cu. ft. (4 kg/cu. m)]<Insert value>** of loose sawdust or ground bark.
- E. Manure: Well-rotted, unleached, stable or cattle manure containing not more than 25 percent by volume of straw, sawdust, or other bedding materials; free of toxic substances, stones, sticks, soil, weed seed, debris, and material harmful to plant growth.

2.5 FERTILIZERS

- A. Superphosphate: Commercial, phosphate mixture, soluble; a minimum of **[20][33][50]** percent available phosphoric acid.
- B. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:
 1. Composition: **[1 lb/1000 sq. ft. (0.5 kg/100 sq. m)]<Insert value>** of actual nitrogen, 4 percent phosphorous, and 2 percent potassium, by weight.
 2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified testing agency.
- C. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:
 1. Composition: 20 percent nitrogen, 10 percent phosphorous, and 10 percent potassium, by weight.
 2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports

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from a qualified testing agency.

- D. Chelated Iron: Commercial-grade FeEDDHA for dicots and woody plants, and commercial-grade FeDTPA for ornamental grasses and monocots.

PART 3 - EXECUTION

3.1 GENERAL

- A. Place planting soil and fertilizers according to requirements in other Specification Sections.
- B. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in planting soil.
- C. Proceed with placement only after unsatisfactory conditions have been corrected.

3.2 PREPARATION OF UNAMENDED, ON-SITE SOIL BEFORE AMENDING

- A. Excavation: Excavate soil from designated area(s) to a depth of **[6 inches (150 mm)]<Insert dimension>** and stockpile until amended.
- B. Unacceptable Materials: Clean soil of concrete slurry, concrete layers or chunks, cement, plaster, building debris, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, acid, and other extraneous materials that are harmful to plant growth.
- C. Unsuitable Materials: Clean soil to contain a maximum of **[8]<Insert number>** percent by dry weight of stones, roots, plants, sod, clay lumps, and pockets of coarse sand.
- D. Screening: Pass unamended soil through a **[2-inch (50-mm)][3-inch (75-mm)]<Insert dimension>** sieve to remove large materials.

3.3 PLACING AND MIXING PLANTING SOIL OVER EXPOSED SUBGRADE

- A. General: Apply and mix unamended soil with amendments on-site to produce required planting soil. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.
- B. Subgrade Preparation: Till subgrade to a minimum depth of **[4 inches (100 mm)][6 inches (150 mm)][8 inches (200 mm)][12 inches (300 mm)][18 inches (450 mm)]<Insert dimension>**. Remove stones larger than **[1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension>** in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.
 - 1. Apply, add soil amendments, and mix approximately half the thickness of unamended soil over prepared, loosened subgrade according to "Mixing" Paragraph below. Mix thoroughly into top **[2 inches (50 mm)][4 inches (100 mm)]** of subgrade. Spread remainder of planting soil.
- C. Mixing: Spread unamended soil to total depth **[of 4 inches (100 mm)][of 6 inches (150 mm)][of 8 inches (200 mm)][of 12 inches (300 mm)][indicated on Drawings]<Insert dimension>**, but not less than required to meet finish grades after mixing with amendments and natural settlement. Do not spread

if soil or subgrade is frozen, muddy, or excessively wet.

1. Amendments: Apply soil amendments[, **except compost**,] and fertilizer, if required, evenly on surface, and thoroughly blend them with unamended soil to produce planting soil.
 - a. Mix [**lime**][**and**][**sulfur**] with dry soil before mixing fertilizer.
 - b. Mix fertilizer with planting soil no more than seven days before planting.
2. Lifts: Apply and mix unamended soil and amendments in lifts not exceeding [**8 inches (200 mm)**][**12 inches (300 mm)**]**<Insert dimension>** in loose depth for material compacted by compaction equipment, and not more than [**4 inches (100 mm)**][**6 inches (150 mm)**] in loose depth for material compacted by hand-operated tampers.
- D. Compaction: Compact each blended lift of planting soil to [**75 to 82**]**<Insert number range>** percent of maximum Standard Proctor density according to ASTM D698 and tested in-place[**except where a different compaction value is indicated on Drawings**].
- E. Finish Grading: Grade planting soil to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

3.4 PLACING MANUFACTURED PLANTING SOIL OVER EXPOSED SUBGRADE

- A. General: Apply manufactured soil on-site in its final, blended condition. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.
- B. Subgrade Preparation: Till subgrade to a minimum depth of [**4 inches (100 mm)**][**6 inches (150 mm)**][**8 inches (200 mm)**][**12 inches (300 mm)**][**18 inches (450 mm)**]**<Insert dimension>**. Remove stones larger than [**1-1/2 inches (38 mm)**][**2 inches (50 mm)**][**3 inches (75 mm)**]**<Insert dimension>** in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.
 1. Apply approximately half the thickness of planting soil over prepared, loosened subgrade. Mix thoroughly into top [**2 inches (50 mm)**][**4 inches (100 mm)**] of subgrade. Spread remainder of planting soil.
- C. Application: Spread planting soil to total depth [**of 4 inches (100 mm)**][**of 6 inches (150 mm)**][**of 8 inches (200 mm)**][**of 12 inches (300 mm)**][**indicated on Drawings**]**<Insert dimension>**, but not less than required to meet finish grades after natural settlement. Do not spread if soil or subgrade is frozen, muddy, or excessively wet.
 1. Lifts: Apply planting soil in lifts not exceeding [**8 inches (200 mm)**][**12 inches (300 mm)**]**<Insert dimension>** in loose depth for material compacted by compaction equipment, and not more than [**4 inches (100 mm)**][**6 inches (150 mm)**] in loose depth for material compacted by hand-operated tampers.
- D. Compaction: Compact each lift of planting soil to [**75 to 82**]**<Insert number range>** percent of maximum Standard Proctor density according to ASTM D698[**except where a different compaction value is indicated on Drawings**].
- E. Finish Grading: Grade planting soil to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

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3.5 BLENDING PLANTING SOIL IN PLACE

- A. General: Mix amendments with in-place, unamended soil to produce required planting soil. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.
- B. Preparation: Till unamended, existing soil in planting areas to a minimum depth of **[of 4 inches (100 mm)][of 6 inches (150 mm)][of 8 inches (200 mm)][of 12 inches (300 mm)][of 18 inches (450 mm)][indicated on Drawings]<Insert dimension>**. Remove stones larger than **[1-1/2 inches (38 mm)][2 inches (50 mm)][3 inches (75 mm)]<Insert dimension>** in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.
- C. Mixing: Apply soil amendments[, **except compost**,] and fertilizer, if required, evenly on surface, and thoroughly blend them into full depth of unamended, in-place soil to produce planting soil.
 - 1. Mix **[lime][and][sulfur]** with dry soil before mixing fertilizer.
 - 2. Mix fertilizer with planting soil no more than seven days before planting.
- D. Compaction: Compact blended planting soil to **[75 to 82]<Insert number range>** percent of maximum Standard Proctor density according to ASTM D698[**except where a different compaction value is indicated on Drawings**].
- E. Finish Grading: Grade planting soil to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

3.6 APPLYING COMPOST TO SURFACE OF PLANTING SOIL

- A. Application: Apply **[compost component of planting-soil mix][4 inches (100 mm) of compost][6 inches (150 mm) of compost]<Insert depth>** to surface of in-place planting soil. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.
- B. Finish Grading: Grade surface to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

3.7 LAYERED SOIL ASSEMBLIES

- A. Layered Soil Assembly **<Insert designation>**:
 - 1. **[Top Layer]<Insert layer designation>**: Planting-soil type **<Insert drawing designation>**.
 - 2. **<Insert layer designation>**: Planting-soil type **<Insert drawing designation>**.

3.8 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Perform the following tests[**and inspections**]:
 - 1. Compaction: Test planting-soil compaction after placing each lift and at completion using a densitometer or soil-compaction meter calibrated to a reference test value based on laboratory testing according to ASTM D698. Space tests at no less than one for each **[1000 sq. ft. (100 sq. m)][2000 sq. ft. (200 sq. m)]<Insert dimension>** of in-place soil or part thereof.

2. <Insert name of test>: <Insert requirement>.
3. <Insert name of inspection>: <Insert requirement>.

- C. Soil will be considered defective if it does not pass tests[**and inspections**].
- D. Prepare test[**and inspection**] reports.
- E. Label each sample and test report with the date, location keyed to a site plan or other location system, visible conditions when and where sample was taken, and sampling depth.

3.9 PROTECTION

- A. Protection Zone: Identify protection zones according to Section 015639 "Temporary Tree and Plant Protection."
- B. Protect areas of in-place soil from additional compaction, disturbance, and contamination. Prohibit the following practices within these areas except as required to perform planting operations:
 1. Storage of construction materials, debris, or excavated material.
 2. Parking vehicles or equipment.
 3. Vehicle traffic.
 4. Foot traffic.
 5. Erection of sheds or structures.
 6. Impoundment of water.
 7. Excavation or other digging unless otherwise indicated.
- C. If planting soil or subgrade is overcompacted, disturbed, or contaminated by foreign or deleterious materials or liquids, remove the planting soil and contamination; restore the subgrade as directed by Architect and replace contaminated planting soil with new planting soil.

3.10 CLEANING

- A. Protect areas adjacent to planting-soil preparation and placement areas from contamination. Keep adjacent paving and construction clean and work area in an orderly condition.
- B. Remove surplus soil and waste material including excess subsoil, unsuitable materials, trash, and debris and legally dispose of them off Owner's property unless otherwise indicated.
 1. Dispose of excess subsoil and unsuitable materials on-site where directed by Owner.

END OF SECTION 32 91 13 00



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Task	Specification	Specification Description
32 91 13 16	32 91 13 00	Soil Preparation
32 91 13 16	32 96 00 00	Transplanting
32 91 13 26	32 91 13 00	Soil Preparation
32 91 13 26	32 96 00 00	Transplanting
32 91 13 33	31 20 00 00	Earth Moving
32 91 13 33	32 91 13 00	Soil Preparation
32 91 13 33	32 92 00 00	Turf and Grasses
32 91 13 36	32 91 13 00	Soil Preparation
32 91 13 36	32 92 00 00	Turf and Grasses
32 91 13 36	32 96 00 00	Transplanting



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SECTION 32 91 19 13 - FACILITY SEPTIC TANKS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Concrete septic tanks.
2. Fiberglass septic tanks.
3. Polyethylene septic tanks.
4. Filters.
5. Dosing tanks.
6. Automatic siphons.
7. Concrete distribution boxes.
8. Plastic distribution boxes.
9. PE distribution pipe and fittings.
10. PVC distribution pipe and fittings.
11. Nonpressure pipe couplings.
12. Trench and bed absorption system materials.
13. Mound absorption-system materials.
14. Chamber absorption-system materials.
15. Seepage-pit absorption-system materials.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components, and profiles.
2. Include manhole openings, covers, and pipe connections.

B. Shop Drawings: For **[trench absorption systems][bed absorption systems][mound absorption systems][seepage pits]**.

1. Include manhole openings, covers, pipe connections, and accessories.
2. Include piping with sizes and invert elevations.
3. Include underground structures.
4. Include other utilities.

1.3 PROJECT CONDITIONS

A. Interruption of Existing Septic Tank System Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:

1. Notify **[Architect][Construction Manager][Owner]** no fewer than **[two]<Insert number>** days in advance of proposed interruption of service.
2. Do not proceed with interruption of service without **[Architect's][Construction Manager's][Owner's]** written permission.

PART 2 - PRODUCTS

2.1 CONCRETE SEPTIC TANKS

- A. Description: ASTM C1227, precast, reinforced-concrete tank and covers; **[single chamber][single chamber with internal baffle][two chambers]**.
- B. Design: For **[A-8 (H10-44)][A-12 (HS15-44)][A-16 (HS20-44)]** traffic loading according to ASTM C890.
- C. Manholes: **[20-inch- (508-mm-)][22-inch- (559-mm-)][24-inch- (610-mm-)]<Insert size>** minimum diameter opening with reinforced-concrete risers to grade and access lid with steel lift rings. Include manhole in center of each septic tank compartment top.
- D. Filter Access: Reinforced-concrete access hole, large enough to remove filter, over filter position.
- E. Inlet and Outlet Access: **[12-inch (305-mm)]<Insert size>** minimum diameter, reinforced-concrete access lids with steel lift rings. Include access centered over inlet and outlet.
- F. Resilient Connectors: **ASTM C923 (ASTM C923M)**, of size required for piping, fitted into inlet and outlet openings.
- G. Capacity and Characteristics:
 - 1. Capacity: **<Insert gal. (L)>**.
 - 2. Inlet and Outlet Size: **<Insert NPS (DN)>**.

2.2 FIBERGLASS SEPTIC TANKS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Containment Solutions, Inc]**
 - 2. **[Xerxes by Shawcor Ltd.]**
 - 3. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Containment Solutions, Inc]**
 - 2. **[Xerxes by Shawcor Ltd.]**
 - 3. **<Insert manufacturer's name>**
- C. Description: UL 1316, single chamber, FRP construction; fabricated for septic tank application with at least one access riser and manhole.
- D. Manholes: **[22-inch- (559-mm-)][24-inch- (610-mm-)]<Insert size>** minimum diameter opening with FRP access risers to grade and cover.
- E. Filter Access: Include access hole, large enough to remove filter, over filter position.
- F. Resilient Connectors: **ASTM C923 (ASTM C923M)** or other watertight seal, of size required for piping,

fitted into inlet and outlet openings.

G. Capacity and Characteristics:

1. Capacity: **<Insert gal. (L)>**.
2. Inlet and Outlet Size: **<Insert NPS (DN)>**.

2.3 POLYETHYLENE SEPTIC TANKS

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

1. **[Chem-Tainer Industries]**
2. **[Norwesco, Inc]**
3. **[Plastic-Mart, Inc.]**
4. **[Premier Plastics Inc.]**
5. **[Premier Tech Environment]**
6. **<Insert manufacturer's name>**

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

1. **[Chem-Tainer Industries]**
2. **[Norwesco, Inc]**
3. **[Plastic-Mart, Inc.]**
4. **[Premier Plastics Inc.]**
5. **[Premier Tech Environment]**
6. **<Insert manufacturer's name>**

C. Description: Molded, HDPE or PE construction; fabricated for septic tank application; **[single chamber][single chamber with baffle and at least one access riser and manhole][two chambers each with an access riser and manhole]**.

D. Manholes: **[18-inch- (457-mm-)][20-inch- (508-mm-)][22-inch- (559-mm-)]<Insert size>** minimum diameter opening with HDPE or PE access risers to grade and cover.

E. Filter Access: Include access hole, large enough to remove filter, over filter position.

F. Resilient Connectors: **ASTM C923 (ASTM C923M)** or other watertight seal, of size required for piping, fitted into inlet and outlet openings.

G. Capacity and Characteristics:

1. Capacity: **<Insert gal. (L)>**.
2. Inlet and Outlet Size: **<Insert NPS (DN)>**.

2.4 FILTERS

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

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1. [Premier Tech Environment]
2. [Tuf-Tite Corporation]
3. [Zabel Industries International, Ltd.]
4. <Insert manufacturer's name>

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

1. [Premier Tech Environment]
2. [Tuf-Tite Corporation]
3. [Zabel Industries International, Ltd.]
4. <Insert manufacturer's name>

C. Description: Removable, septic-tank-outlet filter that restricts discharge solids to 1/8 inch (3.2 mm).

D. Housing: HDPE or PVC.

E. Outlet Size: [NPS 4 (DN 100)][NPS 6 (DN 150)]<Insert NPS (DN)>.

2.5 DOSING TANKS

A. Description: Comply with ASTM C913 for precast, reinforced-concrete tank and cover; designed for structural loading according to ASTM C890.

B. Design: For [effluent pump][automatic siphon] installation and [A-8 (H10-44)][A-12 (HS15-44)][A-16 (HS20-44)] traffic loading according to ASTM C890.

C. Manholes: [20-inch- (508-mm-)][22-inch- (559-mm-)][24-inch- (610-mm-)]<Insert size> minimum diameter opening with reinforced-concrete risers to grade and access lid with steel lift rings. Include manhole in center of each septic tank compartment top.

D. Resilient Connectors: **ASTM C923 (ASTM C923M)** or other watertight seal, of size required for piping, fitted into inlet and outlet openings.

E. Capacity and Characteristics:

1. Capacity: <Insert gal. (L)>.
2. Inlet and Outlet Size: <Insert NPS (DN)>.

2.6 AUTOMATIC SIPHONS

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

1. [American Manufacturing Company, Inc]
2. [Fluid Dynamic Siphons, Inc]
3. [Zabel Industries International, Ltd.]
4. <Insert manufacturer's name>

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

1. [American Manufacturing Company, Inc]
2. [Fluid Dynamic Siphons, Inc]
3. [Zabel Industries International, Ltd.]
4. <Insert manufacturer's name>

C. Description: Manufactured siphon assembly of molded-HDPE trap, pipe, and bell, with PVC vent piping and stainless-steel bolts.

D. Capacity and Characteristics:

1. Number Required: [One][Two].
2. Capacity of Each: <Insert gpm (L/s)>.
3. Effluent Outlet Size: <Insert NPS (DN)>.

2.7 CONCRETE DISTRIBUTION BOXES

A. Description: Precast concrete, single-chamber box and cover.

B. Design: Made according to ASTM C913, and for [A-8 (H10-44)][A-12 (HS15-44)][A-16 (HS20-44)] traffic loading according to ASTM C890. [Include baffle opposite inlet].

C. Manholes: [20-inch- (508-mm-)][22-inch- (559-mm-)][24-inch- (610-mm-)]<Insert size> minimum diameter opening with reinforced-concrete risers to grade and cover with steel lift rings in center of distribution box cover.

D. Resilient Connectors: **ASTM C923 (ASTM C923M)**, of size required for piping, fitted into inlet and outlet openings. Include watertight plugs in outlets not required.

E. Capacity and Characteristics

1. Inlet Size: <Insert NPS (DN)>.
2. Number of Outlets: [Two][Three][Four]<Insert number>.
3. Outlet Size: <Insert NPS (DN)>.

2.8 PLASTIC DISTRIBUTION BOXES

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

1. [American Manufacturing Company, Inc]
2. [Premier Plastics Inc.]
3. [Tuf-Tite Corporation]
4. [Zabel Industries International, Ltd.]
5. <Insert manufacturer's name>

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

1. [American Manufacturing Company, Inc]
2. [Premier Plastics Inc.]
3. [Tuf-Tite Corporation]
4. [Zabel Industries International, Ltd.]

5. **<Insert manufacturer's name>**

- C. Description: Molded-HDPE or -PE, single-chamber box and cover.
- D. Manholes:
 - 1. **[18-inch- (457-mm-)][20-inch- (508-mm-)][22-inch- (559-mm-)]<Insert size>** minimum diameter opening with HDPE or PE access risers to grade and cover. Access for PE distribution boxes may be a removable plastic cover and is usually small.
 - 2. Manufacturer's standard cover, or other access opening of size that permits access to distribution-box inlet and outlets.
- E. Pipe Connections: With seal that prevents leakage. Include watertight plugs in outlets not required.
- F. Capacity and Characteristics:
 - 1. Inlet Size: **<Insert NPS (DN)>**.
 - 2. Number of Outlets: **[Two][Three][Four]<Insert number>**.
 - 3. Outlet Size: **<Insert NPS (DN)>**.

2.9 PE DISTRIBUTION PIPE AND FITTINGS

- A. Tube and Fittings: ASTM F405, perforated corrugated tube with solid-wall fittings.
- B. Couplings: PE band, matching tube and fitting dimensions.

2.10 PVC DISTRIBUTION PIPE AND FITTINGS

- A. Pipe and Fittings: ASTM D2729, perforated, for solvent-cemented joints.
- B. Solvent Cement: ASTM D2564. Include primer according to ASTM F656.

2.11 NONPRESSURE PIPE COUPLINGS

- A. Description: Comply with ASTM C1173, elastomeric, sleeve-type, reducing or transition coupling, for joining underground nonpressure piping. Include ends of same sizes as piping to be joined, with corrosion-resistant-metal tension band and tightening mechanism on each end.
 - 1. Sleeve Materials for Plastic Pipes: ASTM F477, elastomeric seal or ASTM D5926, PVC.
 - 2. Sleeve Materials for Dissimilar Pipes: ASTM D5926, PVC or other material compatible with pipe materials being joined.

2.12 TRENCH AND BED ABSORPTION-SYSTEM MATERIALS

- A. Filter Material: ASTM D448, Size No. 24, **3/4 to 2-1/2 inches (19 to 63 mm)**, washed, crushed stone or gravel; or broken, hard-burned clay brick.
- B. Filter Mat: **[Geotextile woven or spun filter fabric, in one or more layers, for minimum total unit weight of 3 oz./sq. yd. (101 g/sq. m)][Untreated building paper or similar porous material]**.

- C. Cover for Distribution Pipe: Geotextile woven filter fabric, in one or more layers, for minimum total unit weight of **3 oz./sq. yd. (101 g/sq. m)**.
- D. Fill Material: Soil removed from trench.

2.13 MOUND ABSORPTION-SYSTEM MATERIALS

- A. Sand-Filter Material: 25 percent or more of very coarse, coarse, or medium sand or combination; maximum of 50 percent fine or very fine sand or combination; and silt and clay combination not to exceed 25 percent. If clay exceeds 60 percent in combination with silt, mixture cannot exceed 15 percent of sand-filter material.
- B. Aggregate-Filter Material: Coarse, **1/2 to 2-1/2 inches (13 to 63 mm)**.
- C. Cap: Clay, silt, or combination of clay and silt.
- D. Topsoil: Good quality, free of stones, metal, and glass.
- E. Vegetation Cover: Grass compatible with adjacent ground cover. No shrubs or trees.
- F. Filter Mat: **[Geotextile woven or spun filter fabric, in one or more layers, for minimum total unit weight of 3 oz./sq. yd. (101 g/sq. m)][Untreated building paper or similar porous material]**.
- G. Cover for Distribution Pipe: Geotextile woven filter fabric, in one or more layers, for minimum total unit weight of **3 oz./sq. yd. (101 g/sq. m)**.

2.14 CHAMBER ABSORPTION-SYSTEM MATERIALS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[Advanced Drainage Systems, Inc]**
 - 2. **[CULTEC, Inc]**
 - 3. **[Hancor Inc.]**
 - 4. **[Infiltrator Systems Inc]**
 - 5. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[Advanced Drainage Systems, Inc]**
 - 2. **[CULTEC, Inc]**
 - 3. **[Hancor Inc.]**
 - 4. **[Infiltrator Systems Inc]**
 - 5. **<Insert manufacturer's name>**
- C. Chamber: Arched, molded-PE structures with solid top, perforated sides, open ends, and open bottom.
- D. End Pieces: Blank without opening for distribution pipe at end of last chamber in row, and with opening for distribution pipe where pipe penetrates chamber.
- E. Effluent Distribution Piping: PE or PVC pipe, with holes or slots along pipe, attached to underside of top

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of chambers.

F. Capacity and Characteristics:

1. Total System Storage Capacity: **<Insert gal. (L or cu. m)>**.
2. Effluent Distribution Piping Size: **<Insert NPS (DN)>**.

2.15 SEEPAGE-PIT ABSORPTION-SYSTEM MATERIALS

- A. Pit Lining: ASTM C62, Type SW, clay bricks; ASTM C55, concrete bricks; ASTM C90, hollow, concrete masonry units; or precast concrete rings with notches or weep holes.
- B. Filter Material: ASTM D448, Size No. 24, **3/4 to 2-1/2 inches (19 to 63 mm)**, washed, crushed stone or gravel; or broken, hard-burned clay brick.
- C. Cover: Precast concrete slab; designed for **[A-8 (H10-44)][A-12 (HS15-44)][A-16 (HS20-44)]** traffic loading according to ASTM C890 and made according to ASTM C913. Include slab dimensions that will extend minimum of **12 inches (305 mm)** beyond edge of excavation. Cast cover with opening for manhole in center.
- D. Manholes: **[20-inch- (508-mm-)][22-inch- (559-mm-)][24-inch- (610-mm-)]<Insert size>** minimum diameter opening with reinforced-concrete risers to grade and access lid with steel lift rings.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Excavating, trenching, and backfilling for piping[**and seepage pits**] are specified in Section 312000 "Earth Moving."
 1. Stockpile topsoil for reuse in finish grading without intermixing with other excavated material. Stockpile materials away from edge of excavation and do not store within drip line of remaining trees.
 2. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.
- B. Excavating and Backfilling for Septic[**and Dosing**] Tanks:
 1. Excavate sufficient width and length for tanks to depth determined by tank inlet elevation. Provide level bottom.
 2. Backfill with excavated soil, mounding soil above original grade without compacting.
- C. Excavating and Backfilling for Trench Absorption Systems:
 1. Excavate for trench absorption systems **30 inches (762 mm)** wide and **24 inches (610 mm)** deep, minimum.
 2. Backfill with excavated soil, mounding soil above original grade without compacting.
- D. Excavating and Backfilling for Bed Absorption Systems:
 1. Excavate for bed absorption systems of width indicated and **24 inches (610 mm)** deep, minimum.

2. Backfill with excavated soil, mounding soil above original grade without compacting.

E. Excavating and Backfilling for Chamber Absorption Systems:

1. Excavate for trench-type chamber absorption systems [**30 inches (762 mm) wide and 24 inches (610 mm)]<Insert dimensions>** deep, minimum.
2. Excavate for bed-type chamber absorption systems of width indicated and [**24 inches (610 mm)]<Insert dimensions>** deep, minimum.
3. Backfill chamber absorption systems with excavated soil, mounding soil above original grade without compacting.

F. Excavating and Backfilling for Seepage-Pit Absorption Systems:

1. Excavate sufficient hole diameter for pits to depth determined by tank inlet and bottom elevations. Provide level bottom.
2. Backfill with excavated soil, mounding soil above original grade without compacting.

3.2 SEPTIC TANK INSTALLATION

- A. Install precast concrete septic tanks according to ASTM C891.
- B. Install septic tanks level.
- C. Connect septic tank to concrete ballast pad.
- D. Install filter in septic tank outlet. Secure filter to septic tank wall. Make direct connections to distribution piping.
- E. Install insulation on exterior sides and top of septic tank. Comply with requirements for insulation specified in Section 220716 "Plumbing Equipment Insulation."
- F. Fill septic tank with water.

3.3 DOSING TANK INSTALLATION

- A. Install dosing tanks according to ASTM C891.
- B. Install dosing tanks level.
- C. Install automatic siphons embedded in precast-concrete dosing tank. Make direct connections to distribution piping.
- D. Set submersible effluent pumps on dosing tank floor. Make direct connections to distribution piping. Comply with requirements for effluent pumps specified in Section 221329 "Sanitary Sewerage Pumps."
- E. Fill dosing tanks with water.

3.4 DISTRIBUTION BOX INSTALLATION

- A. Install precast-concrete distribution boxes according to ASTM C891 and at invert elevations indicated. Set level and plumb.

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- B. Install PE distribution boxes at invert elevations indicated and according to manufacturer's written instructions. Set level and plumb.

3.5 PIPING INSTALLATION

- A. Comply with requirements for sewer pipe installation specified in Section 333115 "Site Sanitary Sewerage Piping."
- B. Install distribution piping according to the following:
 - 1. Use perforated pipe and fittings for **[trench][bed][mound]** absorption systems with perforations at bottom.
 - 2. PE Tube and Fittings: ASTM F481.
 - 3. PVC Sewer Pipe and Fittings: ASTM F481.

3.6 PIPE JOINT CONSTRUCTION

- A. Join distribution piping with or according to the following:
 - 1. Install pipe and fittings for **[trench][bed][mound]** absorption systems with closed joints unless otherwise indicated.
 - 2. PE Tube and Fittings: With PE band couplings.
 - 3. PVC Sewer Pipe and Fittings: With solvent-cemented joints according to ASTM F402 and ASTM D2321.
- B. Join dissimilar pipe materials according to ASTM D5926, with couplings and gaskets compatible with pipe materials being joined.

3.7 CLEANOUT INSTALLATION

- A. Install cleanouts according to the following:
 - 1. Inlet and Outlet of Septic Tanks: Cast-iron cleanouts.
 - 2. Inlet and Outlet of Dosing Tanks: Cast-iron cleanouts.
 - 3. Inlet and Outlet of Distribution Boxes: **[Cast-iron][PVC]** cleanouts.
 - 4. At Each Change in Direction of Sewer Piping: **[Cast-iron][PVC]** cleanouts.
 - 5. At Ends of Each Row **[and at Each Change in Direction]** of Distribution Piping: **[Cast-iron][PVC]** cleanouts.
- B. Comply with requirements for cleanouts specified in Section 333115 "Site Sanitary Sewerage Piping."
- C. Cast-Iron Cleanouts: Install with PVC riser from sewer and distribution piping to cast-iron cleanout housing at grade. Use **NPS 4 (DN 100)** PVC sewer pipe and fittings with solvent-cemented joints for risers. Attach riser to cleanout housing with rubber gasket or coupling.
- D. PVC Cleanouts: Install with PVC riser from sewer and distribution piping to PVC cleanout at grade. Use **NPS 4 (DN 100)** PVC sewer pipe and fittings with solvent-cemented joints for risers and cleanout fitting.
- E. Cleanout Support: Set cleanouts in concrete blocks **[18-by-18-by-12-inches (457-by-457-by-305-mm)]**<Insert dimensions> deep unless location is in concrete pavement. Formwork, reinforcement, and concrete are specified in Section 033000 "Cast-in-Place Concrete."

- F. Set top of cleanout [1 inch (25 mm)][2 inches (51 mm)] above surrounding rough grade, or set flush with grade if installed in pavement.

3.8 [TRENCH][BED] ABSORPTION-SYSTEM INSTALLATION

- A. Filter Material: Place supporting layer of filter material over the compacted [trench][bed] base to a compacted depth not less than 6 inches (152 mm) below bottom of pipe.
- B. Install sewer piping [at minimum slope of 1 percent and maximum slope of 2 percent][at no slope]<Insert slope>.
- C. Install distribution piping solidly bedded in filter material, with full bearing for each pipe section throughout its length. Maintain pipe alignment with no slope.
 - 1. Install perforated pipe with perforations down and joints tightly closed. Install couplings as required.
 - 2. Install elbow fittings with tight joints.
 - 3. Install absorption-system materials as follows from surface of excavation to grade:
 - a. Trench Size: [12 inches (305 mm)][36 inches (914 mm)]<Insert value> wide by <Insert value> long.
 - b. Bed Size: <Insert value> wide with distribution piping [36 inches (914 mm) minimum]<Insert value> apart by <Insert value> long.
 - c. Bottom Filter Material Layer: [6 inches (152 mm)][8 inches (203 mm)]<Insert value> thick below distribution piping.
 - d. Intermediate Filter Material Layer: OD of distribution piping.
 - e. Top Filter Material Layer: [6-inch (152-mm)][8-inch (203-mm)]<Insert value> minimum thickness above distribution piping.
 - f. Filter Mat: Above final filter-material layer.
 - g. Fill: Above filter mat to final grade.
- D. Install filter mat over filter material before backfilling.

3.9 MOUND ABSORPTION-SYSTEM INSTALLATION

- A. Plow top [6 inches (152 mm)]<Insert dimension> of surface.
- B. Place layers of sand, [aggregate,] cap, and topsoil above plowed area. Provide grass topping to match adjacent vegetation. Provide side slope not steeper than 3:1. Tie slope toe smoothly into existing grade.
- C. Provide solid vent pipe with vent cap extending [12 inches (305 mm)]<Insert dimension> above top of mounds.
- D. Install sewer piping [flat][at minimum slope of 1 percent and maximum slope of 2 percent][at no slope]<Insert slope>.
- E. Install distribution piping solidly bedded in filter material, with full bearing for each pipe section throughout its length. Maintain pipe alignment with no slope.
 - 1. Install perforated pipe with perforations down and joints tightly closed. Install collars and couplings as required.
 - 2. Install elbow fittings with tight joints.

- F. Install and grade materials around mound absorption systems to prevent storm runoff from washing away a portion of mound absorption systems and to prevent exposing pipes.
1. Install absorption-system materials as follows from surface of excavation to grade:
 - a. Bed Size: **<Insert value>** wide with distribution piping **[36 inches (914 mm) minimum]<Insert value>** apart by **<Insert value>** long.
 - b. Sand Fill: Not less than **[6-inch (152-mm)]<Insert value>** thickness above plowed earth or broken-up sod.
 - c. Aggregate Filter Material Layer: OD of distribution piping minimum.
 - d. Filter Mat: Above final filter-material layer.
 - e. Cap: As required to make rounded mound above filter mat.
 - f. Topsoil: **[2-inch (51-mm)]<Insert value>** thickness above cap and extended to edges of mound.
 - g. Vegetation Cover: Grass **[or match adjacent ground cover]** at surface.

3.10 CHAMBER ABSORPTION-SYSTEM INSTALLATION

- A. Install sewer piping **[flat][at minimum slope of 1 percent and maximum slope of 2 percent][at no slope]<Insert slope>**.
- B. Install chambers with no slope above plowed area.
1. Install chamber distribution piping with tight joints throughout chambers.

3.11 SEEPAGE-PIT ABSORPTION-SYSTEM INSTALLATION

- A. Excavate hole for **[60-inch (1524-mm)]<Insert value>** diameter seepage pit plus minimum of **6 inches (152 mm)** around outside of pit and lining.
- B. Do not extend pit depth into ground-water table.
- C. Install constructed-in-place seepage pits according to the following procedure if no requirements of authorities having jurisdiction apply:
1. Install brick pit-lining material dry and laid flat with staggered joints for seepage.
 2. Install block pit-lining material dry with staggered joints and a minimum of 20 percent of blocks on side for seepage. Install precast concrete rings with notches or weep holes for seepage.
 3. Extend pit-lining material so top of manhole will be approximately **[8 inches (203 mm)]<Insert dimension>** below finished grade.
 4. Backfill bottom of inside of pit with filtering material at least **[12 inches (305 mm)]<Insert dimension>** above bottom of lining material.
 5. Extend effluent inlet pipe **[12 inches (305 mm)]<Insert dimension>** into seepage pit and terminate into side of tee fitting.
 6. Backfill around outside of pit lining with filtering material to top of lining.
 7. Install manhole risers from top of pit to grade. Support cover on undisturbed soil. Do not support cover on pit lining.

3.12 IDENTIFICATION

- A. Identification materials and their installation are specified in Section 312000 "Earth Moving." Arrange for

installation of green, detectable warning tape directly over piping, at outside edges of underground structures, and at outside edges of absorption systems.

3.13 FIELD QUALITY CONTROL

- A. System Tests: Perform testing of completed septic tank system piping and structures according to authorities having jurisdiction.
- B. Additional Tests: Fill underground structures with water and let stand overnight. If water level recedes, locate and repair leaks and retest. Repeat tests and repairs until no leaks exist.

3.14 CLEANING

- A. Clear interior of piping and structures of dirt and other superfluous material as work progresses.
- B. Maintain swab or drag in piping, and pull past each joint as it is completed. Place plugs in ends of uncompleted pipe at end of workday or when work stops.

END OF SECTION 32 91 19 13



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Task	Specification	Specification Description
32 91 19 13	31 10 00 00	Site Clearing
32 91 19 13	31 20 00 00	Earth Moving
32 91 19 13	32 92 00 00	Turf and Grasses



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SECTION 32 92 00 00 - TURF AND GRASSES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Seeding.
2. Hydroseeding.
3. Sodding.
4. Plugging.
5. Sprigging.
6. Meadow grasses and wildflowers.
7. Turf renovation.
8. Erosion-control materials.
9. Grass-paving materials.

B. Related Requirements:

1. Section 329300 "Plants" for trees, shrubs, ground covers, and other plants as well as border edgings and mow strips.

1.2 DEFINITIONS

- A. Finish Grade: Elevation of finished surface of planting soil.
- B. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. Pesticides include insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. They also include substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.
- C. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. Pests include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.
- D. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth. See [Section 329113 "Soil Preparation"] [Section 329115 "Soil Preparation (Performance Specification)"] and drawing designations for planting soils.
- E. Subgrade: The surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.
- F. <Insert definition>.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at [Project site] <Insert location>.
1. <Insert requirements>.

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1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For landscape Installer.
- B. Certification of Grass Seed: From seed vendor for each grass-seed monostand or mixture, stating the botanical and common name, percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.
 - 1. Certification of each seed mixture for **[turfgrass sod][plugs]**. Include identification of source and name and telephone number of supplier.
- C. Product Certificates: For fertilizers, from manufacturer.
- D. Pesticides and Herbicides: Product label and manufacturer's application instructions specific to Project.

1.5 CLOSEOUT SUBMITTALS

- A. Maintenance Data: Recommended procedures to be established by Owner for maintenance of turf[**and meadows**] during a calendar year. Submit before expiration of required maintenance periods.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful turf[**and meadow**] establishment.
 - 1. Professional Membership: Installer shall be a member in good standing of either the National Association of Landscape Professionals or AmericanHort.
 - 2. Experience: **[Three][Five]<Insert number>** years' experience in turf installation in addition to requirements in Section 014000 "Quality Requirements."
 - 3. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
 - 4. Personnel Certifications: Installer's **[field supervisor][personnel assigned to the Work]** shall have certification in **[one of][all of]** the following categories from the National Association of Landscape Professionals:
 - a. Landscape Industry Certified Technician - Exterior.
 - b. Landscape Industry Certified Lawn Care Manager.
 - c. Landscape Industry Certified Lawn Care Technician.
 - 5. Pesticide Applicator: State licensed, commercial.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Seed and Other Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of compliance with state and Federal laws, as applicable.
- B. Sod: Harvest, deliver, store, and handle sod according to requirements in "Specifications for Turfgrass Sod Materials" and "Specifications for Turfgrass Sod Transplanting and Installation" sections in TPI's "Guideline Specifications to Turfgrass Sodding." Deliver sod within 24 hours of harvesting and in time for planting promptly. Protect sod from breakage and drying.

C. Bulk Materials:

1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
2. Provide erosion-control measures to prevent erosion or displacement of bulk materials; discharge of soil-bearing water runoff; and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
3. Accompany each delivery of bulk materials with appropriate certificates.

1.8 FIELD CONDITIONS

- A. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with initial maintenance periods to provide required maintenance from date of **[planting completion]****[Substantial Completion]****<Insert starting time>**.
1. Spring Planting: **<Insert dates>**.
 2. Fall Planting: **<Insert dates>**.
- B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions.

PART 2 - PRODUCTS

2.1 SEED

- A. Grass Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Rules for Testing Seeds" for purity and germination tolerances.
- B. Seed Species:
1. Quality, State Certified: State-certified seed of grass species as listed below for solar exposure.
 2. Quality, Non-State Certified: Seed of grass species as listed below for solar exposure, with not less than **[85]****<Insert number>** percent germination, not less than **[95]****<Insert number>** percent pure seed, and not more than **[0.5]****<Insert number>** percent weed seed:
 3. Full Sun, Warm-Season Grass: Bermudagrass (*Cynodon dactylon*).
 4. Full Sun, Cool-Season Grass: Kentucky bluegrass (*Poa pratensis*), a minimum of three cultivars.
 5. Sun and Partial Shade, Cool-Season Grass: Proportioned by weight as follows:
 - a. 50 percent Kentucky bluegrass (*Poa pratensis*).
 - b. 30 percent chewings red fescue (*Festuca rubra* variety).
 - c. 10 percent perennial ryegrass (*Lolium perenne*).
 - d. 10 percent redtop (*Agrostis alba*).
 6. Shade, Cool-Season Grass: Proportioned by weight as follows:
 - a. 50 percent chewings red fescue (*Festuca rubra* variety).
 - b. 35 percent rough bluegrass (*Poa trivialis*).
 - c. 15 percent redtop (*Agrostis alba*).
- C. Grass-Seed Mix: Proprietary seed mix as follows:

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

- a. <Insert manufacturer's name; product name or designation>.

2.2 TURFGRASS SOD

- A. Turfgrass Sod: [Certified][Approved][Number 1 Quality/Premium, including limitations on thatch, weeds, diseases, nematodes, and insects], complying with "Specifications for Turfgrass Sod Materials" in TPI's "Guideline Specifications to Turfgrass Sodding." Furnish viable sod of uniform density, color, and texture that is strongly rooted and capable of vigorous growth and development when planted.
- B. Turfgrass Species, Warm-Season Grass: [Bermudagrass (*Cynodon dactylon*)][Carpetgrass (*Axonopus affinis*)][Centipedegrass (*Eremochloa ophiuroides*)][St. Augustinegrass (*Stenotaphrum secundatum*)][Zoysiagrass (*Zoysia japonica*)][Zoysiagrass (*Zoysia matrella*)][Turf-type tall fescue (*Festuca arundinacea*), shade tolerant blend]<Insert species>.
- C. Turfgrass Species, Cool-Season Grass: Sod of grass species as follows, with not less than [85]<Insert number> percent germination, not less than [95]<Insert number> percent pure seed, and not more than [0.5]<Insert number> percent weed seed:
 1. Full Sun: Kentucky bluegrass (*Poa pratensis*), a minimum of three cultivars.
 2. Sun and Partial Shade: Proportioned by weight as follows:
 - a. 50 percent Kentucky bluegrass (*Poa pratensis*).
 - b. 30 percent chewings red fescue (*Festuca rubra* variety).
 - c. 10 percent perennial ryegrass (*Lolium perenne*).
 - d. 10 percent redtop (*Agrostis alba*).
 3. Shade: Proportioned by weight as follows:
 - a. 50 percent chewings red fescue (*Festuca rubra* variety).
 - b. 35 percent rough bluegrass (*Poa trivialis*).
 - c. 15 percent redtop (*Agrostis alba*).

2.3 PLUGS

- A. Plugs: Turfgrass sod, [Certified][Approved][Number 1 Quality/Premium, including limitations on thatch, weeds, diseases, nematodes, and insects], complying with "Specifications for Turfgrass Sod Materials" in TPI's "Guideline Specifications to Turfgrass Sodding." Furnish viable sod of uniform density, color, and texture that is cut into square or round plugs, strongly rooted, and capable of vigorous growth and development when planted; of the following turfgrass species and plug size:
 1. Turfgrass Species: [Bermudagrass (*Cynodon dactylon*)][Carpetgrass (*Axonopus affinis*)][Centipedegrass (*Eremochloa ophiuroides*)][St. Augustinegrass (*Stenotaphrum secundatum*)][Zoysiagrass (*Zoysia japonica*)][Zoysiagrass (*Zoysia matrella*)]<Insert species>.
 2. Plug Size: [2 inches (50 mm)][3 inches (75 mm)][4 inches (100 mm)]<Insert dimension>.

2.4 SPRIGS

- A. Sod Sprigs: Healthy living stems, rhizomes, or stolons with a minimum of two nodes and attached roots free of soil, of the following turfgrass species:
 - 1. Turfgrass Species, Warm-Season Grass: **[Bermudagrass (*Cynodon dactylon*)]****[Carpetgrass (*Axonopus affinis*)]****[Centipedegrass (*Eremochloa ophiuroides*)]****[St. Augustinegrass (*Stenotaphrum secundatum*)]****[Zoysiagrass (*Zoysia japonica*)]****[Zoysiagrass (*Zoysia matrella*)]****<Insert species>**.
 - 2. Turfgrass Species, Cool-Season Grass: Creeping bentgrass (*Agrostis palustris*).

2.5 MEADOW GRASSES AND WILDFLOWERS

- A. Wildflower Seed: Fresh, clean, and dry new seed, of mixed species as follows:
 - 1. **<Insert mix of wildflower species>**.
- B. Native-Grass Seed: Fresh, clean, and dry new seed, of mixed species as follows:
 - 1. **<Insert mix of native-grass species>**.
- C. Wildflower and Native-Grass Seed: Fresh, clean, and dry new seed, of mixed species as follows:
 - 1. **<Insert mix of wildflower and native-grass species>**.
- D. Seed Carrier: Inert material, sharp clean sand or perlite.

2.6 FERTILIZERS

- A. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:
 - 1. Composition:
 - a. **[1 lb/1000 sq. ft. (0.45 kg/92.9 sq. m)]****<Insert value>** of actual nitrogen, 4 percent phosphorous, and 2 percent potassium, by weight.
 - b. Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.
- B. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:
 - 1. Composition:
 - a. 20 percent nitrogen, 10 percent phosphorous, and 10 percent potassium, by weight.
 - b. Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

2.7 MULCHES

- A. Straw Mulch: Provide air-dry, clean, mildew- and seed-free, salt hay or threshed straw of wheat, rye,

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oats, or barley.

- B. Sphagnum Peat Mulch: Partially decomposed sphagnum peat moss, finely divided or of granular texture, and with a pH range of 3.4 to 4.8.
- C. Muck Peat Mulch: Partially decomposed moss peat, native peat, or reed-sedge peat, finely divided or of granular texture, with a pH range of 6 to 7.5, and having a water-absorbing capacity of 1100 to 2000 percent, and containing no sand.
- D. Compost Mulch: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through **1-inch (25-mm)** sieve; soluble salt content of **[2 to 5]<Insert range or value>** decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:
 - 1. Organic Matter Content: **[50 to 60]<Insert number range>** percent of dry weight.
 - 2. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.
- E. Fiber Mulch: Biodegradable, dyed-wood, cellulose-fiber mulch; nontoxic and free of plant-growth or germination inhibitors; with a maximum moisture content of 15 percent and a pH range of 4.5 to 6.5.
- F. Nonasphaltic Tackifier: Colloidal tackifier recommended by fiber-mulch manufacturer for slurry application; nontoxic and free of plant-growth or germination inhibitors.
- G. Asphalt Emulsion: ASTM D977, Grade SS-1; nontoxic and free of plant-growth or germination inhibitors.

2.8 PESTICIDES

- A. General: Pesticide, registered and approved by the EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.
- B. Pre-Emergent Herbicide (Selective and Nonselective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.
- C. Post-Emergent Herbicide (Selective and Nonselective): Effective for controlling weed growth that has already germinated.

2.9 EROSION-CONTROL MATERIALS

- A. Erosion-Control Blankets: Biodegradable wood excelsior, straw, or coconut-fiber mat enclosed in a photodegradable plastic mesh. Include manufacturer's recommended steel wire staples, **6 inches (150 mm)** long.
- B. Erosion-Control Fiber Mesh: Biodegradable burlap or spun-coir mesh, a minimum of **0.92 lb/sq. yd. (0.5 kg/sq. m)**, with 50 to 65 percent open area. Include manufacturer's recommended steel wire staples, **6 inches (150 mm)** long.
- C. Erosion-Control Mats: Cellular, nonbiodegradable slope-stabilization mats designed to isolate and contain small areas of soil over steeply sloped surface, of **[3-inch (75-mm)][4-inch (100-mm)][6-inch (150-mm)]<Insert dimension>** nominal mat thickness. Include manufacturer's recommended

anchorage system for slope conditions.

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

2.10 GRASS-PAVING MATERIALS

- A. Grass Paving: Cellular, nonbiodegradable plastic mats, designed to contain small areas of soil and enhance the ability of turf to support vehicular and pedestrian traffic, of **[1-inch (25-mm)][1-3/4-inch (45-mm)][2-inch (50-mm)][manufacturer's standard]<Insert dimension>** nominal mat thickness. Include manufacturer's recommended anchorage system for slope conditions.
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Airfield Systems, LLC]**
 - b. **[Geo Products, LLC]**
 - c. **[Grid Technologies, Inc.]**
 - d. **[Invisible Structures, Inc.]**
 - e. **[NDS Inc]**
 - f. **[PermaTurf Co., Inc.]**
 - g. **[Presto Products Company]**
 - h. **[RK Manufacturing, Inc.]**
 - i. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Airfield Systems, LLC]**
 - b. **[Geo Products, LLC]**
 - c. **[Grid Technologies, Inc.]**
 - d. **[Invisible Structures, Inc.]**
 - e. **[NDS Inc]**
 - f. **[PermaTurf Co., Inc.]**

- g. [Presto Products Company]
- h. [RK Manufacturing, Inc.]
- i. <Insert manufacturer's name>

- B. Base Course: Sound crushed stone or gravel complying with [ASTM D448 for Size No. 8][Section 312000 "Earth Moving" for base-course material]<Insert requirements>.
- C. Sand: Sound, sharp, washed, natural sand or crushed stone complying with gradation requirements in ASTM C33/C33M for fine aggregate.
- D. Proprietary Growing Mix: As submitted and acceptable to Architect.
- E. Sandy Loam Soil Mix: Sound, sharp, washed, natural sand or crushed stone complying with gradation requirements in ASTM C33/C33M for fine aggregate blended with planting soil . Use blend consisting of [1/2 sand and 1/2 planting soil][2/3 sand and 1/3 planting soil]<Insert proportions>.
- F. Soil for Paving Fill: Planting soil .

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to be planted for compliance with requirements and other conditions affecting installation and performance of the Work.
 - 1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
 - 2. Suspend planting operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
 - 3. Uniformly moisten excessively dry soil that is not workable or which is dusty.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.
- C. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Architect and replace with new planting soil.

3.2 PREPARATION

- A. Protect structures; utilities; sidewalks; pavements; and other facilities, trees, shrubs, and plantings from damage caused by planting operations.
 - 1. Protect adjacent and adjoining areas from hydroseeding and hydromulching overspray.
 - 2. Protect grade stakes set by others until directed to remove them.
- B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

3.3 TURF AREA PREPARATION

- A. General: Prepare planting area for soil placement and mix planting soil according to [Section 329113 "Soil Preparation."][Section 329115 "Soil Preparation (Performance Specification)."]
- B. Placing Planting Soil: [Place and mix planting soil in place over exposed subgrade][Place manufactured planting soil over exposed subgrade][Blend planting soil in place]<Insert requirement>.
 - 1. Reduce elevation of planting soil to allow for soil thickness of sod.
- C. Moisten prepared area before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.
- D. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

3.4 PREPARATION FOR EROSION-CONTROL MATERIALS

- A. Prepare area as specified in "Turf Area Preparation" Article.
- B. For erosion-control mats, install planting soil in two lifts, with second lift equal to thickness of erosion-control mats. Install erosion-control mat and fasten as recommended by material manufacturer.
- C. Fill cells of erosion-control mat with planting soil and compact before planting.
- D. For erosion-control blanket or mesh, install from top of slope, working downward, and as recommended by material manufacturer for site conditions. Fasten as recommended by material manufacturer.
- E. Moisten prepared area before planting if surface is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

3.5 PREPARATION FOR GRASS-PAVING MATERIALS

- A. Reduce subgrade elevation soil to allow for thickness of grass-paving system. Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Grade so that installed paving is within plus or minus 1/2 inch (13 mm) of finish elevation. Roll and rake, remove ridges, and fill depressions.
- B. Install [base course][and][sand course] and [sandy loam soil mix][proprietary growing mix][soil for paving fill] as recommended by paving-material manufacturer for site conditions and according to details indicated on Drawings. Compact according to paving-material manufacturer's written instructions.
- C. Install paving mat and fasten according to paving-material manufacturer's written instructions.
- D. Before planting, fill cells of paving mat with [planting soil][sandy loam soil mix][proprietary growing mix][sand half full] and compact according to manufacturer's written instructions.
- E. Moisten prepared area before planting if surface is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

3.6 SEEDING

- A. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds **5 mph (8 km/h)**.
 1. Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.
 2. Do not use wet seed or seed that is moldy or otherwise damaged.
 3. Do not seed against existing trees. Limit extent of seed to outside edge of planting saucer.
- B. Sow seed at a total rate of **[2 lb/1000 sq. ft. (0.9 kg/92.9 sq. m)][3 to 4 lb/1000 sq. ft. (1.4 to 1.8 kg/92.9 sq. m)][5 to 8 lb/1000 sq. ft. (2.3 to 3.6 kg/92.9 sq. m)]<Insert values>**.
- C. Rake seed lightly into top **1/8 inch (3 mm)** of soil, roll lightly, and water with fine spray.
- D. Protect seeded areas with slopes exceeding **[1:4 with erosion-control blankets][and][1:6 with erosion-control fiber mesh]** installed and stapled according to manufacturer's written instructions.
- E. Protect seeded areas with erosion-control mats where indicated on Drawings; install and anchor according to manufacturer's written instructions.
- F. Protect seeded areas with slopes not exceeding 1:6 by spreading straw mulch. Spread uniformly at a minimum rate of **[2 tons/acre (42 kg/92.9 sq. m)]<Insert values>** to form a continuous blanket **[1-1/2 inches (38 mm)]<Insert dimension>** in loose thickness over seeded areas. Spread by hand, blower, or other suitable equipment.
 1. Anchor straw mulch by crimping into soil with suitable mechanical equipment.
 2. Bond straw mulch by spraying with asphalt emulsion at a rate of **[10 to 13 gal./1000 sq. ft. (38 to 49 L/92.9 sq. m)]<Insert values>**. Take precautions to prevent damage or staining of structures or other plantings adjacent to mulched areas. Immediately clean damaged or stained areas.
- G. Protect seeded areas from hot, dry weather or drying winds by applying **[compost mulch][peat mulch][planting soil]** within 24 hours after completing seeding operations. Soak areas, scatter mulch uniformly to a thickness of **[3/16 inch (4.8 mm)]<Insert dimension>**, and roll surface smooth.

3.7 HYDROSEEDING

- A. Hydroseeding: Mix specified seed, **[commercial fertilizer][slow-release fertilizer]<Insert type>**, and fiber mulch in water, using equipment specifically designed for hydroseed application. Continue mixing until uniformly blended into homogeneous slurry suitable for hydraulic application.
 1. Mix slurry with **[nonasphaltic][asphalt-emulsion][fiber-mulch manufacturer's recommended]** tackifier.
 2. Spray-apply slurry uniformly to all areas to be seeded in a one-step process. Apply slurry at a rate so that mulch component is deposited at not less than **[1500-lb/acre (15.6-kg/92.9 sq. m)]<Insert values>** dry weight, and seed component is deposited at not less than the specified seed-sowing rate.
 3. Spray-apply slurry uniformly to all areas to be seeded in a two-step process. Apply first slurry coat at a rate so that mulch component is deposited at not less than **[500-lb/acre (5.2-kg/92.9 sq. m)]<Insert values>** dry weight, and seed component is deposited at not less than the specified seed-sowing rate. Apply slurry cover coat of fiber mulch (hydromulching) at a rate of **[1000 lb/acre (10.4 kg/92.9 sq. m)]<Insert values>**.

3.8 SODDING

- A. Lay sod within 24 hours of harvesting[**unless a suitable preservation method is accepted by Architect prior to delivery time**]. Do not lay sod if dormant or if ground is frozen or muddy.
- B. Lay sod to form a solid mass with tightly fitted joints. Butt ends and sides of sod; do not stretch or overlap. Stagger sod strips or pads to offset joints in adjacent courses. Avoid damage to soil or sod during installation. Tamp and roll lightly to ensure contact with soil, eliminate air pockets, and form a smooth surface. Work sifted soil or fine sand into minor cracks between pieces of sod; remove excess to avoid smothering sod and adjacent grass.
 - 1. Lay sod across slopes exceeding 1:3.
 - 2. Anchor sod on slopes exceeding 1:6 with wood pegs[**or steel staples**] spaced as recommended by sod manufacturer but not less than two anchors per sod strip to prevent slippage.
- C. Saturate sod with fine water spray within two hours of planting. During first week after planting, water daily or more frequently as necessary to maintain moist soil to a minimum depth of **1-1/2 inches (38 mm)** below sod.

3.9 PLUGGING

- A. Plant plugs in holes or furrows, spaced [**12 inches (300 mm)**][**18 inches (450 mm)**]**<Insert dimension>** apart in [**both directions**][**triangular pattern**]. On slopes, contour furrows to near level.

3.10 SPRIGGING

- A. Plant freshly shredded sod sprigs in furrows [**1 to 1-1/2 inches (25 to 38 mm)**][**1-1/2 to 2 inches (38 to 50 mm)**][**2-1/2 to 3 inches (64 to 75 mm)**] deep. Place individual sprigs with roots and portions of stem in moistened soil, [**6 inches (150 mm)**][**12 inches (300 mm)**]**<Insert dimension>** apart in rows [**10 inches (250 mm)**][**18 inches (450 mm)**]**<Insert dimension>** apart, and fill furrows without covering growing tips. Lightly roll and firm soil around sprigs after planting.
- B. Broadcast sprigs uniformly over prepared surface at a rate of [**10 cu. ft./1000 sq. ft. (0.28 cu. m/92.9 sq. m)**]**<Insert values>** and mechanically force sprigs into lightly moistened soil.
 - 1. Spread a **1/4-inch- (6-mm-)** thick layer of [**compost mulch**][**peat mulch**][**planting soil**] on sprigs.
 - 2. Lightly roll and firm soil around sprigs after planting.
 - 3. Water sprigs immediately after planting and keep moist by frequent watering until well rooted.

3.11 TURF RENOVATION

- A. Renovate existing turf where indicated.
- B. Renovate turf damaged by Contractor's operations, such as storage of materials or equipment and movement of vehicles.
 - 1. Reestablish turf where settlement or washouts occur or where minor regrading is required.
 - 2. Install new planting soil as required.
- C. Remove sod and vegetation from diseased or unsatisfactory turf areas; do not bury in soil.

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- D. Remove topsoil containing foreign materials, such as oil drippings, fuel spills, stones, gravel, and other construction materials resulting from Contractor's operations, and replace with new planting soil.
- E. Mow, dethatch, core aerate, and rake existing turf.
- F. Remove weeds before seeding. Where weeds are extensive, apply selective herbicides as required. Do not use pre-emergence herbicides.
- G. Remove waste and foreign materials, including weeds, soil cores, grass, vegetation, and turf, and legally dispose of them off Owner's property.
- H. Till stripped, bare, and compacted areas thoroughly to a soil depth of **6 inches (150 mm)**.
- I. Apply[**soil amendments and**] initial fertilizer required for establishing new turf and mix thoroughly into top **4 inches (100 mm)** of existing soil. Install new planting soil to fill low spots and meet finish grades.
 - 1. Soil Amendment(s): **<Insert required soil amendment(s)>** according to requirements of **[Section 329113 "Soil Preparation."][Section 329115 "Soil Preparation (Performance Specification)."]** Apply **<Insert soil amendment>** at the rate of **<Insert application rate>**.
 - 2. Initial Fertilizer: **[Commercial fertilizer][Slow-release fertilizer]<Insert type>** applied according to manufacturer's recommendations.
- J. Apply **[seed and protect with straw mulch][sod][plugs][sprigs]** as required for new turf.
- K. Water newly planted areas and keep moist until new turf is established.

3.12 TURF MAINTENANCE

- A. General: Maintain and establish turf by watering, fertilizing, weeding, mowing, trimming, replanting, and performing other operations as required to establish healthy, viable turf. Roll, regrade, and replant bare or eroded areas and remulch to produce a uniformly smooth turf. Provide materials and installation the same as those used in the original installation.
 - 1. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace materials and turf damaged or lost in areas of subsidence.
 - 2. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.
 - 3. Apply treatments as required to keep turf and soil free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards.
- B. Watering: Install and maintain temporary piping, hoses, and turf-watering equipment to convey water from sources and to keep turf uniformly moist to a depth of **4 inches (100 mm)**.
 - 1. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
 - 2. Water turf with fine spray at a minimum rate of **1 inch (25 mm)** per week unless rainfall precipitation is adequate.
- C. Mow turf as soon as top growth is tall enough to cut. Repeat mowing to maintain specified height without cutting more than one-third of grass height. Remove no more than one-third of grass-leaf growth in initial or subsequent mowings. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet. Schedule initial and subsequent mowings to maintain the following grass height:

1. Mow **[bentgrass]<Insert grass species>** to a height of **1/2 inch (13 mm)** or less.
 2. Mow **[bermudagrass]<Insert grass species>** to a height of **1/2 to 1 inch (13 to 25 mm)**.
 3. Mow **[carpetgrass][centipedegrass][perennial ryegrass][zoysiagrass]<Insert grass species>** to a height of **1 to 2 inches (25 to 50 mm)**.
 4. Mow **[Kentucky bluegrass][buffalograss][annual ryegrass][chewings red fescue]<Insert grass species>** to a height of **1-1/2 to 2 inches (38 to 50 mm)**.
 5. Mow **[bahiaagrass][turf-type tall fescue][St. Augustinegrass]<Insert grass species>** to a height of **2 to 3 inches (50 to 75 mm)**.
- D. Turf Postfertilization: Apply **[commercial fertilizer][slow-release fertilizer]<Insert type>** after initial mowing and when grass is dry.
1. Use fertilizer that provides actual nitrogen of at least **[1 lb/1000 sq. ft. (0.45 kg/92.9 sq. m)]<Insert value>** to turf area.

3.13 SATISFACTORY TURF

- A. Turf installations shall meet the following criteria as determined by Architect:
1. Satisfactory Seeded Turf: At end of maintenance period, a healthy, uniform, close stand of grass has been established, free of weeds and surface irregularities, with coverage exceeding **[90 percent over any 10 sq. ft. (0.92 sq. m) and bare spots not exceeding 5 by 5 inches (125 by 125 mm)]<Insert coverage>**.
 2. Satisfactory Sodded Turf: At end of maintenance period, a healthy, well-rooted, even-colored, viable turf has been established, free of weeds, open joints, bare areas, and surface irregularities.
 3. Satisfactory Plugged Turf: At end of maintenance period, the required number of plugs has been established as well-rooted, viable patches of grass, and areas between plugs are free of weeds and other undesirable vegetation.
 4. Satisfactory Sprigged Turf: At end of maintenance period, the required number of sprigs has been established as well-rooted, viable plants, and areas between sprigs are free of weeds and other undesirable vegetation.
- B. Use specified materials to reestablish turf that does not comply with requirements, and continue maintenance until turf is satisfactory.

3.14 MEADOW

- A. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds **5 mph (8 km/h)**.
1. Before sowing, mix seed with seed carrier at a ratio of not less than **[two][three][four]<Insert number>** parts seed carrier to one part seed.
 2. Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.
 3. Do not use wet seed or seed that is moldy or otherwise damaged.
- B. Sow seed at a total rate of **[4 oz./1000 sq. ft. (113 g/92.9 sq. m)][5 oz./1000 sq. ft. (142 g/92.9 sq. m)][6 oz./1000 sq. ft. (170 g/92.9 sq. m)]<Insert values>**.
- C. Brush seed into top **1/16 inch (1.6 mm)** of soil, roll lightly, and water with fine spray.
- D. Protect seeded areas from hot, dry weather or drying winds by applying **[peat][or][compost]** mulch within 24 hours after completing seeding operations. Soak areas, scatter mulch uniformly to a thickness of **3/16 inch (4.8 mm)**, and roll surface smooth.

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- E. Water newly planted areas and keep moist until meadow is established.

3.15 MEADOW MAINTENANCE

- A. Maintain and establish meadow by watering, weeding, mowing, trimming, replanting, and performing other operations as required to establish a healthy, viable meadow. Roll, regrade, and replant bare or eroded areas and mulch. Provide materials and installation the same as those used in the original installation.
 - 1. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace materials and meadow damaged or lost in areas of subsidence.
 - 2. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.
 - 3. Apply treatments as required to keep meadow and soil free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards.
- B. Watering: Install and maintain temporary piping, hoses, and meadow-watering equipment to convey water from sources and to keep meadow uniformly moist.
 - 1. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
 - 2. Water meadow with fine spray at a minimum rate of **1/2 inch (13 mm)** per week for **[four][six][eight]** weeks after planting unless rainfall precipitation is adequate.
- C. **<Insert requirements>**.

3.16 PESTICIDE APPLICATION

- A. Apply pesticides and other chemical products and biological control agents according to requirements of authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.
- B. Post-Emergent Herbicides (Selective and Nonselective): Apply only as necessary to treat already-germinated weeds and according to manufacturer's written recommendations.

3.17 CLEANUP AND PROTECTION

- A. Promptly remove soil and debris created by turf work from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.
- B. Remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash, and debris, and legally dispose of them off Owner's property.
- C. Erect temporary fencing or barricades and warning signs as required to protect newly planted areas from traffic. Maintain fencing and barricades throughout initial maintenance period and remove after plantings are established.
- D. Remove nondegradable erosion-control measures after grass establishment period.

3.18 MAINTENANCE SERVICE

- A. Turf Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in "Turf Maintenance" Article. Begin maintenance immediately after each area is planted and continue until acceptable turf is established, but for not less than the following periods:
1. Seeded Turf: **[60]<Insert number>** days from date of **[planting completion][Substantial Completion]<Insert starting time>**.
 - a. When initial maintenance period has not elapsed before end of planting season, or if turf is not fully established, continue maintenance during next planting season.
 2. Sodded Turf: **[30]<Insert number>** days from date of **[planting completion][Substantial Completion]<Insert starting time>**.
 3. Plugged Turf: **[30]<Insert number>** days from date of **[planting completion][Substantial Completion]<Insert starting time>**.
 4. Sprigged Turf: **[30]<Insert number>** days from date of **[planting completion][Substantial Completion]<Insert starting time>**.
- B. Meadow Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in "Meadow Maintenance" Article. Begin maintenance immediately after each area is planted and continue until acceptable meadow is established, but for not less than maintenance period below.
1. Maintenance Period: **[40]<Insert number>** days from date of **[planting completion][Substantial Completion]<Insert starting time>**.

END OF SECTION 32 92 00 00



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Task	Specification	Specification Description
32 92 16 00	32 92 00 00	Turf and Grasses
32 92 19 00	32 92 00 00	Turf and Grasses
32 92 19 13	32 92 00 00	Turf and Grasses
32 92 19 19	32 92 00 00	Turf and Grasses
32 92 23 00	32 92 00 00	Turf and Grasses



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SECTION 32 93 00 00 - PLANTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Plant materials.
2. Fertilizers.
3. Weed-control barriers.
4. Mulches.
5. Herbicides and pesticides.
6. Tree-stabilization materials.
7. Landscape edgings.
8. Tree grates.
9. Tree-watering devices.

B. Related Requirements:

1. Section 015639 "Temporary Tree and Plant Protection" for protecting, trimming, pruning, repairing, and replacing existing trees to remain that interfere with, or are affected by, execution of the Work.
2. Section 129200 "Interior Planters and Artificial Plants" for planters for live and artificial interior plants.
3. Section 328400 "Planting Irrigation" for complete irrigation systems.
4. Section 329200 "Turf and Grasses" for turf (lawn) and meadow planting, hydroseeding, and erosion-control materials.
5. Section 329600 "Transplanting" for transplanting non-nursery-grown trees.

1.2 ALLOWANCES

- A.** See Section 012100 "Allowances" for description of allowances affecting items specified in this Section.

1.3 UNIT PRICES

- A.** See Section 012200 "Unit Prices" for description of unit prices affecting items specified in this Section.

1.4 COORDINATION

- A.** Coordination with Turf Areas (Lawns): Plant trees, shrubs, and other plants after finish grades are established and before planting turf areas unless otherwise indicated.
1. When planting trees, shrubs, and other plants after planting turf areas, protect turf areas, and promptly repair damage caused by planting operations.

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1.5 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at **[Project site]<Insert location>**.

1.6 ACTION SUBMITTALS

- A. Product Data:

1. Plant materials.
2. Fertilizers.
3. Weed-control barriers.
4. Mulches.
5. Herbicides and pesticides.
6. Tree-stabilization materials.
7. Landscape edgings.
8. Tree grates.
9. Tree-watering devices.

- B. Product Data Submittals: For each product.

1. Plant Materials: Include quantities, sizes, quality, and verified sources for plant materials.

- C. Samples for Verification: Actual sample of finished products for each of the following:

1. Organic Mulch: **[1-pint (0.5-L)][1-quart (1-L)]<Insert value>** volume of each organic mulch required; typical of the lot of material to be furnished, in sealed plastic bags labeled with composition of materials by percentage of weight and source of mulch. Provide an accurate representation of color, texture, and organic makeup.
2. Mineral Mulch: **[2 lb (1.0 kg)][5 lb (2.5 kg)]<Insert value>** of each mineral mulch required; typical of the lot of material to be furnished, in sealed plastic bags labeled with source of mulch. Provide accurate indication of color, texture, and makeup.
3. Weed-Control Barrier: **12 by 12 inches (300 by 300 mm)**.
4. Proprietary Root-Ball-Stabilization Device: One unit.
5. Slow-Release, Tree-Watering Device: One unit of each size required.
6. Edging Materials and Accessories: Manufacturer's standard size, to verify color selected.
7. Root Barrier: Width of panel by **12 inches (300 mm)**.

1.7 INFORMATIONAL SUBMITTALS

- A. Field Quality-Control Reports: Percolation tests for tree pits. Include the following:

1. Tree identification number matching the plans.
2. Date of test.
3. Time when water was added to tree pit to start percolation test.
4. Time with photo documentation showing increments of testing with water level in tree pit.
5. Identification of tester.

- B. Qualification Statements: For landscape Installer. Include list of similar projects completed by Installer demonstrating Installer's capabilities and experience. Include project names, addresses, and year completed, and include names and addresses of owners' contact persons.

- C. Product Certificates: For each type of manufactured product, from manufacturer, and complying with manufacturer's certified analysis of standard products.

- D. Pesticides and Herbicides: Product label and manufacturer's written application instructions specific to Project.
- E. Sample Warranty: For special warranty.

1.8 CLOSEOUT SUBMITTALS

- A. Maintenance Data: Recommended procedures to be established by Owner for maintenance of plants during a calendar year. Submit before expiration of required maintenance periods.

1.9 QUALITY ASSURANCE

- A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful establishment of plants.
 - 1. Professional Membership: Member in good standing of either the National Association of Landscape Professionals or AmericanHort.
 - 2. Experience: **[Three][Five]<Insert number>** years' experience in landscape installation in addition to requirements in Section 014000 "Quality Requirements."
 - 3. Installer's Field Supervision: Maintain an experienced full-time supervisor on Project site when work is in progress.
 - 4. Personnel Certification: Installer's **[field supervisor][personnel assigned to the Work]** certified in **[one][all]** of the following categories from the National Association of Landscape Professionals:
 - a. Landscape Industry Certified Technician - Exterior.
 - b. Landscape Industry Certified Interior.
 - c. Landscape Industry Certified Horticultural Technician.
 - 5. Pesticide Applicator: State licensed, commercial.
- B. Provide quality, size, genus, species, and variety of plants indicated, complying with applicable requirements in ANSI Z60.1.
 - 1. Selection of plants purchased under allowances is made by Architect, who tags plants at their place of growth before they are prepared for transplanting.
- C. Measurements: Measure in accordance with ANSI Z60.1. Do not prune to obtain required sizes.
 - 1. Trees and Shrubs: Measure with branches and trunks or canes in their normal position. Take height measurements from or near the top of the root flare for field-grown stock and container-grown stock. Measure main body of tree or shrub for height and spread; do not measure branches or roots tip to tip. Take caliper measurements **6 inches (150 mm)** above the root flare for trees up to **4-inch (100-mm)** caliper size, and **12 inches (300 mm)** above the root flare for larger sizes.
 - 2. Other Plants: Measure with stems, petioles, and foliage in their normal position.
- D. Plant Material Observation: Architect may observe plant material either at place of growth or at site before planting for compliance with requirements for genus, species, variety, cultivar, size, and quality. Architect may also observe trees and shrubs further for size and condition of balls and root systems, pests, disease symptoms, injuries, and latent defects and may reject unsatisfactory or defective material at any time during progress of work. Remove rejected trees or shrubs immediately from Project site.
 - 1. Notify Architect of sources of planting materials **[seven]<Insert number>** days in advance of delivery to site.

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1.10 DELIVERY, STORAGE, AND HANDLING

- A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of compliance with state and Federal laws if applicable.
- B. Bulk Materials:
 - 1. Do not dump or store bulk materials near structures, utilities, or walkways and pavements; or on existing turf areas or plants.
 - 2. Provide erosion-control measures to prevent erosion or displacement of bulk materials; discharge of soil-bearing water runoff; and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
 - 3. Accompany each delivery of bulk materials with appropriate certificates.
- C. Deliver bare-root stock plants within **[24 hours][36 hours]<Insert time>** of digging. Immediately after digging up bare-root stock, pack root system in wet straw, hay, or other suitable material to keep root system moist until planting. Transport in covered, temperature-controlled vehicles, and keep plants cool and protected from sun and wind at all times.
- D. Do not prune trees and shrubs before delivery. Protect bark, branches, and root systems from sun scald, drying, wind burn, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy their natural shape. Provide protective covering of plants during shipping and delivery. Do not drop plants during delivery and handling.
- E. Handle planting stock by root ball.
- F. Store bulbs, corms, and tubers in a dry place at **60 to 65 deg F (16 to 18 deg C)** until planting.
- G. Apply antidesiccant to trees and shrubs using power spray to provide an adequate film over trunks (before wrapping), branches, stems, twigs, and foliage to protect during digging, handling, and transportation.
 - 1. If deciduous trees or shrubs are moved in full leaf, spray with antidesiccant at nursery before moving and again two weeks after planting.
- H. Wrap trees and shrubs with burlap fabric over trunks, branches, stems, twigs, and foliage to protect from wind and other damage during digging, handling, and transportation.
- I. Deliver plants after preparations for planting have been completed, and install immediately. If planting is delayed more than six hours after delivery, set plants and trees in their appropriate aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist.
 - 1. Heel-in bare-root stock. Soak roots that are in less than moist condition in water for two hours. Reject plants with dry roots.
 - 2. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.
 - 3. Do not remove container-grown stock from containers before time of planting.
 - 4. Water root systems of plants stored on-site deeply and thoroughly with a fine-mist spray. Water as often as necessary to maintain root systems in a moist, but not overly wet condition.

1.11 FIELD CONDITIONS

- A. Field Measurements: Verify actual grade elevations, service and utility locations, irrigation system

components, and dimensions of plantings and construction contiguous with new plantings by field measurements before proceeding with planting work.

- B. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with maintenance periods to provide required maintenance from date of Substantial Completion.
 - 1. Spring Planting: **<Insert dates>**.
 - 2. Fall Planting: **<Insert dates>**.
- C. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions in accordance with manufacturer's written instructions and warranty requirements.

1.12 WARRANTY

- A. Special Warranty: Installer agrees to repair or replace plantings and accessories that fail in materials, workmanship, or growth within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Death and unsatisfactory growth, except for defects resulting from abuse, lack of adequate maintenance, or neglect by Owner.
 - b. Structural failures, including plantings falling or blowing over.
 - c. Faulty performance of **[tree stabilization][edgings][and][tree grates]<Insert item>**.
 - d. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
 - 2. Warranty Periods: From date of **[planting completion][Substantial Completion]<Insert starting time>**.
 - a. Trees, Shrubs, Vines, and Ornamental Grasses: **[12]<Insert number>** months.
 - b. Ground Covers, Biennials, Perennials, and Other Plants: **[12][Nine][Six][Three]<Insert number>** months.
 - c. Annuals: **[Three][Two]<Insert number>** months.
 - 3. Include the following remedial actions as a minimum:
 - a. Immediately remove dead plants and replace unless required to plant in the succeeding planting season.
 - b. Replace plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.
 - c. A limit of one replacement of each plant is required except for losses or replacements due to failure to comply with requirements.
 - d. Provide extended warranty for period equal to original warranty period, for replaced plant material.

PART 2 - PRODUCTS

2.1 PLANT MATERIALS

- A. General: Furnish nursery-grown plants true to genus, species, variety, cultivar, stem form, shearing, and other features indicated in Plant List, Plant Schedule, or Plant Legend indicated on Drawings and

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complying with ANSI Z60.1; and with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock, densely foliated when in leaf and free of disease, pests, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.

1. Trees with damaged, crooked, or multiple leaders; with tight vertical branches where bark is squeezed between two branches or between branch and trunk ("included bark"); with crossing trunks; with cut-off limbs more than **3/4 inch (19 mm)** in diameter; or with stem girdling roots are unacceptable.
 2. Collected Stock: Do not use plants harvested from the wild, from native stands, from an established landscape planting, or not grown in a nursery unless otherwise indicated.
- B. Provide plants of sizes, grades, and ball or container sizes complying with ANSI Z60.1 for types and form of plants required. Plants of a larger size may be used if acceptable to Architect, with a proportionate increase in size of roots or balls.
- C. Root-Ball Depth: Furnish trees and shrubs with root balls measured from top of root ball, which begins at root flare in accordance with ANSI Z60.1.
- D. Labeling: Label **[each][at least one]** plant of each variety, size, and caliper with a securely attached, waterproof tag bearing legible designation of common name and full scientific name, including genus and species. Include nomenclature for hybrid, variety, or cultivar, if applicable for plant.
- E. If formal arrangements or consecutive order of plants is indicated on Drawings, select stock for uniform height and spread, and number the labels to ensure symmetry in planting.
- F. Annuals and Biennials: Provide healthy, disease-free plants of species and variety shown or listed, with well-established root systems reaching to sides of the container to maintain a firm ball, but not with excessive root growth encircling the container. Provide only plants that are acclimated to outdoor conditions before delivery **[and that are in bud but are not yet in bloom]**.
- G. **<Insert requirements>**.

2.2 FERTILIZERS

- A. Granular Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:
1. Composition:
 - a. **[0.75 lb/1000 sq. ft. (0.34 kg/92.9 sq. m),]**3 percent of actual nitrogen, 4 percent phosphorous, and 3 percent potassium, by weight.
 - b. Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.
- B. Mycorrhizal Fungi: Dry, granular inoculant containing at least 5300 spores per **lb (0.45 kg)** of vesicular-arbuscular mycorrhizal fungi and 95 million spores per **lb (0.45 kg)** of ectomycorrhizal fungi, 33 percent hydrogel, and maximum of 5.5 percent inert material.

2.3 WEED-CONTROL BARRIERS

- A. Nonwoven Geotextile Filter Fabric: Polypropylene or polyester fabric, **3 oz./sq. yd. (101 g/sq. m)** minimum, composed of fibers inert to biological degradation and naturally resistant to chemicals, alkalis, and acids, formed into a stable network so that fibers retain their relative position.
- B. Composite Fabric: Woven, needle-punched polypropylene substrate bonded to a nonwoven polypropylene fabric, **4.8 oz./sq. yd. (162 g/sq. m)**.

2.4 MULCHES

- A. Organic Mulch: Free from deleterious materials and suitable as a top dressing of trees and shrubs, consisting of one of the following:
 - 1. Type: **[Shredded hardwood][Ground or shredded bark][Wood and bark chips][Pine straw][Salt hay or threshed straw][Pine needles][Peanut, pecan, and cocoa-bean shells]<Insert type>**.
 - 2. Size Range: **[3 inches (76 mm) maximum, 1/2 inch (13 mm) minimum]<Insert dimensions>**.
 - 3. Color: Natural.
- B. Compost Mulch: Well-composted, stable, and weed-free organic matter, pH of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through a **1-inch (25-mm)** sieve; soluble-salt content of **[2 to 5]<Insert range or value>** dS/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:
 - 1. Organic Matter Content: **[50 to 60]<Insert number range>** percent of dry weight.
 - 2. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.
- C. Mineral Mulch: Hard, durable stone, washed free of loam, sand, clay, and other foreign substances, of the following type, size range, and color:
 - 1. Type: **[Rounded riverbed gravel or smooth-faced stone][Crushed stone or gravel][Marble chips][Granite chips]<Insert type>**.
 - 2. Size Range: **[1-1/2 inches (38 mm) maximum, 3/4 inch (19 mm) minimum][3/4 inch (19 mm) maximum, 1/4 inch (6.4 mm) minimum]<Insert dimensions>**.
 - 3. Color: **[Uniform tan-beige color range acceptable to Architect][Readily available natural gravel color range]<Insert color>**.

2.5 HERBICIDES AND PESTICIDES

- A. Pre-Emergent Herbicide (Selective and Nonselective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.
- B. Post-Emergent Herbicide (Selective and Nonselective): Effective for controlling weed growth that has already germinated.
- C. Pesticides: Registered and approved by the EPA, acceptable to authorities having jurisdiction, and of type recommended in writing by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

2.6 TREE-STABILIZATION MATERIALS

A. Trunk-Stabilization Materials:

1. Upright and Guy Stakes: Rough-sawn, sound, new **[hardwood][softwood with specified wood pressure-preservative treatment]**, free of knots, holes, cross grain, and other defects, **2-by-2-inch nominal (38-by-38-mm actual)** by length indicated, pointed at one end.
2. Wood Deadmen: Timbers measuring **8 inches (200 mm)** in diameter and **48 inches (1200 mm)** long, treated with specified wood pressure-preservative treatment.
3. Flexible Ties: Wide rubber or elastic bands or straps of length required to reach stakes or **[turnbuckles][compression springs]**.
4. Guys and Tie Wires: ASTM A641/A641M, Class 1, galvanized-steel wire, two-strand, twisted, **0.106 inch (2.7 mm)** in diameter.
5. Tree-Tie Webbing: UV-resistant polypropylene or nylon webbing with brass grommets.
6. Guy Cables: Five-strand, **3/16-inch- (4.8-mm-)** diameter, galvanized-steel cable, with zinc-coated **[turnbuckles][compression springs]**, a minimum of **3 inches (75 mm)** long, with two **3/8-inch (10-mm)** galvanized eyebolts.
7. Flags: Standard surveyor's plastic flagging tape, white, **6 inches (150 mm)** long.
8. Proprietary Staking-and-Guying Devices: Proprietary stake or anchor and adjustable tie systems to secure each new planting by plant stem; sized as indicated and in accordance with manufacturer's written instructions.

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

- 1) **[Arborbrace]**
- 2) **[Better Bilt Products, Inc.]**
- 3) **[DeepRoot Green Infrastructure, LLC]**
- 4) **[J. R. Partners]**
- 5) **[MacLean Power Systems]**
- 6) **[Villa Root Barrier; Villa Landscape Products]**
- 7) **<Insert manufacturer's name>**

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

- 1) **[Arborbrace]**
- 2) **[Better Bilt Products, Inc.]**
- 3) **[DeepRoot Green Infrastructure, LLC]**
- 4) **[J. R. Partners]**
- 5) **[MacLean Power Systems]**
- 6) **[Villa Root Barrier; Villa Landscape Products]**
- 7) **<Insert manufacturer's name>**

B. Root-Ball Stabilization Materials:

1. Upright Stakes and Horizontal Hold-Down: Rough-sawn, sound, new hardwood or softwood, free of knots, holes, cross grain, and other defects, **2-by-2-inch nominal (38-by-38-mm actual)** by length indicated; stakes pointed at one end.
2. Wood Screws: ASME B18.6.1.
3. Proprietary Root-Ball Stabilization Devices: Proprietary at- or below-grade stabilization systems to secure each new planting by root ball and that do not encircle the trunk; sized in accordance with

manufacturer's written instructions unless otherwise indicated.

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

- 1) **[Border Concepts, Inc]**
- 2) **[MacLean Power Systems]**
- 3) **[Tree Staple, Inc.]**
- 4) **<Insert manufacturer's name>**

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

- 1) **[Border Concepts, Inc]**
- 2) **[MacLean Power Systems]**
- 3) **[Tree Staple, Inc.]**
- 4) **<Insert manufacturer's name>**

C. Palm Bracing: Battens or blocks, struts, straps, and protective padding.

1. Battens or Blocks and Struts: Rough-sawn, sound, new hardwood or softwood, free of knots, holes, cross grain, and other defects, **2-by-4-inch nominal (38-by-89-mm actual)** by lengths indicated.
2. Straps: Adjustable steel or plastic package banding.
3. Padding: Burlap.
4. Proprietary Palm-Bracing Devices: Proprietary systems to secure each new planting by trunk; sized in accordance with manufacturer's written instructions unless otherwise indicated.

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

- 1) **[Arborbrace]**
- 2) **[Better Bilt Products, Inc.]**
- 3) **[Horticultural Consultants, Inc.]**
- 4) **[Villa Root Barrier; Villa Landscape Products]**
- 5) **<Insert manufacturer's name>**

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

- 1) **[Arborbrace]**
- 2) **[Better Bilt Products, Inc.]**
- 3) **[Horticultural Consultants, Inc.]**
- 4) **[Villa Root Barrier; Villa Landscape Products]**
- 5) **<Insert manufacturer's name>**

2.7 LANDSCAPE EDGINGS

- A. Wood Edging: Of sizes indicated on Drawings, and wood stakes as follows:



1. Species: **[Western red cedar, all heart][Southern pine with specified wood pressure-preservative treatment]**.
 2. Stakes: Same species as edging, **1-by-2-inch nominal (19-by-38-mm actual)** by 18 inches (450 mm) long, with galvanized nails for anchoring edging.
- B. Steel Edging: Standard commercial-steel edging, fabricated in sections of standard lengths, with loops stamped from or welded to face of sections to receive stakes.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Border Concepts, Inc]**
 - b. **[COLMET]**
 - c. **[J. D. Russell Company (The)]**
 - d. **[Sure-loc Edging Corporation.]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Border Concepts, Inc]**
 - b. **[COLMET]**
 - c. **[J. D. Russell Company (The)]**
 - d. **[Sure-loc Edging Corporation.]**
 - e. **<Insert manufacturer's name>**
 3. Edging Size: **[3/16 inch (4.8 mm) thick by 4 inches (100 mm) deep][1/4 inch (6.4 mm) thick by 5 inches (125 mm) deep][1/4 inch (6.4 mm) thick by 4 inches (100 mm) deep][1/8 inch (3.2 mm) thick by 4 inches (100 mm) deep][1/8 inch (3.2 mm) thick by 6 inches (150 mm) deep][0.1 inch (2.5 mm) thick by 4 inches (100 mm) deep]<Insert dimensions>**.
 4. Stakes: Tapered steel, a minimum of **[12 inches (300 mm)][15 inches (380 mm)]<Insert dimension>** long.
 5. Accessories: Standard tapered ends, corners, and splicers.
 6. Finish: **[Manufacturer's standard paint][Zinc coated][Unfinished]**.
 - a. Paint Color: **[Black][Green][Brown]**.
- C. Aluminum Edging: Standard-profile extruded-aluminum edging, **ASTM B221 (ASTM B221M)**, Alloy 6063-T6, fabricated in standard lengths with interlocking sections with loops stamped from face of sections to receive stakes.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Curv-Rite, Inc]**
 - b. **[J. D. Russell Company (The)]**
 - c. **[Permaloc Corporation]**
 - d. **[Sure-loc Edging Corporation.]**
 - e. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Curv-Rite, Inc]**
 - b. **[J. D. Russell Company (The)]**
 - c. **[Permaloc Corporation]**
 - d. **[Sure-loc Edging Corporation.]**
 - e. **<Insert manufacturer's name>**
 3. Edging Size: **[3/16 inch (4.8 mm) thick by 5-1/2 inches (140 mm) deep][3/16 inch (4.8 mm) thick by 4 inches (100 mm) deep][1/8 inch (3.2 mm) thick by 5-1/2 inches (140 mm) deep][1/8 inch (3.2 mm) thick by 4 inches (100 mm) deep]<Insert dimensions>**.
 4. Stakes: Aluminum, **ASTM B221 (ASTM B221M)**, Alloy 6061-T6, approximately **1-1/2 inches (38 mm)** wide by **12 inches (300 mm)** long.
 5. Finish: **[Manufacturer's standard paint][Powder-coat paint][Mill (natural aluminum)][Black anodized]**.
 - a. Paint Color: **[Black][Green][Brown]**.
- D. Plastic Edging: Standard black polyethylene or vinyl edging, **[V-lipped bottom][horizontally grooved]<Insert configuration>**, extruded in standard lengths, with **9-inch (225-mm) [steel angle][plastic]** stakes.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Oly-Ola Edgings, Inc.]**
 - b. **[Permaloc Corporation]**
 - c. **[Sure-loc Edging Corporation.]**
 - d. **[Valley View Industries]**
 - e. **[Villa Root Barrier; Villa Landscape Products]**
 - f. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Oly-Ola Edgings, Inc.]**
 - b. **[Permaloc Corporation]**
 - c. **[Sure-loc Edging Corporation.]**
 - d. **[Valley View Industries]**
 - e. **[Villa Root Barrier; Villa Landscape Products]**
 - f. **<Insert manufacturer's name>**
 3. Edging Size: **[0.1 inch (2.5 mm) thick by 5 inches (125 mm) deep][0.07 inch (1.8 mm) thick by 5 inches (125 mm) deep]<Insert dimensions>**.
 4. Top Profile: **[Straight, with top 2 inches (50 mm) being 1/4 inch (6.4 mm) thick][Round top, 1/2 inch (13 mm) in diameter][Round top, 1 inch (25 mm) in diameter]**.
 5. Accessories: Manufacturer's standard alignment clips or plugs.

2.8 TREE GRATES

- A. Tree Grates: Manufacturer's **[standard][custom designed]** tree grates **[and frames]**.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Barry Pattern & Foundry Co., Inc]**
 - b. **[EJ Group, Inc.]**
 - c. **[Ironsmith Inc.]**
 - d. **[Neenah Foundry Company]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Barry Pattern & Foundry Co., Inc]**
 - b. **[EJ Group, Inc.]**
 - c. **[Ironsmith Inc.]**
 - d. **[Neenah Foundry Company]**
 - e. **<Insert manufacturer's name>**
 3. Grates: ASTM A48/A48M, **Class 35 (Class 250)** or better, gray-iron castings.
 4. Frames: **[ASTM A48/A48M, Class 35 (Class 250) or better, gray-iron castings][or][ASTM A36/A36M steel-angle, hot-dip galvanized,]** of shape, pattern, and size indicated.
- B. Shape and Size: **[As indicated on Drawings][Round, 36 inches (914 mm) in diameter][Round, 72 inches (1828 mm) in diameter][48 inches (1219 mm) square][60 inches (1524 mm) square][Rectangular, 36 by 60 inches (914 by 1524 mm)][Rectangular, 48 by 72 inches (1219 by 1828 mm)]<Insert shape and dimensions>**.
- C. Finish: **[As fabricated][Powder-coat finish]<Insert finish>**.
1. Color: Low-gloss **[black][dark brown][dark green][dark gray]<Insert color>**.

2.9 TREE-WATERING DEVICES

- A. Watering Pipe: PVC pipe **4 inches (100 mm)** in diameter, site-cut to length as required, and with snug-fitting removable cap.
- B. Slow-Release Watering Device: Standard product manufactured for drip irrigation of plants and emptying its water contents over **[an extended time period][two to nine hours][two to three weeks]<Insert number or range>**; manufactured from UV-light-stabilized nylon-reinforced polyethylene sheet, PVC, or HDPE plastic.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[BIO-PLEX]**

- b. [Engineered Watering Solutions; PQ Partners, LLC]
 - c. [Spectrum Products, Inc.]
 - d. <Insert manufacturer's name>
- 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [BIO-PLEX]
 - b. [Engineered Watering Solutions; PQ Partners, LLC]
 - c. [Spectrum Products, Inc.]
 - d. <Insert manufacturer's name>
- 3. Color: [As selected by Architect from manufacturer's full range][black][dark chocolate][green][or][tan]<Insert color>.

2.10 MISCELLANEOUS PRODUCTS

- A. Root Barrier: Black, molded, modular panels [18 inches (457 mm)][24 inches (610 mm)]<Insert dimension> high (deep), 85 mils (2.2 mm) thick, and with vertical root deflecting ribs protruding 3/4 inch (19 mm) out from panel surface; manufactured with minimum 50 percent recycled polyethylene plastic with UV inhibitors.
 - 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [DeepRoot Green Infrastructure, LLC]
 - b. [NDS Inc]
 - c. [Villa Root Barrier; Villa Landscape Products]
 - d. <Insert manufacturer's name>
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [DeepRoot Green Infrastructure, LLC]
 - b. [NDS Inc]
 - c. [Villa Root Barrier; Villa Landscape Products]
 - d. <Insert manufacturer's name>
- B. Antidesiccant: Water-insoluble emulsion, permeable moisture retarder, film forming, for trees and shrubs. Deliver in original, sealed, and fully labeled containers and mix in accordance with manufacturer's written instructions.
- C. Planter Drainage Gravel: Washed, sound crushed stone or gravel complying with [ASTM D448 for Size No. 8]<Insert requirements>.
- D. Planter Filter Fabric: [Woven][Nonwoven] geotextile manufactured for separation applications and made of polypropylene, polyolefin, or polyester fibers or combination of them.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive plants, with Installer present, for compliance with requirements and conditions affecting installation and performance of the Work.
 - 1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
 - 2. Verify that plants and vehicles loaded with plants can travel to planting locations with adequate overhead clearance.
 - 3. Suspend planting operations during periods of excessive soil moisture until moisture content reaches acceptable levels to attain required results.
 - 4. Uniformly moisten excessively dry soil that is not workable or which is dusty.
- B. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove soil and contamination as directed by Architect and replace with new planting soil.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities and turf areas and existing plants from damage caused by planting operations.
- B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.
- C. Lay out individual tree and shrub locations and areas for multiple plantings. Stake locations, outline areas, adjust locations when requested, and obtain Architect's acceptance of layout before excavating or planting. Make minor adjustments as required.
- D. Lay out plants at locations directed by Architect. Stake locations of individual trees and shrubs and outline areas for multiple plantings.

3.3 PLANTING AREA ESTABLISHMENT

- A. General: Prepare planting area for soil placement and mix planting soil in accordance with **[Section 329113 "Soil Preparation."][Section 329115 "Soil Preparation (Performance Specification)."]**
- B. Placing Planting Soil: **[Place and mix planting soil in-place over exposed subgrade][Place manufactured planting soil over exposed subgrade][Blend planting soil in place]<Insert requirement>**.
- C. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.
- D. Application of Mycorrhizal Fungi: At time directed by Architect, broadcast dry product uniformly over prepared soil at application rate **[indicated on Drawings][in accordance with manufacturer's written instructions]<Insert application rate>**.

3.4 EXCAVATION FOR TREES AND SHRUBS

- A. Planting Pits and Trenches: Excavate circular planting pits.
 - 1. Excavate planting pits with sides sloping inward at a 45-degree angle. Excavations with vertical sides are unacceptable. Trim perimeter of bottom leaving center area of bottom raised slightly to support root ball and assist in drainage away from center. Do not further disturb base. Ensure that root ball will sit on undisturbed base soil to prevent settling. Scarify sides of planting pit smeared or smoothed during excavation.
 - 2. Excavate approximately three times as wide as ball diameter for **[balled and burlapped][balled and potted][container-grown][fabric bag-grown]** stock.
 - 3. Excavate at least **12 inches (300 mm)** wider than root spread and deep enough to accommodate vertical roots for bare-root stock.
 - 4. Do not excavate deeper than depth of root ball, measured from the root flare to the bottom of root ball.
 - 5. If area under the plant was initially dug too deep, add soil to raise it to correct level and thoroughly tamp the added soil to prevent settling.
 - 6. Maintain angles of repose of adjacent materials to ensure stability. Do not excavate subgrades of adjacent paving, structures, hardscapes, or other new or existing improvements.
 - 7. Maintain supervision of excavations during working hours.
 - 8. Keep excavations covered or otherwise protected **[overnight][after working hours][when unattended by Installer's personnel]**.
 - 9. If drain tile is indicated on Drawings or required under planting areas, excavate to top of porous backfill over tile.
- B. Backfill Soil: Subsoil and topsoil removed from excavations may **[not]** be used as backfill soil unless otherwise indicated.
- C. Obstructions: Notify Architect if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.
 - 1. Hardpan Layer: Drill **6-inch- (150-mm-)** diameter holes, **24 inches (600 mm)** apart, into free-draining strata or to depth of **10 ft. (3 m)**, whichever is less, and backfill with free-draining material.
- D. Drainage: Notify Architect if subsoil conditions evidence unexpected water seepage or retention in tree or shrub planting pits.
- E. Fill excavations with water and allow to percolate away before positioning trees and shrubs.

3.5 TREE, SHRUB, AND VINE PLANTING

- A. Inspection: At time of planting, verify that root flare is visible at top of root ball in accordance with ANSI Z60.1. If root flare is not visible, remove soil in a level manner from root ball to where the top-most root emerges from the trunk. After soil removal to expose root flare, verify that root ball still meets size requirements.
- B. Roots: Remove stem girdling roots and kinked roots. Remove injured roots by cutting cleanly; do not break.
- C. Balled and Burlapped Stock: Set each plant plumb and in center of planting pit or trench with root flare **[1 inch (25 mm) above][2 inches (50 mm) above]<Insert requirement>** adjacent finish grades.
 - 1. Backfill: Planting soil .**[For trees, use excavated soil for backfill.]**
 - 2. After placing some backfill around root ball to stabilize plant, carefully cut and remove burlap,

rope, and wire baskets from tops of root balls and from sides, but do not remove from under root balls. Remove pallets, if any, before setting. Do not use planting stock if root ball is cracked or broken before or during planting operation.

3. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
4. Distribute granular fertilizer around each planting pit when pit is approximately one-half filled. Do not place in bottom of the hole.

- a. Quantity: **[As indicated on Drawings][Two per plant][Three for each caliper inch of plant]<Insert requirement>**.

5. Continue backfilling process. Water again after placing and tamping final layer of soil.

- D. **[Balled and Potted][and][Container-Grown]** Stock: Set each plant plumb and in center of planting pit or trench with root flare **[1 inch (25 mm) above][2 inches (50 mm) above]<Insert requirement>** adjacent finish grades.

1. Backfill: Planting soil .**[For trees, use excavated soil for backfill.]**
2. Carefully remove root ball from container without damaging root ball or plant.
3. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
4. Distribute granular fertilizer around each planting pit when pit is approximately one-half filled. Do not place in bottom of the hole.
5. Continue backfilling process. Water again after placing and tamping final layer of soil.

- E. Fabric Bag-Grown Stock: Set each plant plumb and in center of planting pit or trench with root flare **[1 inch (25 mm) above][2 inches (50 mm) above]<Insert requirement>** adjacent finish grades.

1. Backfill: Planting soil .**[For trees, use excavated soil for backfill.]**
2. Carefully remove root ball from fabric bag without damaging root ball or plant. Do not use planting stock if root ball is cracked or broken before or during planting operation.
3. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
4. Distribute granular fertilizer around each planting pit when pit is approximately one-half filled. Do not place in bottom of the hole.
5. Continue backfilling process. Water again after placing and tamping final layer of soil.

- F. Bare-Root Stock: Set and support each plant in center of planting pit or trench with root flare **[1 inch (25 mm) above][2 inches (50 mm) above]<Insert requirement>** adjacent finish grade.

1. Backfill: Planting soil .**[For trees, use excavated soil for backfill.]**
2. Spread roots without tangling or turning toward surface. Plumb before backfilling, and maintain plumb while working.
3. Carefully work backfill in layers around roots by hand. Bring roots into close contact with the soil.
4. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
5. Distribute granular fertilizer around each planting pit when pit is approximately one-half filled. Do not place in bottom of the hole or touching the roots.
6. Continue backfilling process. Water again after placing and tamping final layer of soil.

- G. Watering Pipe: During backfilling, install watering pipe **4 ft. (1.25 m)** deep into the planting pit outside the root ball **[as indicated on Drawings][and][with top of pipe 1 inch (25 mm) above the mulched**

surface].

- H. Slopes: When planting on slopes, set the plant so the root flare on the uphill side is flush with the surrounding soil on the slope; the edge of root ball on the downhill side will be above the surrounding soil. Apply enough soil to cover the downhill side of root ball.

3.6 MECHANIZED TREE-SPADE PLANTING

- A. Plant trees with approved mechanized tree spade at designated locations. Do not use tree spade to move trees larger than maximum size allowed for similar field-grown, balled-and-burlapped, root-ball diameter in accordance with ANSI Z60.1, or trees larger than manufacturer's maximum size recommendation for tree spade being used, whichever is smaller.
- B. Use same tree spade to excavate the planting hole as will be used to extract and transport the tree.
- C. When extracting tree, center the trunk within the tree spade and move tree with solid ball of earth.
- D. Cut exposed roots cleanly during transplanting operations.
- E. Plant trees following procedures in "Tree, Shrub, and Vine Planting" Article.
- F. Where possible, orient the tree in same direction as in its original location.

3.7 TREE, SHRUB, AND VINE PRUNING

- A. Remove only dead, dying, or broken branches. Do not prune for shape.
- B. Prune, thin, and shape trees, shrubs, and vines as directed by Architect.
- C. Prune, thin, and shape trees, shrubs, and vines in accordance with standard professional horticultural and arboricultural practices. Unless otherwise indicated by Architect, do not cut tree leaders; remove only injured, dying, or dead branches from trees and shrubs; and prune to retain natural character.
- D. Do not apply pruning paint to wounds.

3.8 INSTALLATION OF TREE-STABILIZATION MATERIALS

- A. Trunk Stabilization by Upright Staking and Tying: Install trunk stabilization as follows unless otherwise indicated:
 - 1. Upright Staking and Tying:
 - a. Stake trees of **2- through 5-inch (50- through 125-mm)** caliper. Stake trees of less than **2-inch (50-mm)** caliper only as required to prevent wind tip out. Use a minimum of two stakes of length required to penetrate at least **18 inches (450 mm)** below bottom of backfilled excavation and to extend **[to the dimension indicated on Drawings][at least 72 inches (1830 mm)][one-third of trunk height]<Insert dimension or requirement>** above grade. Set vertical stakes and space to avoid penetrating root balls or root masses.
 - b. Stake trees with two stakes for trees up to **12 ft. (3.6 m)** high and **2-1/2 inches (63 mm)** or less in caliper; three stakes for trees less than **14 ft. (4.2 m)** high and up to **4 inches (100 mm)** in caliper. Space stakes equally around trees.

2. Support trees with bands of flexible ties at contact points with tree trunk. Allow enough slack to avoid rigid restraint of tree.
 3. Support trees with two strands of tie wire, connected to the brass grommets of tree-tie webbing at contact points with tree trunk. Allow enough slack to avoid rigid restraint of tree.
- B. Trunk Stabilization by Staking and Guying: Install trunk stabilization as follows unless otherwise indicated on Drawings. Stake and guy trees more than **14 ft. (4.2 m)** in height and more than **3 inches (75 mm)** in caliper unless otherwise indicated.
1. Site-Fabricated, Staking-and-Guying Method: Install no fewer than three guys spaced equally around tree.
 - a. Securely attach guys to stakes **30 inches (760 mm)** long, driven to grade. Adjust spacing to avoid penetrating root balls or root masses. Provide **[turnbuckle][compression spring]** for each guy wire and tighten securely.
 - b. For trees more than **[6 inches (150 mm) in caliper]<Insert size>**, anchor guys to wood deadmen buried at least **36 inches (900 mm)** below grade. Provide **[turnbuckle][compression spring]** for each guy wire and tighten securely.
 - c. Support trees with bands of flexible ties at contact points with tree trunk and reaching to **[turnbuckle][compression spring]**. Allow enough slack to avoid rigid restraint of tree.
 - d. Support trees with **[guy cable][or][multiple strands of tie wire]**, connected to brass grommets of tree-tie webbing at contact points with tree trunk and reaching to **[turnbuckle][compression spring]**. Allow enough slack to avoid rigid restraint of tree.
 - e. Attach flags to each guy wire, **30 inches (760 mm)** above finish grade.
 - f. Paint **[turnbuckles][compression springs]** with luminescent white paint.
 2. Proprietary Staking and Guying Device: Install staking and guying system sized and positioned as recommended by manufacturer unless otherwise indicated and in accordance with manufacturer's written instructions.
- C. Root-Ball Stabilization: Install at- or below-grade stabilization system to secure each new planting by root ball unless otherwise indicated.
1. Wood Hold-Down Method: Place vertical stakes against side of root ball and drive them into subsoil; place horizontal wood hold-down stake across top of root ball and screw at each end to one of vertical stakes.
 - a. Install stakes of length required to penetrate at least **[to dimension indicated on Drawings][18 inches (450 mm)]<Insert dimension>** below bottom of backfilled excavation. Saw stakes off at horizontal stake.
 - b. Install screws through horizontal hold-down and penetrating at least **1 inch (25 mm)** into stakes. Predrill holes if necessary to prevent splitting wood.
 - c. Install second set of stakes on other side of root trunk for larger trees.
 2. Proprietary Root-Ball Stabilization Device: Install root-ball stabilization system sized and positioned as recommended by manufacturer unless otherwise indicated and in accordance with manufacturer's written instructions.
- D. Palm Bracing: Install bracing system at three or more places equally spaced around perimeter of trunk to secure each palm until established unless otherwise indicated.
1. Site-Fabricated Palm-Bracing Method:
 - a. Place battens over padding and secure battens in place around trunk perimeter with at least two straps, tightened to prevent displacement. Ensure that straps do not contact

- trunk.
 - b. Place diagonal braces and cut to length. Secure upper ends of diagonal braces with galvanized nails into battens or into nail-attached blocks on battens. Do not drive nails, screws, or other securing devices into palm trunk; do not penetrate palm trunk in any fashion. Secure lower ends of diagonal braces with stakes driven into ground to prevent outward slippage of braces.
2. Proprietary Palm-Bracing Device: Install palm-bracing system sized and positioned as recommended by manufacturer unless otherwise indicated and in accordance with manufacturer's written instructions.

3.9 INSTALLATION OF ROOT BARRIER

- A. Install root barrier where trees are planted within **[60 inches (1500 mm)][48 inches (1200 mm)]<Insert dimension>** of paving or other hardscape elements, such as walls, curbs, and walkways, unless otherwise indicated on Drawings.
- B. Align root barrier **[vertically][with bottom edge angled at 20 degrees away from the paving or other hardscape element]**, and run it linearly along and adjacent to paving or other hardscape elements to be protected from invasive roots.
- C. Install root barrier continuously for distance of **[60 inches (1500 mm)]<Insert dimension>** in each direction from tree trunk, for total distance of **[10 ft. (3 m)]<Insert dimension>** per tree. If trees are spaced closer, use single continuous piece of root barrier.
 - 1. Position top of root barrier **[flush with finish grade][1/2 inch (13 mm) above finish grade][in accordance with manufacturer's written instructions]**.
 - 2. Overlap root barrier minimum of **12 inches (300 mm)** at joints.
 - 3. Do not distort or bend root barrier during construction activities.
 - 4. Do not install root barrier surrounding the root ball of tree.

3.10 PLACING SOIL IN PLANTERS

- A. Place a layer of drainage gravel at least **4 inches (100 mm)** thick in bottom of planter. Cover bottom with filter fabric and wrap filter fabric **[4 inches (100 mm)][6 inches (150 mm)]<Insert dimension>** up on all sides. Duct tape along the entire top edge of filter fabric, to secure filter fabric against the sides during soil-filling process.
- B. Fill planter with planting soil . Place soil in lightly compacted layers to elevation of **1-1/2 inches (38 mm)** below top of planter, allowing natural settlement.

3.11 GROUND COVER AND PLANT PLANTING

- A. Set out and space ground cover and plants other than trees, shrubs, and vines **[9 inches (225 mm) apart][12 inches (300 mm) apart][18 inches (450 mm) apart][24 inches (600 mm) apart][as indicated on Drawings]** in even rows with triangular spacing.
- B. Use planting soil for backfill.
- C. Dig holes large enough to allow spreading of roots.
- D. For rooted cutting plants supplied in flats, plant each in a manner that minimally disturbs the root system

but to depth not less than two nodes.

- E. Work soil around roots to eliminate air pockets and leave slight saucer indentation around plants to hold water.
- F. Water thoroughly after planting, taking care not to cover plant crowns with wet soil.
- G. Protect plants from hot sun and wind; remove protection if plants show evidence of recovery from transplanting shock.

3.12 INSTALLATION OF MULCHES

- A. Install weed-control barriers before mulching in accordance with manufacturer's written instructions. Completely cover area to be mulched, overlapping edges minimum of **[6 inches (150 mm)]****[12 inches (300 mm)]**, and secure seams with galvanized pins.
- B. Mulch backfilled surfaces of planting areas and other areas indicated.
 - 1. Trees and Treelike Shrubs in Turf Areas: Apply **[organic]****[mineral]** mulch ring of **[2-inch (50-mm)]****[3-inch (75-mm)]****<Insert dimension>** average thickness, with **[12-inch (300-mm)]****[24-inch (600-mm)]****[36-inch (900-mm)]****<Insert dimension>** radius around trunks or stems. Do not create a mulch cone or place mulch within **[3 inches (75 mm)]****[6 inches (150 mm)]****<Insert distance>** of trunks or stems.
 - 2. Organic Mulch in Planting Areas: Apply **[2-inch (50-mm)]****[3-inch (75-mm)]****<Insert dimension>** average thickness of organic mulch **[extending 12 inches (300 mm) beyond edge of individual planting pit or trench]****[and]****[over whole surface of planting area]**, and finish level with adjacent finish grades. Do not place mulch within **[3 inches (75 mm)]****[6 inches (150 mm)]****<Insert distance>** of trunks or stems.
 - 3. Mineral Mulch in Planting Areas: Apply **[2-inch (50-mm)]****[3-inch (75-mm)]****<Insert dimension>** average thickness of mineral mulch **[extending 12 inches (300 mm) beyond edge of individual planting pit or trench]****[and]****[over whole surface of planting area]**, and finish level with adjacent finish grades. Do not place mulch within **[3 inches (75 mm)]****[6 inches (150 mm)]****<Insert distance>** of trunks or stems.

3.13 INSTALLATION OF LANDSCAPE EDGINGS

- A. Wood Edging: Install wood edging where indicated. **[Mitre cut joints and connections at a 45-degree angle.]** Fasten each cut joint or connection with two galvanized nails. Anchor with wood stakes spaced up to **36 inches (900 mm)** apart, driven at least **1 inch (25 mm)** below top elevation of edging. Use two galvanized nails per stake to fasten edging, of length as needed to penetrate both edging and stake and provide **1/2-inch (13-mm)** clinch at point. Predrill stakes if needed to avoid splitting. Replace stakes that crack or split during installation process.
- B. Steel Edging: Install steel edging where indicated in accordance with manufacturer's written instructions. Anchor with steel stakes spaced approximately **30 inches (760 mm)** apart, driven below top elevation of edging.
- C. Aluminum Edging: Install aluminum edging where indicated in accordance with manufacturer's written instructions. Anchor with aluminum stakes spaced approximately **[36 inches (900 mm)]****[48 inches (1200 mm)]** apart, driven below top elevation of edging.
- D. Plastic Edging: Install plastic edging where indicated in accordance with manufacturer's written instructions. Anchor with steel stakes spaced approximately **[36 inches (900 mm)]****[48 inches (1200 mm)]** apart, driven below top elevation of edging.

mm)] apart, driven through upper base grooves or V-lip of edging.

- E. Shovel-Cut Edging: Separate mulched areas from turf areas[, **curbs, and paving**] with 45-degree, **4- to 6-inch- (100- to 150-mm-)** deep, shovel-cut edge[**as indicated on Drawings**].
- F. Mow-Strip Installation:
 - 1. Excavate for mow strip[**as indicated on Drawings**].
 - 2. Compact subgrade uniformly beneath mow strip.
 - 3. Apply nonselective, pre-emergent herbicide that inhibits growth of grass and weeds.
 - 4. Install [**wood**][**steel**][**aluminum**][**plastic**] edging, delineating the edge of mow strip.
 - 5. Install weed-control barrier before mulching, covering area of mow strip, and overlapping and pinning edges of barrier at least **6 inches (150 mm)** and in accordance with manufacturer's written instructions.
 - 6. Place indicated thickness of [**organic**][**mineral**] mulch, fully covering weed barrier.
 - 7. Rake mulch to uniform surface level with adjacent finish grades.

3.14 INSTALLATION OF TREE GRATES

- A. Tree Grates: Install in accordance with manufacturer's written instructions. Set grate segments flush with adjoining surfaces. Shim from supporting substrate with soil-resistant plastic. Maintain **3-inch- (75-mm-)** minimum growth radius around base of tree; break away portions of casting, if necessary, in accordance with manufacturer's written instructions.

3.15 INSTALLATION OF TREE-WATERING DEVICES

- A. Provide one device for each tree.
- B. Place device on top of the mulch at base of tree stem and fill with water in accordance with manufacturer's written instructions.

3.16 APPLICATION OF HERBICIDES AND PESTICIDES

- A. Pre-Emergent Herbicides (Selective and Nonselective): Apply to tree, shrub, and ground-cover areas in accordance with manufacturer's written instructions. Do not apply to seeded areas.
- B. Post-Emergent Herbicides (Selective and Nonselective): Apply only as necessary to treat already-germinated weeds and in accordance with manufacturer's written instructions.
- C. Apply pesticides and other chemical products and biological control agents according to authorities having jurisdiction and in accordance with manufacturer's written instructions. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.

3.17 PLANT MAINTENANCE

- A. Maintain plantings by pruning, cultivating, watering, weeding, fertilizing, mulching, restoring planting saucers, adjusting and repairing tree-stabilization devices, resetting to proper grades or vertical position, and performing other operations as required to establish healthy, viable plantings.
- B. Fill in, as necessary, soil subsidence that may occur because of settling or other processes. Replace

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mulch materials damaged or lost in areas of subsidence.

- C. Apply treatments as required to keep plant materials, planted areas, and soils free of pests and pathogens or disease. Use integrated pest management practices when possible to minimize use of pesticides and reduce hazards. Treatments include physical controls such as hosing off foliage, mechanical controls such as traps, and biological control agents.

3.18 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- B. Tests and Inspections:
 - 1. Perform tree pit percolation tests.
 - 2. Tree pit construction will be considered defective if it does not pass percolation tests and inspections.
 - 3. Do not proceed with planting in tree pits until satisfactory percolation is demonstrated.
- C. Prepare test and inspection reports.

3.19 REPAIR AND REPLACEMENT

- A. Repair or replace existing or new trees and other plants that are damaged by construction operations, in a manner approved by Architect.
 - 1. Submit details of proposed pruning and repairs.
 - 2. Perform repairs of damaged trunks, branches, and roots within 24 hours, if approved.
 - 3. Replace trees and other plants that cannot be repaired and restored to full-growth status, as determined by Architect.
- B. Remove and replace trees that are more than **[25]<Insert number>** percent dead or in unhealthy condition **[before end of corrections period]** or are damaged during construction operations that Architect determines are incapable of restoring to normal growth pattern.
 - 1. Provide new trees of same size as those being replaced for each tree of **[6 inches (150 mm)][4 inches (100 mm)]<Insert dimension>** or smaller in caliper size.
 - 2. Provide **[one][two]<Insert number>** new tree(s) of **[6-inch (150-mm)][4-inch (100-mm)]<Insert dimension>** caliper size for each tree being replaced that measures more than **[6 inches (150 mm)][4 inches (100 mm)]** in caliper size.
 - 3. Species of Replacement Trees: **[Same species being replaced][Species selected by Architect]<Insert species>**.

3.20 CLEANING AND PROTECTION

- A. During planting, keep adjacent paving and construction clean and work area in an orderly condition. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.
- B. Remove surplus soil and waste material including excess subsoil, unsuitable soil, trash, and debris and legally dispose of them off Owner's property.



- C. Protect plants from damage due to landscape operations and operations of other contractors and trades. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plantings.
- D. After installation and before **[Substantial Completion]**<Insert time>, remove nursery tags, nursery stakes, tie tape, labels, wire, burlap, and other debris from plant material, planting areas, and Project site.
- E. At time of Substantial Completion, verify that tree-watering devices are in good working order and leave them in place. Replace improperly functioning devices.

END OF SECTION 32 93 00 00



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Task	Specification	Specification Description
32 93 13 00	32 93 00 00	Plants
32 93 23 00	32 93 00 00	Plants
32 93 33 00	31 10 00 00	Site Clearing
32 93 33 00	32 93 00 00	Plants
32 93 43 00	32 93 00 00	Plants
32 93 83 00	32 93 00 00	Plants
32 93 83 00	32 96 00 00	Transplanting
32 94 13 00	32 13 13 00	Concrete Paving
32 94 13 00	32 93 00 00	Plants
32 94 16 00	32 93 00 00	Plants
32 94 43 00	32 33 00 00	Site Furnishings
32 94 49 00	32 93 00 00	Plants



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SECTION 32 96 00 00 - TRANSPLANTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Planting materials.
2. Tree-stabilization materials.
3. Tree-watering devices.

B. Owner-Furnished Material: **<Insert product or material>**.

C. Related Requirements:

1. Section 015639 "Temporary Tree and Plant Protection" for protecting, trimming, pruning, repairing, and replacing existing trees to remain that interfere with, or are affected by, execution of the Work.
2. Section 329300 "Plants" for new trees from nursery-grown sources.

1.2 UNIT PRICES

- A. See Section 012200 "Unit Prices" for description of unit prices affecting items specified in this Section.
- B. Unit prices apply to additions to and deletions from the Work as authorized by Change Orders.

1.3 DEFINITIONS

- A. General: See definitions in ANSI A300 (Part 6) and in ANSI Z60.1 pertaining to field-grown trees, except as otherwise defined in this Section.
- B. Caliper: Diameter of a trunk as measured by **[diameter tape][or][average of the smallest and largest diameters]** at height **6 inches (150 mm)** above the root flair for trees up to, and including, **4-inch (100-mm)** size at this height; and as measured at height of **12 inches (300 mm)** above the root flair for trees larger than **4-inch (100-mm)** size.
- C. Caliper (DBH): Diameter breast height; diameter of a trunk as measured by **[diameter tape][or][average of the smallest and largest diameters]** at height **54 inches (1372 mm)** above the groundline **[for trees with caliper of 8 inches (200 mm) or greater as measured at height of 12 inches (300 mm) above the root flair]**.
- D. Root-Ball Depth: Measured from bottom of trunk flare to bottom of root ball.
- E. Root-Ball Width: Measured horizontally across the root ball with an approximately circular form or the least dimension for non-round root balls, not necessarily centered on the tree trunk **[, but within tolerance in accordance with ANSI Z60.1]**.
- F. Root Flare: Also called "trunk flare." Area at the base of tree's stem or trunk where stem or trunk broadens to form roots; area of transition between root system and stem or trunk.

1.4 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at **[Project site]<Insert location>**.
 - 1. Methods and procedures related to transplanting work include, but are not limited to, the following:
 - a. Construction schedule. Verify availability of materials, personnel, equipment, and unimpeded access needed to make progress and avoid delays.
 - b. Tree and plant protection.
 - c. Tree maintenance.
 - d. Arborist's responsibilities.
 - e. **<Insert agenda items>**.

1.5 ACTION SUBMITTALS

- A. Product Data:
 - 1. Planting materials.
 - 2. Tree-stabilization materials.
 - 3. Tree-watering devices.
- B. Samples for Verification: Actual sample of finished products for each of the following:
 - 1. Weed-control barriers.
 - 2. Proprietary Root-Ball-Stabilization Device: One unit.
 - 3. Slow-Release Watering Device: One unit of each size required.
- C. Pruning Schedule: Written schedule prepared by arborist detailing scope and extent of pruning each tree in preparation for and subsequent to transplanting.
 - 1. Species and size of plant.
 - 2. Location on site plan. Include unique identifier for each.
 - 3. Reason for pruning.
 - 4. Seasonal limitations on pruning.
 - 5. Preparatory Pruning: Time schedule and description of preparatory pruning to be performed.
 - a. Indicate time in months preceding extraction of tree.
 - b. Indicate diameter of root ball and depth of root pruning for each tree.
 - 6. Description of root and crown pruning during and subsequent to transplanting.
 - 7. Description of maintenance after pruning.

1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Statements: For tree-service firm and arborist.
- B. Certification: From arborist, certifying that transplanted trees have been protected during construction and that trees were promptly and properly treated and repaired when damaged.
- C. Maintenance Recommendations: From arborist, recommended procedures to be established by Owner for care and protection of trees after completing the Work.

1. Submit before completing the Work.
- D. Existing Conditions: Documentation of existing trees indicated to be transplanted, which establishes preconstruction conditions that might be misconstrued as damage caused by construction activities.
 1. Use sufficiently detailed color photographs or video recordings. Color must accurately depict hue condition of foliage and bark.
 2. Include drawings and notations to indicate specific wounds and damage conditions of each tree designated to be transplanted.
- E. Tree-Transplanting Program: Submit before work begins.
- F. Sample Warranties: For special warranties.
- G. Tree-maintenance reports.

1.7 QUALITY ASSURANCE

- A. Tree-Service Firm Qualifications: An experienced landscaping contractor or tree-moving firm that has successfully completed transplanting work similar to that required for this Project and that will assign an experienced, qualified arborist to Project site during execution of the Work.
 1. Arborist Qualifications: **[ISA Certified Arborist][ISA Board Certified Master Arborist][ISA Certified Arborist-Municipal Specialist][Licensed arborist in jurisdiction where Project is located][Current member of ASCA][Registered Consulting Arborist as designated by ASCA]<Insert requirement>.**
- B. Tree-Transplanting Program: Prepare a written plan by arborist for transplanting trees for whole Project, including each phase or process, tree maintenance, and protection of surrounding materials during operations. Describe in detail the materials, methods, and equipment to be used for each phase of transplanting work.
 1. Include transplanting times appropriate for each species at Project location unless otherwise indicated on Drawings[**or directed by arborist**].
 2. Include transplanting schedule for each species to be transplanted, coordinated with Project schedule.
 3. Include site plans clearly marked to show tree-moving routes from extraction to planting locations. Indicate proposed equipment, weight, and turning radii.
 4. Show details of temporary protective barriers where needed.
 5. Include diagrams showing clearances to utility lines and other encumbrances along route.
 6. Include care and maintenance provisions[**and eventual removal of tree stabilization**].

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of compliance with state and Federal laws if applicable.
- B. Bulk Materials:
 1. Do not dump or store bulk materials near structures, utilities, or walkways and pavements; or on existing turf areas or trees.
 2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance

- systems, or walkways.
- 3. Accompany each delivery with appropriate certificates.

- C. Protect bark, branches, and root systems from sun scald, drying, wind burn, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees in such a manner as to destroy their natural shape.
- D. Completely cover foliage when transporting trees while they are in foliage.
- E. Handle trees by root ball. Do not drop trees.
- F. Move trees after preparations for planting have been completed, and install immediately. If planting is delayed more than six hours after moving, set trees in their appropriate aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist.

1.9 FIELD CONDITIONS

- A. Field Measurements: Verify final grade elevations and final locations of trees and construction contiguous with trees by field measurements before proceeding with transplanting work. Perform transplanting only after finish grades are established.
- B. Seasonal Restrictions: Transplant trees during the following in-season periods:
 - 1. Spring: **<Insert dates>**.
 - 2. Summer: **<Insert dates>**.
 - 3. Fall: **<Insert dates>**.
 - 4. Winter: **<Insert dates>**.
- C. Weather Limitations: Proceed with transplanting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Do not transplant during excessively wet or frozen conditions. Apply products during favorable weather conditions in accordance with manufacturer's written instructions and warranty requirements.
- D. Coordination with Turf Areas (Lawns): Perform transplanting before planting turf areas unless otherwise indicated.
 - 1. When transplanting after planting turf areas, protect turf areas, and promptly repair damage caused by transplanting operations.
- E. Coordination with Planting Beds: Perform transplanting before planting bedded areas unless otherwise indicated.
 - 1. When transplanting after planting bedded areas, protect bedding plants, and promptly repair damage caused by transplanting operations.

1.10 WARRANTY

- A. Installer's Special Warranty: Tree-service firm agrees to repair or replace trees and related materials that fail within specified warranty period.
 - 1. Failures include, but are not limited to, the following:

- a. Death and unsatisfactory growth except for defects resulting from abuse, lack of adequate maintenance, or neglect by Owner; or incidents that are beyond Contractor's control.
 - b. Death and unsatisfactory growth is defined as more than 25 percent dead or in an unhealthy condition or failure to meet general performance requirements at end of warranty period.
 - c. Structural failures, including trees falling or blowing over.
 - d. Faulty performance of materials and devices related to tree plantings including **[tree stabilization][and][watering devices]<Insert item>**.
2. Warranty Periods from Date of **[Transplanting Completion][Substantial Completion]<Insert starting time>**:
 - a. Trees: **[12][18]<Insert number>** months.
3. Include the following remedial actions as a minimum:
 - a. Remove dead trees and trees with unsatisfactory growth at end of warranty period; replace when directed.
 - b. Limit of one replacement of each tree will be required except for losses or replacements due to failure to comply with requirements.
 - c. Replace materials and devices related to tree plantings.
 - d. Provide extended warranty for period equal to original warranty period, for replaced trees.

1.11 MAINTENANCE SERVICE

- A. Initial Maintenance Service: Provide tree maintenance by skilled employees of tree-service firm and as required in Part 3. Begin maintenance immediately after **[preparatory pruning][trees are installed]** and continue until plantings are healthy and well established, but for not less than maintenance period below:
 1. Maintenance Period: **[12][18]<Insert number>** months from date of **[transplanting completion][Substantial Completion]<Insert starting time>**.
- B. Continuing Maintenance Proposal: From tree-service firm to Owner, in the form of standard yearly (or other period) maintenance agreement, starting on date initial maintenance service is concluded. State services, obligations, conditions, and terms for agreement period and for future renewal options.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. General Performance: Transplanted trees are to be healthy and resume vigorous growth within **[one year][two years]<Insert period>** of transplanting without dieback due to defective extracting, handling, planting, maintenance, or other defects in the Work.

2.2 PLANTING MATERIALS

- A. Backfill Soil: **[Excavated soil][Excavated soil mixed with planting soil][Planting soil]** of suitable moisture content and granular texture for placing and compacting in planting pit around tree, and free of stones, roots, plants, sod, clods, clay lumps, pockets of coarse sand, concrete slurry, concrete layers or chunks, cement, plaster, building debris, and other extraneous materials harmful to plant growth.

1. Mixture: Well-blended mix of **[two parts excavated soil to one part planting soil]<Insert requirement>**.
2. Planting Soil: as specified in **[Section 329113 "Soil Preparation."][Section 329115 "Soil Preparation (Performance Specification)."]**

2.3 TREE-STABILIZATION MATERIALS

A. Trunk-Stabilization Materials:

1. Upright and Guy Stakes: Rough-sawn, sound, new **[hardwood][softwood with specified wood preservative treatment by pressure process]**, free of knots, holes, cross grain, and other defects, **2-by-2-inch nominal (38-by-38-mm actual)** by length indicated, pointed at one end.
2. Wood Deadmen: Timbers measuring **8 inches (200 mm)** in diameter and **48 inches (1200 mm)** long, treated with specified wood preservative treatment by pressure process.
3. Flexible Ties: Wide rubber or elastic bands or straps.
4. Guys and Tie Wires: ASTM A641/A641M, Class 1, galvanized-steel wire, two-strand, twisted, **0.106 inch (2.7 mm)** in diameter.
5. Tree-Tie Webbing: UV-resistant polypropylene or nylon webbing with brass grommets.
6. Guy Cable: Five-strand, **3/16-inch- (4.8-mm-)** diameter, galvanized-steel cable, fitted with zinc-coated **3/8-inch (10-mm)** galvanized eyebolts at ends.
7. Flags: Standard surveyor's plastic flagging tape, white, **6 inches (150 mm)** long.
8. Proprietary Staking-and-Guying Devices: Proprietary stake and adjustable tie systems to secure each new planting by tree stem; sized as indicated and in accordance with manufacturer's written instructions.
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) **[Anchor Tie Down, Inc.]**
 - 2) **[Arborbrace]**
 - 3) **[DeepRoot Green Infrastructure, LLC]**
 - 4) **[J. R. Partners]**
 - 5) **<Insert manufacturer's name>**
 - b. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1) **[Anchor Tie Down, Inc.]**
 - 2) **[Arborbrace]**
 - 3) **[DeepRoot Green Infrastructure, LLC]**
 - 4) **[J. R. Partners]**
 - 5) **<Insert manufacturer's name>**

B. Root-Ball-Stabilization Materials:

1. Upright Stakes and Horizontal Hold-Down: Rough-sawn, sound, new hardwood or softwood, free of knots, holes, cross grain, and other defects, **2-by-2-inch nominal (38-by-38-mm actual)** by length indicated; stakes pointed at one end.
2. Wood Screws: Hot-dip galvanized or stainless steel.
3. Proprietary Root-Ball-Stabilization Devices: Proprietary at- or below-grade stabilization systems to secure each new planting by root ball; sized in accordance with manufacturer's written

instructions unless otherwise indicated.

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

- 1) **[Border Concepts, Inc]**
- 2) **[MacLean Power Systems]**
- 3) **[Tree Staple, Inc.]**
- 4) **<Insert manufacturer's name>**

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

- 1) **[Border Concepts, Inc]**
- 2) **[MacLean Power Systems]**
- 3) **[Tree Staple, Inc.]**
- 4) **<Insert manufacturer's name>**

C. Palm Bracing: Battens or blocks, struts, straps, and protective padding as indicated.

1. Battens or Blocks and Struts: Rough-sawn, sound, new hardwood or softwood, free of knots, holes, cross grain, and other defects, **2-by-4-inch nominal (38-by-89-mm actual)** by lengths indicated.
2. Straps: Adjustable steel or plastic package banding straps.
3. Padding: Burlap.
4. Proprietary Palm-Bracing Devices: Proprietary systems to secure each new planting by trunk; sized in accordance with manufacturer's written instructions unless otherwise indicated.

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

- 1) **[Arborbrace]**
- 2) **[Horticultural Consultants, Inc.]**
- 3) **<Insert manufacturer's name>**

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

- 1) **[Arborbrace]**
- 2) **[Horticultural Consultants, Inc.]**
- 3) **<Insert manufacturer's name>**

2.4 TREE-WATERING DEVICES

- A. Watering Pipe: PVC pipe **4 inches (100 mm)** in diameter, site-cut to length as required, and with snug-fitting removable cap.
- B. Slow-Release Watering Device: Standard product manufactured for drip irrigation of plants and emptying its water contents over a period of **[2 to 9]<Insert number or range>** hours; manufactured

from UV-light-stabilized nylon-reinforced polyethylene sheet, PVC, or HDPE plastic.

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

2.5 MISCELLANEOUS PRODUCTS

- A. Organic Mulch: **[Shredded hardwood][Ground or shredded bark][Wood and bark chips][Compost mulch]<Insert mulch type>** as specified in Section 329300 "Plants."
- B. Mineral Mulch: **[Rounded riverbed gravel or smooth-faced stone][Crushed stone or gravel][Marble chips][Granite chips]<Insert mulch type>** as specified in Section 329300 "Plants."
- C. Antidesiccant: Water-insoluble emulsion, permeable moisture retarder, film forming, for trees. Deliver in original, sealed, and fully labeled containers and mix in accordance with manufacturer's written instructions.
- D. Burlap: Non-synthetic, biodegradable.
- E. Pesticides: Registered and approved by the EPA, acceptable to authorities having jurisdiction, and of type recommended in writing by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.
 1. Pre-Emergent Herbicide (Selective and Non-Selective): Effective for controlling germination or growth of weeds within planted areas at soil level directly below the mulch layer.
 2. Post-Emergent Herbicide (Selective and Non-Selective): Effective for controlling weed growth that has already germinated.
- F. Weed-Control Barriers:
 1. Nonwoven Geotextile Filter Fabric: Polypropylene or polyester fabric, **3 oz./sq. yd. (101 g/sq. m)** minimum, composed of fibers formed into a stable network so that fibers retain their relative position. Fabric is to be inert to biological degradation and resist naturally encountered chemicals, alkalis, and acids.
 2. Composite Fabric: Woven, needle-punched polypropylene substrate bonded to a nonwoven polypropylene fabric, **4.8 oz./sq. yd. (162 g/sq. m)**.
- G. Wood Preservative Treatment by Pressure Process: AWWA U1; Use Category UC4a, using preservative chemicals acceptable to authorities having jurisdiction and containing no arsenic or chromium.

PART 3 - EXECUTION

3.1 TREE-TRANSPLANTING SPECIALIST

- A. Tree-Transplanting Specialist Firms: Subject to compliance with requirements, have tree transplanting performed by one of the following firms:
 - 1. **<Insert, in separate subparagraphs, names of tree-transplanting specialist firms>.**

3.2 EXAMINATION

- A. Erosion and Sedimentation Control: Examine the site to verify that temporary erosion- and sedimentation-control measures are in place. Verify that flows of water redirected from construction areas or generated by construction activity do not enter or cross transplanting areas.
- B. For the record, prepare written report, endorsed by arborist, listing conditions detrimental to transplanting work and tree protection and health.
- C. Proceed with transplanting only after unsatisfactory conditions have been corrected.

3.3 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, other facilities, turf areas, and other plants and planting areas from damage caused by transplanting operations.
- B. Utility Locator Service: Notify **[utility locator service]****["Miss Utility"]****["Call Before You Dig"]****["Dig Safe System"]****["One Call"]****<Insert name>** for area where Project is located before beginning excavation.
- C. Locate and clearly identify trees for transplanting. **[Flag]****[Tie a 1-inch (25-mm) blue-vinyl tape around]****<Insert requirement>** each tree at **54 inches (1372 mm)** above the ground.
- D. Lay out individual transplant locations and areas for multiple plantings. Stake locations, outline areas, adjust locations when requested, and obtain Architect's acceptance of layout before transplanting. Make minor adjustments as required.
- E. Apply antidesiccant to trees uniformly, using power spray to provide an adequate film over trunks (before wrapping), branches, stems, twigs, and foliage to protect during extracting, handling, and transportation.
 - 1. If deciduous trees are moved in full leaf, spray with antidesiccant before extracting and again two weeks after transplanting.
- F. Wrap trees with burlap fabric over trunks, branches, stems, twigs, and foliage to protect from wind and other damage during extracting, handling, and transporting.

3.4 PREPARATORY PRUNING

- A. Root Pruning: Perform preparatory root pruning under direction of arborist as far in advance of extracting each tree as Project schedule allows.
 - 1. Dig exploratory pits or trench **[by hand]****[or]****[with air spade]** around perimeter of tree at indicated

- root-ball width to determine locations of main lateral roots.
2. Dig trench **[by hand][or][with tree spade]** around perimeter of tree at indicated root-ball width to the depth of the root system. Do not use a backhoe or other equipment that rips, tears, or pulls roots.
3. Root-Ball Width: Minimum **[9 inches (229 mm)]<Insert dimension>** of root-ball diameter, or least dimension for non-round root balls, for each **1 inch (25 mm)** of tree caliper being transplanted.
4. If encountering large, main lateral roots, expose roots beyond excavation limits as required to bend and redirect them without breaking.
5. Use narrow-tine spading forks to comb soil to expose roots with minimal damage to root system.
6. Cut exposed roots manually with sharp pruning instruments; do not break, tear, chop, or slant the cuts. Do not use a backhoe or other equipment that rips, tears, or pulls roots.
7. Do not paint or apply sealants on cut root ends.
8. Backfill trench with excavated soil.

B. Crown Pruning (Tip Pruning):

1. Do not perform preparatory crown pruning (tip pruning).
2. Perform preparatory crown pruning **[as indicated on Drawings, under direction of arborist][as directed by arborist]**. Follow procedures as specified in "Crown Pruning" Article.

3.5 EXCAVATION AND PLANTING EQUIPMENT

- A. Tree Spade: Track-mounted mechanized tree mover; sized in accordance with manufacturer's size recommendation for each tree being transplanted.

3.6 EXCAVATION OF PLANTING PITS

A. General: Excavate under supervision of arborist.

1. Excavate planting pits or trenches with sides sloping. Trim perimeter of bottom leaving center area of bottom raised slightly to support root ball and assist in drainage away from center. Do not further disturb base. Ensure that root ball will sit on undisturbed base soil. Scarify sides of planting pit smeared or smoothed during excavation.
2. Excavate approximately **[two][three]<Insert requirement>** times as wide as root ball.
3. Keep excavations covered or otherwise protected until replanting trees.

B. Subsoil and topsoil removed from excavations may **[not]** be used as planting soil.

C. Obstructions: Notify Architect if unexpected rock or obstructions detrimental to trees are encountered in excavations.

1. Hardpan Layer: Drill **6-inch- (150-mm-)** diameter holes, **24 inches (600 mm)** apart, into free-draining strata or to a depth of **10 ft. (3 m)**, whichever is less, and backfill with free-draining material.

D. Seepage: Notify Architect if subsoil conditions evidence unexpected water seepage into tree-planting pits.

E. Drainage: Fill planting pit or trench with **[6 inches (152 mm)]<Insert dimension>** of water and time the infiltration rate of soil. If drainage rate is less than **[0.25 inch (6 mm)]<Insert dimension>** per hour, notify Architect to determine need for subsurface drainage.

- F. Saline or Sodic Soils: Completely fill excavations with water and allow to percolate away before positioning trees.

3.7 EXTRACTION OF TREES

- A. General: Extract trees under supervision of arborist.
- B. Orientation Marking: Mark the north side of each tree with non-permanent paint before extracting.
- C. Root-Ball Width: Minimum **[10 inches (250 mm)]<Insert dimension>** of root-ball diameter, or least dimension for non-round root balls, for each **1 inch (25 mm)** of tree caliper being transplanted.
 - 1. Out-of-Season Planting: If planting before or after the in-season period for tree, provide minimum root-ball diameter of **[12 inches (305 mm)]<Insert dimension>** for each **1 inch (25 mm)** of tree caliper being transplanted.
- D. Root-Ball Depth: As determined by arborist for each species and size of tree and for site conditions at original and planting locations.
- E. Digging:
 - 1. Dig and clear a pit **[by hand][or][with tree spade]** to depth of root system. Do not use backhoe or other equipment that rips, tears, or pulls roots.
 - 2. Use narrow-tine spading forks to comb soil to expose roots with minimal damage to root system.
 - 3. If encountering large, main lateral roots, expose roots beyond excavation limits as required to bend and redirect them without breaking.
 - 4. Cut exposed roots manually with sharp pruning instruments; do not break, tear, chop, or slant the cuts. Do not paint or apply sealants on cut root ends.
 - 5. Construct box tight against root system sides and bottom as pit is dug. Brace and support box to prevent breaking of root ball.
 - 6. Temporarily support and protect exposed roots from damage until they are permanently redirected and covered with soil. Cover roots with burlap and keep them moist until planted.
- F. Extracting with Tree Spade: Use same tree spade to extract the tree as will be used to transport and plant the tree.
 - 1. Do not use tree spade to move trees larger than manufacturer's maximum size recommendation for tree spade being used.
 - 2. When extracting the tree, center the trunk within tree spade and move tree with solid ball of earth.

3.8 PLANTING

- A. Planting Standard: Perform planting in accordance with ANSI A300 (Part 6) unless otherwise indicated.
- B. Before planting, verify that root flare is visible at top of root ball. If root flare is not visible, remove soil in a level manner from root ball to where the top-most root emerges from the trunk. After soil removal to expose root flare, verify that root ball still meets size requirements.
- C. Ensure that root flare is visible after planting.
- D. Remove injured roots by cutting cleanly; do not break. Do not paint or apply sealants on cut root ends.
- E. Orientation: Position the tree so that its north side, marked before extracting, is facing north in its new

location.

- F. Set tree plumb and in center of planting pit with **[bottom][top]** of root flare **[1 inch (25 mm)][2 inches (50 mm)]<Insert dimension>** above adjacent finish grades.
 - 1. Use specified backfill soil for backfill.
 - 2. If area under the tree was initially dug too deep, add backfill to raise it to the correct level and thoroughly tamp the added soil to prevent settling.
 - 3. After placing some backfill around root ball to stabilize plant, begin backfilling.
 - 4. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
 - 5. Redirect exposed root ends downward in backfill areas where possible. Hand-expose roots as required to bend and redirect them without breaking. If encountered immediately adjacent to location of new construction and redirection is impractical, cut roots approximately **3 inches (75 mm)** back from new construction and as required for root pruning.
 - 6. Continue backfilling process. Water again after placing and tamping final layer of soil.
- G. Watering Pipe: During backfilling, install watering pipe **4 ft. (1220 mm)** deep into the planting pit outside the root ball **[as indicated on Drawings][and][with top of pipe 1 inch (25 mm) above the mulched surface]**.
- H. Planting with Tree Spade: Use same tree spade for planting as was used to extract and transport the tree. Do not use tree spade for trees larger than manufacturer's maximum size recommendation for tree spade being used.
- I. Slopes: When planting on slopes, set the tree so root flare on the uphill side is flush with surrounding soil on the slope; edge of root ball on the downhill side will be above the surrounding soil. Apply enough soil to cover the downhill side of root ball.

3.9 CROWN PRUNING

- A. Prune branches **[as indicated on Drawings, under direction of arborist][as directed by arborist]**.
 - 1. Prune to remove only **[injured,]** broken, dying, or dead branches. Do not prune for shape.
 - 2. Do not remove or reduce living branches to compensate for root loss caused by cutting root system or to improve natural tree form.
 - 3. Pruning Standards: Perform pruning in accordance with ANSI A300 (Part 1).
- B. Unless otherwise directed by arborist and acceptable to Architect, do not cut tree leaders.
- C. Cut branches with sharp pruning instruments; do not break or chop.
- D. Do not paint or apply sealants to wounds.
- E. Provide subsequent maintenance during Contract period as recommended by arborist.
- F. Chip removed branches and **[spread over areas identified by Architect][stockpile in areas approved by Architect][dispose of off-site]<Insert requirement>**.

3.10 INSTALLATION OF TREE-STABILIZATION MATERIALS

- A. Trunk Stabilization by Upright Staking and Tying: Install trunk stabilization as follows unless otherwise indicated on Drawings[**or directed by arborist**].
 1. Upright Staking and Tying: Stake only as required to prevent wind tip out. Use a minimum of **[two][three]** stakes of length required to penetrate at least **18 inches (450 mm)** below bottom of backfilled excavation and to extend **[to dimension indicated on Drawings][one-third of trunk height]<Insert dimension or requirement>** above grade. Set stakes vertical and space to avoid penetrating root balls or root masses.
 2. Support trees with bands of flexible ties at contact points with tree trunk. Allow enough slack to avoid rigid restraint of tree.
 3. Support trees with two strands of tie wire, connected to brass grommets of tree-tie webbing at contact points with tree trunk. Allow enough slack to avoid rigid restraint of tree.
- B. Trunk Stabilization by Staking and Guying: Install trunk stabilization as follows unless otherwise indicated on Drawings[**or directed by arborist**].
 1. Site-Fabricated Staking-and-Guying Method: Install no fewer than three guys spaced equally around tree.
 - a. Securely attach guys to stakes **30 inches (760 mm)** long, driven to grade. Adjust spacing to avoid penetrating root balls or root masses. Provide **[turnbuckle][compression spring]** for each guy wire and tighten securely.
 - b. For trees more than **[6 inches (150 mm) in caliper]<Insert size>**, anchor guys to wood deadmen buried at least **36 inches (900 mm)** below grade. Provide **[turnbuckle][compression spring]** for each guy wire and tighten securely.
 - c. Support trees with bands of flexible ties at contact points with tree trunk and reaching to a **[turnbuckle][compression spring]**. Allow enough slack to avoid rigid restraint of tree.
 - d. Support trees with **[guy cable][or][multiple strands of tie wire]**, connected to brass grommets of tree-tie webbing at contact points with tree trunk and reaching to **[turnbuckle][compression spring]**. Allow enough slack to avoid rigid restraint of tree.
 - e. Attach flags to each guy wire, **30 inches (760 mm)** above finish grade.
 - f. Paint **[turnbuckles][compression springs]** with luminescent white paint.
 2. Proprietary Staking-and-Guying Device: Install staking and guying system sized and positioned as recommended by manufacturer unless otherwise indicated and in accordance with manufacturer's written instructions.
- C. Root-Ball Stabilization: Install at- or below-grade stabilization system to secure each new planting by root ball unless otherwise indicated on Drawings[**or directed by arborist**].
 1. Wood Hold-Down Method: Place vertical stakes against side of root ball and drive them into subsoil; place horizontal wood hold-down stake across top of root ball and screw at each end to one of vertical stakes.
 - a. Install stakes of length required to penetrate at least **[to dimension indicated on Drawings][18 inches (450 mm)]<Insert dimension>** below bottom of backfilled excavation. Saw stakes off at horizontal stake.
 - b. Install screws through horizontal hold-down and penetrating at least **1 inch (25 mm)** into stakes. Predrill holes if necessary to prevent splitting wood.
 - c. Install second set of stakes on other side of root trunk for larger trees as indicated.
 2. Proprietary Root-Ball-Stabilization Device: Install root-ball-stabilization system sized and positioned as recommended by manufacturer unless otherwise indicated and in accordance with manufacturer's written instructions.

- D. Palm Bracing: Install bracing system at three or more places equally spaced around perimeter of trunk to secure each palm until established unless otherwise indicated.

1. Site-Fabricated Palm-Bracing Method:

- a. Place battens over padding and secure battens in place around trunk perimeter with at least two straps, tightened to prevent displacement. Ensure that straps do not contact trunk.
- b. Place diagonal braces and cut to length. Secure upper ends of diagonal braces with galvanized nails into battens or into nail-attached blocks on battens. Do not drive nails, screws, or other securing devices into palm trunk; do not penetrate palm trunk in any fashion. Secure lower ends of diagonal braces with stakes driven into ground to prevent outward slippage of braces.

2. Proprietary Palm-Bracing Device: Install palm-bracing system sized and positioned as recommended by manufacturer unless otherwise indicated and in accordance with manufacturer's written instructions.

3.11 INSTALLATION OF MULCHES

- A. Install weed-control barriers before mulching in accordance with manufacturer's written instructions. Completely cover area to be mulched, overlapping edges minimum of **[6 inches (150 mm)][12 inches (300 mm)]** and secure seams with galvanized pins.
- B. Organic Mulch: Apply **[2-inch (50-mm)][3-inch (75-mm)]**<Insert dimension> average thickness of organic mulch **[extending 12 inches (300 mm) beyond edge of individual planting pit][and][over whole surface of planting area]**, and finish level with adjacent finish grades. Do not place mulch within **[3 inches (75 mm)][6 inches (150 mm)]**<Insert distance> of trunks or stems.
- C. Mineral Mulch in Planting Areas: Apply **[2-inch (50-mm)][3-inch (75-mm)]**<Insert dimension> average thickness of mineral mulch **[extending 12 inches (300 mm) beyond edge of individual planting pit][and][over whole surface of planting area]**, and finish level with adjacent finish grades. Do not place mulch within **[3 inches (75 mm)][6 inches (150 mm)]**<Insert distance> of trunks or stems.

3.12 INSTALLATION OF TREE-WATERING DEVICES

- A. Provide one device for each tree.
- B. Place device on top of the mulch at base of tree and fill with water in accordance with manufacturer's written instructions.

3.13 TREE MAINTENANCE

- A. Perform tree maintenance as recommended by arborist. Maintain arborist observation of transplanting work.
- B. Maintain trees by pruning, cultivating, watering, weeding, fertilizing, mulching, restoring planting saucers, adjusting and repairing tree-stabilization devices, resetting to proper grades or vertical position, and performing other operations as required to establish healthy, viable plantings. Treat as required to keep trees free of insects and disease.

- C. From time of **[preparatory root pruning][or][tree extraction]**, measure soil moisture adjacent to edge of each root ball **[weekly]<Insert period>**. Record findings and weather conditions.
- D. Fill areas of soil subsidence with backfill soil. Replenish mulch materials damaged or lost in areas of subsidence.
- E. Apply treatments as required to keep tree materials, planted areas, and soils free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize use of pesticides and reduce hazards. Treatments include physical controls such as hosing off foliage, mechanical controls such as traps, and biological control agents.
- F. Pesticide Application: Apply pesticides and other chemical products and biological control agents in accordance with authorities having jurisdiction and manufacturer's written instructions. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.
 - 1. Pre-Emergent Herbicides (Selective and Non-Selective): Apply in accordance with manufacturer's written instructions. Do not apply to seeded areas.
 - 2. Post-Emergent Herbicides (Selective and Non-Selective): Apply only as necessary to treat already-germinated weeds and in accordance with manufacturer's written instructions.
- G. Reports: Have arborist prepare **[monthly]<Insert period>** inspection reports.

3.14 REPAIR AND REPLACEMENT

- A. Repair or replace transplanted trees and other plants indicated to remain or be relocated that are damaged by construction operations, in a manner recommended by arborist and approved by Architect.
 - 1. Submit details of proposed pruning and repairs.
 - 2. Perform repairs of damaged trunks, branches, and roots within 24 hours in accordance with arborist's written instructions.
 - 3. Replace trees and other plants that cannot be repaired and restored to full-growth status, as determined by Architect.
- B. Remove and replace trees that are more than **[25]<Insert number>** percent dead or in unhealthy condition **[before end of corrections period]** or are damaged during construction operations that Architect determines are incapable of restoring to normal growth pattern.
 - 1. Provide new trees of same size as those being replaced for each tree of **[6 inches (150 mm)][4 inches (100 mm)]<Insert dimension>** or smaller in caliper size.
 - 2. Provide **[one][two]<Insert number>** new tree(s) of **[6-inch (150-mm)][4-inch (100-mm)]<Insert dimension>** caliper size for each tree being replaced that measures more than **[6 inches (150 mm)][4 inches (100 mm)]** in caliper size.
 - 3. Species of Replacement Trees: **[Same species being replaced][Species selected by Architect]<Insert species>**.

3.15 CLEANING AND PROTECTION

- A. During transplanting, keep adjacent paving and construction clean and work area in an orderly condition.
- B. Protect trees from damage due to transplanting operations and operations of other contractors and trades. Maintain protection during transplanting and maintenance periods. Treat, repair, or replace damaged plantings.



32 - Exterior Improvements

- C. After planting and before **[Substantial Completion]**<Insert time>, remove tags, markings, tie tape, labels, wire, burlap, and other debris from transplanted trees, planting areas, and Project site.

END OF SECTION 32 96 00 00



32 - Exterior Improvements

Task	Specification	Specification Description
32 96 33 00	32 96 00 00	Transplanting
32 96 43 00	32 96 00 00	Transplanting



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Task	Specification	Specification Description
33 01 10 54	33 01 30 41	Cleaning of Sewers
33 01 10 58	33 01 30 41	Cleaning of Sewers



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SECTION 33 01 30 41 - CLEANING OF SEWERS

1.1 GENERAL

- A. Description Of Work
 - 1. This specification covers sewer line cleaning. Cleaning procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.
- B. Submittals: Submit product data and manufacturer's instruction.

1.2 PRODUCTS

- A. All materials shall be clean, free of defects, corrosion, and damage. All items shall be of proper type, size, design, and characteristics for the use intended. Unless otherwise specified, all items shall be factory-made.
- B. Portable Cleaning Equipment: Equipment used in the cleaning of sewer lines shall be as required to complete the work for the size, length, and conditions of the sewer. Portable and mobile equipment shall comply with Water Pollution Control Federation Manual No. 7.
- C. Chemicals shall be of the strength required to perform the work. The chemicals shall not be damaging to pipe materials, manholes, pumping equipment, nor treatment process and shall not be contaminated by foreign substances.

1.3 EXECUTION

- A. Preparation
 - 1. Protection required to prevent damage to adjacent materials, equipment, fixtures, and finishes shall be provided. Necessary protective clothing and accessories for personnel working with chemicals shall be provided.
 - 2. Ventilation of Sewers: Contractor shall provide proper ventilation for personnel working in the sewer.
 - 3. Alternate Sewage Discharge: Contractor shall provide an alternate routing of sewage discharge to a downstream manhole.
 - 4. Traffic: Contractor shall provide all traffic signs required to safely direct traffic at and around work areas.
- B. Installation
 - 1. Direction of Work: Sewer line cleaning work, with the exception of hydraulic scouring, shall proceed in the downstream direction. Cleaning by hydraulic scouring shall proceed in the upstream direction.
 - 2. Testing: Upon completion of cleaning operation, test sewer lines for proper operation and observe for a period of 24 hours. Clean out all stoppages and the retest the line for proper operation.

END OF SECTION 33 01 30 41



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Task	Specification	Specification Description
33 01 30 42	33 01 30 41	Cleaning of Sewers
33 01 30 81	26 05 43 00	Underground Ducts and Utility Structures
33 01 30 81	33 42 00 00	Stormwater Conveyance
33 01 40 00	33 42 00 00	Stormwater Conveyance



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SECTION 33 05 00 00 - COMMON WORK RESULTS FOR UTILITIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Piping joining materials.
2. Transition fittings.
3. Dielectric fittings.
4. Sleeves.
5. Identification devices.
6. Grout.
7. Flowable fill.
8. Piped utility demolition.
9. Piping system common requirements.
10. Equipment installation common requirements.
11. Painting.
12. Concrete bases.
13. Metal supports and anchorages.

1.2 DEFINITIONS

- A. Exposed Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions.
- B. Concealed Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.
- C. ABS: Acrylonitrile-butadiene-styrene plastic.
- D. CPVC: Chlorinated polyvinyl chloride plastic.
- E. PE: Polyethylene plastic.
- F. PVC: Polyvinyl chloride plastic.

1.3 ACTION SUBMITTALS

- A. Product Data: For the following:
1. Dielectric fittings.
 2. Identification devices.

1.4 INFORMATIONAL SUBMITTALS

- A. Welding certificates.

1.5 QUALITY ASSURANCE

- A. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Steel Piping Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
 - 1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
 - 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
- C. Comply with ASME A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
- B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.7 COORDINATION

- A. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.
- B. Coordinate installation of identifying devices after completing covering and painting if devices are applied to surfaces.
- C. Coordinate size and location of concrete bases. Formwork, reinforcement, and concrete requirements are specified in Section 033000 "Cast-in-Place Concrete."

PART 2 - PRODUCTS

2.1 PIPING JOINING MATERIALS

- A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
 - 1. ASME B16.21, nonmetallic, flat, asbestos free, **1/8-inch (3.2-mm)** maximum thickness, unless otherwise indicated.
 - a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
 - b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
 - 2. AWWA C110, rubber, flat face, **1/8 inch (3.2 mm)** thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.
- B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

- C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.
- D. Solder Filler Metals: ASTM B32, lead-free alloys. Include water-flushable flux according to ASTM B813.
- E. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.
- F. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- G. Solvent Cements for Joining Plastic Piping:
 - 1. ABS Piping: ASTM D2235.
 - 2. CPVC Piping: ASTM F493.
 - 3. PVC Piping: ASTM D2564. Include primer according to ASTM F656.
 - 4. PVC to ABS Piping Transition: ASTM D3138.
- H. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.

2.2 TRANSITION FITTINGS

- A. Transition Fittings, General: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.
- B. Transition Couplings NPS 1-1/2 (DN 40) and Smaller:
 - 1. Underground Piping: Manufactured piping coupling or specified piping system fitting.
 - 2. Aboveground Piping: Specified piping system fitting.
- C. AWWA Transition Couplings NPS 2 (DN 50) and Larger:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Cascade Waterworks Mfg. Co.]**
 - b. **[Dresser Utility Solutions]**
 - c. **[Ford Meter Box Company, Inc. (The)]**
 - d. **[JCM Industries, Inc]**
 - e. **[Smith-Blair, a Xylem brand.]**
 - f. **[Viking Johnson]**
 - g. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Cascade Waterworks Mfg. Co.]**
 - b. **[Dresser Utility Solutions]**
 - c. **[Ford Meter Box Company, Inc. (The)]**
 - d. **[JCM Industries, Inc]**
 - e. **[Smith-Blair, a Xylem brand.]**

- f. **[Viking Johnson]**
- g. **<Insert manufacturer's name>**

3. Description: AWWA C219, metal sleeve-type coupling for underground pressure piping.

D. Plastic-to-Metal Transition Fittings:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Spears Manufacturing Company]**
 - b. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Spears Manufacturing Company]**
 - b. **<Insert manufacturer's name>**
3. Description: **[CPVC][CPVC and PVC][PVC]** one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint[**or threaded**] end.

E. Plastic-to-Metal Transition Unions:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Colonial Engineering, Inc.]**
 - b. **[NIBCO INC.]**
 - c. **[Spears Manufacturing Company]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Colonial Engineering, Inc.]**
 - b. **[NIBCO INC.]**
 - c. **[Spears Manufacturing Company]**
 - d. **<Insert manufacturer's name>**
3. Description: MSS SP-107, **[CPVC][CPVC and PVC][PVC]** four-part union. Include brass[**or stainless steel**] threaded end, solvent-cement-joint[**or threaded**] plastic end, rubber O-ring, and union nut.

F. Flexible Transition Couplings for Underground Nonpressure Drainage Piping:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering**

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

- a. [Cascade Waterworks Mfg. Co.]
 - b. [Fernco Inc]
 - c. [Mission Rubber Company, LLC]
 - d. [Plastic Oddities]
 - e. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Cascade Waterworks Mfg. Co.]
 - b. [Fernco Inc]
 - c. [Mission Rubber Company, LLC]
 - d. [Plastic Oddities]
 - e. <Insert manufacturer's name>
3. Description: ASTM C1173 with elastomeric sleeve, ends same size as piping to be joined, and corrosion-resistant metal band on each end.

2.3 DIELECTRIC FITTINGS

- A. Dielectric Fittings, General: Assembly of copper alloy and ferrous materials or ferrous material body with separating nonconductive insulating material suitable for system fluid, pressure, and temperature.
- B. Dielectric Unions:
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Capitol Manufacturing Company]
 - b. [Epco Sales, Inc]
 - c. [GF Piping Systems: Georg Fischer LLC]
 - d. [HART Industrial Unions, LLC]
 - e. [WATTS; A Watts Water Technologies Company]
 - f. [Zurn Industries, LLC]
 - g. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Capitol Manufacturing Company]
 - b. [Epco Sales, Inc]
 - c. [GF Piping Systems: Georg Fischer LLC]
 - d. [HART Industrial Unions, LLC]
 - e. [WATTS; A Watts Water Technologies Company]
 - f. [Zurn Industries, LLC]
 - g. <Insert manufacturer's name>
 3. Description: Factory fabricated, union, **NPS 2 (DN 50)** and smaller.



- a. Pressure Rating: **[150 psig (1035 kPa) minimum][250 psig (1725 kPa)]** at 180 deg F (82 deg C).
- b. End Connections: Solder-joint copper alloy and threaded ferrous; threaded ferrous.

C. Dielectric Flanges:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Capitol Manufacturing Company]**
 - b. **[Epco Sales, Inc]**
 - c. **[GF Piping Systems: Georg Fischer LLC]**
 - d. **[WATTS; A Watts Water Technologies Company]**
 - e. **[Zurn Industries, LLC]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Capitol Manufacturing Company]**
 - b. **[Epco Sales, Inc]**
 - c. **[GF Piping Systems: Georg Fischer LLC]**
 - d. **[WATTS; A Watts Water Technologies Company]**
 - e. **[Zurn Industries, LLC]**
 - f. **<Insert manufacturer's name>**
3. Description: Factory-fabricated, bolted, companion-flange assembly, **NPS 2-1/2 to NPS 4 (DN 65 to DN 100)** and larger.
 - a. Pressure Rating: **[150 psig (1035 kPa) minimum][175 psig (1200 kPa) minimum][300 psig (2070 kPa)]**.
 - b. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Kits:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Advance Products & Systems, LLC]**
 - b. **[CALPICO, Inc.]**
 - c. **[GF Piping Systems: Georg Fischer LLC]**
 - d. **[GPT; a division of EnPRO Industries]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Advance Products & Systems, LLC]**

- b. [CALPICO, Inc.]
 - c. [GF Piping Systems: Georg Fischer LLC]
 - d. [GPT; a division of EnPRO Industries]
 - e. <Insert manufacturer's name>
- 3. Description: Nonconducting materials for field assembly of companion flanges, **NPS 2-1/2 (DN 65)** and larger.
 - a. Pressure Rating: **[150 psig (1035 kPa) minimum]**<Insert pressure>.
 - b. Gasket: Neoprene or phenolic.
 - c. Bolt Sleeves: Phenolic or polyethylene.
 - d. Washers: Phenolic with steel backing washers.
- E. Dielectric Couplings:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. [CALPICO, Inc.]
 - b. [Lochinvar, LLC]
 - c. <Insert manufacturer's name>
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. [CALPICO, Inc.]
 - b. [Lochinvar, LLC]
 - c. <Insert manufacturer's name>
 - 3. Description: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining, **NPS 3 (DN 80)** and smaller.
 - a. Pressure Rating: **300 psig (2070 kPa) at 225 deg F (107 deg C)**.
 - b. End Connections: Threaded.
- F. Dielectric Nipples:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. [Elster Perfection; Honeywell]
 - b. [Precision Plumbing Products]
 - c. [Victaulic Company]
 - d. <Insert manufacturer's name>
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. [Elster Perfection; Honeywell]
 - b. [Precision Plumbing Products]

- c. [Victaulic Company]
- d. <Insert manufacturer's name>

3. Description: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining.

- a. Pressure Rating: [300 psig (2070 kPa) at 225 deg F (107 deg C)]<Insert pressure and temperature>.
- b. End Connections: Threaded or grooved.

2.4 SLEEVES

- A. Mechanical sleeve seals for pipe penetrations are specified in Section 220500 "Common Work Results for Plumbing."
- B. Galvanized-Steel Sheet Sleeves: **0.0239-inch (0.6-mm)** minimum thickness; round tube closed with welded longitudinal joint.
- C. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, galvanized, plain ends.
- D. Cast-Iron Sleeves: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
- E. Molded PVC Sleeves: Permanent, with nailing flange for attaching to wooden forms.
- F. PVC Pipe Sleeves: ASTM D1785, Schedule 40.
- G. Molded PE Sleeves: Reusable, PE, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

2.5 IDENTIFICATION DEVICES

- A. General: Products specified are for applications referenced in other utilities Sections. If more than single type is specified for listed applications, selection is Installer's option.
- B. Equipment Nameplates: Metal permanently fastened to equipment with data engraved or stamped.
 - 1. Data: Manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and essential data.
 - 2. Location: Accessible and visible.
- C. Stencils: Standard stencils prepared with letter sizes complying with recommendations in ASME A13.1. Minimum letter height is **1-1/4 inches (30 mm)** for ducts, and **3/4 inch (20 mm)** for access door signs and similar operational instructions.
 - 1. Material: [Fiberboard][Brass].
 - 2. Stencil Paint: Exterior, oil-based, alkyd-gloss black enamel, unless otherwise indicated. Paint may be in pressurized spray-can form.
 - 3. Identification Paint: Exterior, oil-based, alkyd enamel in colors according to ASME A13.1, unless otherwise indicated.
- D. Snap-on Plastic Pipe Markers: Manufacturer's standard preprinted, semirigid, snap-on type. Include color-coding according to ASME A13.1, unless otherwise indicated.

- E. Pressure-Sensitive Pipe Markers: Manufacturer's standard preprinted, color-coded, pressure-sensitive-vinyl type with permanent adhesive.
- F. Pipes with OD, Including Insulation, Less Than **6 Inches (150 mm)**: Full-band pipe markers, extending 360 degrees around pipe at each location.
- G. Pipes with OD, Including Insulation, **6 Inches (150 mm)** and Larger: Either full-band or strip-type pipe markers, at least three times letter height and of length required for label.
- H. Lettering:
 - 1. Manufacturer's standard preprinted captions as selected by Architect.
 - 2. Use piping system terms indicated and abbreviate only as necessary for each application length.
 - a. Arrows: Either integrally with piping system service lettering to accommodate both directions of flow, or as separate unit on each pipe marker to indicate direction of flow.
- I. Plastic Tape: Manufacturer's standard color-coded, pressure-sensitive, self-adhesive vinyl tape, at least **3 mils (0.08 mm)** thick.
 - 1. Width: **1-1/2 inches (40 mm)** on pipes with OD, including insulation, less than **6 inches (150 mm)**; **2-1/2 inches (65 mm)** for larger pipes.
 - 2. Color: Comply with ASME A13.1, unless otherwise indicated.
- J. Valve Tags: Stamped or engraved with **1/4-inch (6.4-mm)** letters for piping system abbreviation and **1/2-inch (13-mm)** sequenced numbers. Include **5/32-inch (4-mm)** hole for fastener.
 - 1. Material:
 - a. **0.032-inch- (0.8-mm-)** thick, **[polished brass][or][aluminum]**.
 - b. **0.0375-inch- (1-mm-)** thick stainless steel.
 - c. **3/32-inch- (2.4-mm-)** thick plastic laminate with 2 black surfaces and a white inner layer.
 - d. Valve manufacturer's standard solid plastic.
 - 2. Size: **1-1/2 inches (40 mm)** in diameter, unless otherwise indicated.
 - 3. Shape: As indicated for each piping system.
- K. Valve Tag Fasteners: Brass, wire-link or beaded chain; or brass S-hooks.
- L. Engraved Plastic-Laminate Signs: ASTM D709, Type I, cellulose, paper-base, phenolic-resin-laminate engraving stock; Grade ES-2, black surface, black phenolic core, with white melamine subcore, unless otherwise indicated. Fabricate in sizes required for message. Provide holes for mechanical fastening.
 - 1. Engraving: Engraver's standard letter style, of sizes and with terms to match equipment identification.
 - 2. Thickness:
 - a. **[1/16 inch (1.6 mm)][1/8 inch (3 mm)]**, unless otherwise indicated.
 - b. **1/16 inch (1.6 mm)**, for units up to **20 sq. in. (130 sq. cm)** or **8 inches (200 mm)** in length, and **1/8 inch (3 mm)** for larger units.
 - 3. Fasteners: Self-tapping, stainless steel screws or contact-type permanent adhesive.
- M. Plastic Equipment Markers: Manufacturer's standard laminated plastic, in the following color codes:

1. Green: Cooling equipment and components.
2. Yellow: Heating equipment and components.
3. Brown: Energy reclamation equipment and components.
4. Blue: Equipment and components that do not meet criteria above.
5. Hazardous Equipment: Use colors and designs recommended by ASME A13.1.
6. Terminology: Match schedules as closely as possible. Include the following:
 - a. Name and plan number.
 - b. Equipment service.
 - c. Design capacity.
 - d. Other design parameters such as pressure drop, entering and leaving conditions, and speed.
7. Size: **2-1/2 by 4 inches (65 by 100 mm)** for control devices, dampers, and valves; **4-1/2 by 6 inches (115 by 150 mm)** for equipment.

N. Plasticized Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with mat finish suitable for writing.

1. Size: **3-1/4 by 5-5/8 inches (83 by 143 mm)**.
2. Fasteners: Brass grommets and wire.
3. Nomenclature: Large-size primary caption such as DANGER, CAUTION, or DO NOT OPERATE.

O. Lettering and Graphics: Coordinate names, abbreviations, and other designations used in piped utility identification with corresponding designations indicated. Use numbers, letters, and terms indicated for proper identification, operation, and maintenance of piped utility systems and equipment.

1. Multiple Systems: Identify individual system number and service if multiple systems of same name are indicated.

2.6 GROUT

A. Description: ASTM C1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.

1. Characteristics: Post hardening, volume adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: **5000-psi (34.5-MPa)**, 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

2.7 FLOWABLE FILL

A. Description: Low-strength-concrete, flowable-slurry mix.

1. Cement: ASTM C150, Type I, portland.
2. Density: **[115- to 145-lb/cu. ft. (1840- to 2325-kg/cu. m)]<Insert value>**.
3. Aggregates:
 - a. ASTM C33, natural sand, fine and crushed gravel or stone, coarse.
 - b. ASTM C33, natural sand, fine.
4. Admixture: ASTM C618, fly-ash mineral.
5. Water: Comply with ASTM C94/C94M.

6. Strength: [100 to 200 psig (690 to 1380 kPa)]<Insert value> at 28 days.

PART 3 - EXECUTION

3.1 PIPED UTILITY DEMOLITION

- A. Refer to Section 024119 "Selective Demolition" for general demolition requirements and procedures.
- B. Disconnect, demolish, and remove piped utility systems, equipment, and components indicated to be removed.
 - 1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
 - 2. Piping to Be Abandoned in Place: Drain piping. Fill abandoned piping with flowable fill, and cap or plug piping with same or compatible piping material.
 - 3. Equipment to Be Removed: Disconnect and cap services and remove equipment.
 - 4. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make operational.
 - 5. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.
- C. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.2 DIELECTRIC FITTING APPLICATIONS

- A. Dry Piping Systems: Connect piping of dissimilar metals with the following:
 - 1. NPS 2 (DN 50) and Smaller: Dielectric unions.
 - 2. NPS 2-1/2 to NPS 12 (DN 65 to DN 300): Dielectric flanges[**or dielectric flange kits**].
- B. Wet Piping Systems: Connect piping of dissimilar metals with the following:
 - 1. NPS 2 (DN 50) and Smaller: Dielectric [**couplings**][**couplings or dielectric nipples**][**nipples**].
 - 2. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Dielectric nipples.
 - 3. NPS 2-1/2 to NPS 8 (DN 65 to DN 200): Dielectric nipples[**or dielectric flange kits**].
 - 4. NPS 10 and NPS 12 (DN 250 and DN 300): Dielectric flange kits.

3.3 INSTALLATION OF PIPING

- A. Install piping according to the following requirements and utilities Sections specifying piping systems.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on the Coordination Drawings.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping to permit valve servicing.

- E. Install piping at indicated slopes.
- F. Install piping free of sags and bends.
- G. Install fittings for changes in direction and branch connections.
- H. Select system components with pressure rating equal to or greater than system operating pressure.
- I. Sleeves are not required for core-drilled holes.
- J. Permanent sleeves are not required for holes formed by removable PE sleeves.
- K. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.
 - 1. Cut sleeves to length for mounting flush with both surfaces.
 - a. Exception: Extend sleeves installed in floors of equipment areas or other wet areas [2 inches (50 mm)]<Insert dimension> above finished floor level.
 - 2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
 - a. Pipe Sleeves: [PVC][Steel]. For pipes smaller than NPS 6 (DN 150).
 - b. Steel Sheet Sleeves: For pipes NPS 6 (DN 150) and larger, penetrating gypsum-board partitions.
- L. Verify final equipment locations for roughing-in.
- M. Refer to equipment specifications in other Sections for roughing-in requirements.

3.4 PIPING JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and utilities Sections specifying piping systems.
- B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- D. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- E. Welded Joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
- F. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

- G. Grooved Joints: Assemble joints with grooved-end pipe coupling with coupling housing, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.
- H. Soldered Joints: Apply ASTM B813 water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B828 or CDA's "Copper Tube Handbook," using lead-free solder alloy (0.20 percent maximum lead content) complying with ASTM B32.
- I. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
- J. Pressure-Sealed Joints: Assemble joints for plain-end copper tube and mechanical pressure seal fitting with proprietary crimping tool to according to fitting manufacturer's written instructions.
- K. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
 - 1. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements.
 - 2. ABS Piping: Join according to ASTM D2235 and ASTM D2661 appendixes.
 - 3. CPVC Piping: Join according to ASTM D2846/D2846M Appendix.
 - 4. PVC Pressure Piping: Join schedule number ASTM D1785, PVC pipe and PVC socket fittings according to ASTM D2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D2855.
 - 5. PVC Nonpressure Piping: Join according to ASTM D2855.
 - 6. PVC to ABS Nonpressure Transition Fittings: Join according to ASTM D3138 Appendix.
- L. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D3139.
- M. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D3212.
- N. Plastic Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D2657.
 - 1. Plain-End PE Pipe and Fittings: Use butt fusion.
 - 2. Plain-End PE Pipe and Socket Fittings: Use socket fusion.
- O. Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

3.5 PIPING CONNECTIONS

- A. Make connections according to the following, unless otherwise indicated:
 - 1. Install unions, in piping **NPS 2 (DN 50)** and smaller, adjacent to each valve and at final connection to each piece of equipment.
 - 2. Install flanges, in piping **NPS 2-1/2 (DN 65)** and larger, adjacent to flanged valves and at final connection to each piece of equipment.
 - 3. Install dielectric fittings at connections of dissimilar metal pipes.

3.6 INSTALLATION OF EQUIPMENT

- A. Install equipment level and plumb, unless otherwise indicated.
- B. Install equipment to facilitate service, maintenance, and repair or replacement of components. Connect

equipment for ease of disconnecting, with minimum interference with other installations. Extend grease fittings to an accessible location.

- C. Install equipment to allow right of way to piping systems installed at required slope.

3.7 PAINTING

- A. Painting of piped utility systems, equipment, and components is specified in Section 099113 "Exterior Painting," Section 099123 "Interior Painting," and Section 099600 "High-Performance Coatings."
- B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.8 IDENTIFICATION

- A. Piping Systems: Install pipe markers on each system. Include arrows showing normal direction of flow.
 - 1. Stenciled Markers: According to ASME A13.1.
 - 2. Plastic markers, with application systems. Install on insulation segment if required for hot noninsulated piping.
 - 3. Locate pipe markers on exposed piping according to the following:
 - a. Near each valve and control device.
 - b. Near each branch, excluding short takeoffs for equipment and terminal units. Mark each pipe at branch if flow pattern is not obvious.
 - c. Near locations where pipes pass through walls or floors or enter inaccessible enclosures.
 - d. At manholes and similar access points that permit view of concealed piping.
 - e. Near major equipment items and other points of origination and termination.
- B. Equipment: Install engraved plastic-laminate sign or equipment marker on or near each major item of equipment.
 - 1. Lettering Size: Minimum **1/4 inch (6.4 mm)** high for name of unit if viewing distance is less than **24 inches (610 mm)**, **1/2 inch (13 mm)** high for distances up to **72 inches (1800 mm)**, and proportionately larger lettering for greater distances. Provide secondary lettering two-thirds to three-fourths of size of principal lettering.
 - 2. Text of Signs: Provide name of identified unit. Include text to distinguish among multiple units, inform user of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.
- C. Adjusting: Relocate identifying devices that become visually blocked by work of this or other Divisions.

3.9 CONCRETE BASES

- A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
 - 1. Construct concrete bases of dimensions indicated, but not less than **4 inches (100 mm)** larger in both directions than supported unit.
 - 2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch (450-mm)** centers around the full perimeter of base.

3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
7. Use [3000-psi (20.7-MPa)]<Insert strength>, 28-day compressive-strength concrete and reinforcement as specified in Section 033000 "Cast-in-Place Concrete."

3.10 ERECTION OF METAL SUPPORTS AND ANCHORAGES

- A. Refer to Section 055000 "Metal Fabrications" for structural steel.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor piped utility materials and equipment.
- C. Field Welding: Comply with AWS D1.1/D1.1M.

3.11 GROUTING

- A. Mix and install grout for equipment base bearing surfaces, pump and other equipment base plates, and anchors.
- B. Clean surfaces that will come into contact with grout.
- C. Provide forms as required for placement of grout.
- D. Avoid air entrapment during placement of grout.
- E. Place grout, completely filling equipment bases.
- F. Place grout on concrete bases and provide smooth bearing surface for equipment.
- G. Place grout around anchors.
- H. Cure placed grout.

END OF SECTION 33 05 00 00



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Task	Specification	Specification Description
33 05 05 43	33 01 30 41	Cleaning of Sewers
33 05 07 00	33 05 00 00	Common Work Results For Utilities
33 05 07 13	33 05 00 00	Common Work Results For Utilities
33 05 07 23	33 05 00 00	Common Work Results For Utilities
33 05 07 24	33 05 00 00	Common Work Results For Utilities
33 05 09 00	33 05 00 00	Common Work Results For Utilities
33 05 09 23	33 05 00 00	Common Work Results For Utilities
33 05 09 33	33 05 00 00	Common Work Results For Utilities
33 05 16 00	33 05 00 00	Common Work Results For Utilities
33 05 17 00	33 05 00 00	Common Work Results For Utilities
33 05 19 00	33 05 00 00	Common Work Results For Utilities
33 05 24 00	33 05 00 00	Common Work Results For Utilities
33 05 24 23	33 05 00 00	Common Work Results For Utilities
33 05 27 00	33 05 00 00	Common Work Results For Utilities
33 05 27 13	33 05 00 00	Common Work Results For Utilities
33 05 27 23	33 05 00 00	Common Work Results For Utilities
33 05 27 33	33 05 00 00	Common Work Results For Utilities
33 05 31 00	33 05 00 00	Common Work Results For Utilities
33 05 31 11	33 05 00 00	Common Work Results For Utilities
33 05 31 13	33 05 00 00	Common Work Results For Utilities
33 05 31 16	33 05 00 00	Common Work Results For Utilities
33 05 33 00	33 05 00 00	Common Work Results For Utilities
33 05 33 13	33 05 00 00	Common Work Results For Utilities
33 05 33 23	33 05 00 00	Common Work Results For Utilities
33 05 33 33	33 05 00 00	Common Work Results For Utilities
33 05 33 36	33 05 00 00	Common Work Results For Utilities
33 05 33 53	33 05 00 00	Common Work Results For Utilities
33 05 33 56	33 05 00 00	Common Work Results For Utilities
33 05 33 63	33 05 00 00	Common Work Results For Utilities
33 05 39 00	33 05 00 00	Common Work Results For Utilities
33 05 39 13	33 05 00 00	Common Work Results For Utilities
33 05 39 41	33 05 00 00	Common Work Results For Utilities
33 05 39 46	33 05 00 00	Common Work Results For Utilities
33 05 41 00	33 05 00 00	Common Work Results For Utilities
33 05 61 00	33 05 00 00	Common Work Results For Utilities
33 05 61 00	33 42 00 00	Stormwater Conveyance
33 05 63 00	26 05 43 00	Underground Ducts and Utility Structures
33 05 63 00	33 05 00 00	Common Work Results For Utilities
33 05 81 00	26 05 43 00	Underground Ducts and Utility Structures
33 05 81 00	33 05 00 00	Common Work Results For Utilities
33 05 81 00	33 42 00 00	Stormwater Conveyance
33 05 83 00	26 05 43 00	Underground Ducts and Utility Structures
33 05 83 00	33 05 00 00	Common Work Results For Utilities
33 05 83 00	33 42 00 00	Stormwater Conveyance
33 05 84 00	33 05 00 00	Common Work Results For Utilities
33 05 84 00	33 42 00 00	Stormwater Conveyance
33 05 97 00	33 05 00 00	Common Work Results For Utilities
33 05 97 16	33 05 00 00	Common Work Results For Utilities
33 05 97 23	33 05 00 00	Common Work Results For Utilities



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SECTION 33 11 13 00 - REHABILITATION OF WATER SUPPLY WELLS

1.1 GENERAL

A. Description Of Work

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

B. Submittals

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

1.2 PRODUCTS

- A.** Repair and Replacement Parts shall be clean, free of rust and scale, and of proper size and design for the specific well repair to be made.

1.3 EXECUTION

- A.** Cement Grout may be hand mixed at the site.
- B.** Level and Re-Sod Area, after heavy equipment has been used or if chemicals have been spilled.
- C.** Abandoned Wells shall be sealed in accordance with AWWA A100.
- D.** Disinfect well, after repair, in accordance with AWWA A100.

END OF SECTION 33 11 13 00



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SECTION 33 11 13 00A - POTABLE WATER SUPPLY WELLS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Well casings.
2. Grout.
3. Water well screens.
4. Pack materials.
5. Jet well pumps.
6. Line-shaft well pumps.
7. Submersible well pumps.

1.2 ALLOWANCES

A. Allowance amounts and quantities are specified in Section 012100 "Allowances."

1. Water Supply Well Depth Allowance: Install complete and functional well to depth indicated in Section 012100 "Allowances." If water supply well depths vary from quantities in the allowance, the Contract Sum will be adjusted according to unit prices listed in "Unit Prices" Article. Include the following in the Contract Amount:
 - a. Labor for water supply well installation.
 - b. Furnishing and installing casing materials, grout, well screen, and packing materials in required diameter to comply with minimum performance requirements specified in the Section Text.
 - c. Furnishing and installing well pump.

B. Water supply wells and well pumps are covered by cash allowance.[**Allowance includes labor and materials.**]

C. Well pumps are covered by cash allowance.[**Allowance includes labor and materials.**]

1.3 UNIT PRICES

- A. Unit-Price Amounts: As stipulated in the Form of Agreement.
- B. Measurement and Payment Procedures: Specified in Section 012200 "Unit Prices."
- C. Measurement Units for Water Supply Wells, Casings, and Grout: Per linear **foot (meter)** of well depth.

1.4 DEFINITIONS

- A. ABS: Acrylonitrile-butadiene-styrene plastic.
- B. PA: Polyamide (nylon) plastic.

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- C. PE: Polyethylene plastic.
- D. PP: Polypropylene plastic.

1.5 ACTION SUBMITTALS

- A. Product Data: Submit certified performance curves and rated capacities of selected well pumps and furnished specialties and accessories for each type and size of well pump indicated.
- B. Shop Drawings: For well pumps. Show layout and connections.
 - 1. Include diagrams for power, signal, and control wiring.
 - 2. Setting Drawings: Include templates and directions for installing foundation bolts, anchor bolts, and other anchorages.

1.6 INFORMATIONAL SUBMITTALS

- A. Field Quality-Control Reports:
 - 1. For each well pump, include the following:
 - a. Substrata formations.
 - b. Water-bearing formations.
 - c. Water levels.
 - d. Laboratory water analysis.
 - e. Well-screen analysis.
 - f. Performance test data.

1.7 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each well pump to include in emergency, operation, and maintenance manuals.
 - 1. Project Record Documents: Record the following data for each water supply well:
 - a. Casings: Material, diameter, thickness, weight per **foot (meter)** of length, and depth below grade.
 - b. Screen: Material, construction, diameter, and opening size.
 - c. Pumping Test: Static water level, maximum safe yield, and drawdown at maximum yield.
 - d. Log: Formation log indicating strata encountered.
 - e. Alignment: Certification that well is aligned and plumb within specified tolerances.

1.8 QUALITY ASSURANCE

- A. Well Driller Qualifications: An experienced water supply well driller licensed in the jurisdiction where Project is located.
- B. Testing Agency Qualifications: Certified by the EPA or State to analyze drinking water for compliance monitoring.

1.9 FIELD CONDITIONS

- A. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:
 - 1. Notify **[Architect][Construction Manager][Owner]** no fewer than **[seven]<Insert number>** days in advance of proposed interruption of water service.
 - 2. Do not proceed with interruption of water service without **[Architect's][Construction Manager's][Owner's]** written permission.
- B. Well Drilling Water: **[Owner will provide][Provide]** temporary water and piping for drilling purposes. Provide necessary piping for water supply.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with AWWA A100 for water supply wells.

2.2 PERFORMANCE REQUIREMENTS

- A. Minimum Tested Water Supply Well Performance Capacity: **<Insert capacity in gpm (L/s)>**.

2.3 WELL CASINGS

- A. Steel Casing: AWWA C200, single ply, steel pipe with threaded ends and threaded couplings for threaded joints.
- B. ABS Casing: ASTM F480, ABS, Schedule **[40][80]** bell-and-spigot pipe and couplings for solvent-cemented joints.
- C. PVC Casing: ASTM F480[**and NSF 14,**] PVC, Schedule **[40][80]** bell-and-spigot pipe and couplings for solvent-cemented joints.[**Include NSF listing mark "NSF wc."**]
- D. Pitless Adapter: Fitting, of shape required to fit onto casing, with waterproof seals.
- E. Pitless Unit: Factory-assembled equipment that includes pitless adapter.
- F. Well Seals: Casing cap, with holes for piping and cables, that fits into top of casing and is removable, waterproof, and vermin proof.

2.4 GROUT

- A. Cement: ASTM C150/C150M, Type II.
- B. Aggregates: ASTM C33/C33M, fine and coarse grades.

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- C. Water: Potable.

2.5 WATER WELL SCREENS

- A. Screen Material: Fabricated of ASTM A666, Type 304 stainless steel[, **welded; with continuous-slot, V-shaped openings that widen inwardly**][**tube; with slotted or perforated surface and designed for well-screen applications**].
 - 1. Screen Couplings: Butt-type, stainless steel coupling rings.
 - 2. Screen Fittings: Screen, with necessary fittings, closes bottom and makes tight seal between top of screen and well casing.
 - 3. Maximum Entering Velocity: **0.1 fps (0.03 m/s)**.

2.6 PACK MATERIALS

- A. Coarse, uniformly graded filter sand, maximum **1/8 inch (3 mm)** in diameter.
- B. Fine gravel, maximum **1/4 inch (6 mm)** in diameter.

2.7 JET WELL PUMPS

- A. Description: [**Shallow**][**Deep**]-well-design, jet well pump; self-priming; centrifugal pump capable of continuous operation.
- B. Manufacturers: Subject to compliance with requirements, [**provide products by the following**][**provide products by one of the following**][**available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following**]:
 - 1. [A.Y. McDonald Mfg. Co.]
 - 2. [Goulds Pumps; a brand of Xylem, Inc.]
 - 3. [Jacuzzi Inc.]
 - 4. [Myers, F.E.; Pentair Ltd]
 - 5. [Pentair Pump Group; Layne/Verti-Line]
 - 6. [Sta-Rite Industries, Inc.; Pentair Ltd.]
 - 7. <Insert manufacturer's name>
- C. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1. [A.Y. McDonald Mfg. Co.]
 - 2. [Goulds Pumps; a brand of Xylem, Inc.]
 - 3. [Jacuzzi Inc.]
 - 4. [Myers, F.E.; Pentair Ltd]
 - 5. [Pentair Pump Group; Layne/Verti-Line]
 - 6. [Sta-Rite Industries, Inc.; Pentair Ltd.]
 - 7. <Insert manufacturer's name>
- D. Housing: Cast iron.
- E. Impeller: [**Single stage**][**Multistage**], centrifugal; fabricated of corrosion-resistant materials.

- F. Seals: Mechanical.
- G. Shaft: Stainless steel.
- H. Motor: Manufacturer's standard, NEMA MG 1 motor, panel, and accessories.
- I. Motor Controls: Electronic; variable speed.
- J. Check valve, ejector, and pressure-control valve.
- K. Pump Capacities and Characteristics:
 - 1. Capacity: <Insert gpm (L/s)>.
 - 2. Discharge Head: <Insert psig (kPa)>.
 - 3. Discharge Size: <Insert NPS (DN)>.
 - 4. Speed: <Insert rpm>.
 - 5. Motor Horsepower: <Insert value>.
 - 6. Lift: <Insert feet (m)>.
 - 7. Pressure Rating: <Insert psig (kPa)>.
 - 8. Volts: <Insert value>.
 - 9. Phases: <Insert value>.
 - 10. Hertz: <Insert value>.
 - 11. Full-Load Amperes: <Insert value>.
 - 12. Minimum Circuit Ampacity: <Insert value>.
 - 13. Maximum Overcurrent Protection: <Insert amperage>.
 - 14. Compression Tank Capacity: <Insert gal. (L)>.
- L. Pump Accessories:
 - 1. Compression Tanks:
 - a. Comply with requirements in Section 221223 "Facility Indoor Potable-Water Storage Tanks."
 - b. Precharged butyl rubber diaphragm, steel shell, fused polymeric lining, and **100-psig (690-kPa)** working pressure.
 - 2. Pressure Switches: For pump control; for installation in piping.
 - 3. Water Piping:
 - a. ASTM A53/A53M, Schedule 40, galvanized-steel pipe with threaded ends.
 - 1) Cast-Iron Fittings: ASME B16.4, threaded, galvanized.
 - b. ASTM D2239, SDR Numbers 5.3, 7, or 9 PE pipe; made with PE compound number required to give pressure rating not less than [**160 psig (1100 kPa)**][**200 psig (1380 kPa)**]. Include NSF listing mark "NSF pw."
 - 1) Fittings for PE Pipe: ASTM D2609, made of PA, PP, or PVC with serrated, male insert ends matching inside of pipe. Include bands or crimp rings.

2.8 LINE-SHAFT WELL PUMPS

- A. Description: Line-shaft, [**water**][**oil**]-lubricated, vertical-turbine well pump.

- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. **[American Turbine Pump Co]**
 2. **[Crane Pumps & Systems]**
 3. **[Fairbanks Morse]**
 4. **[Flowserve Corporation]**
 5. **[Goulds Pumps; a brand of Xylem, Inc.]**
 6. **[Peerless Pump Company]**
 7. **[Pentair Pump Group; Layne/Verti-Line]**
 8. **[Sulzer Pumps Inc.]**
 9. **[WDM Pumps]**
 10. **<Insert manufacturer's name>**
- C. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. **[American Turbine Pump Co]**
 2. **[Crane Pumps & Systems]**
 3. **[Fairbanks Morse]**
 4. **[Flowserve Corporation]**
 5. **[Goulds Pumps; a brand of Xylem, Inc.]**
 6. **[Peerless Pump Company]**
 7. **[Pentair Pump Group; Layne/Verti-Line]**
 8. **[Sulzer Pumps Inc.]**
 9. **[WDM Pumps]**
 10. **<Insert manufacturer's name>**
- D. Standards: HI 2.1-2.2 and HI 2.3.
- E. Impeller Material: **[Stainless steel][Carbon steel][Bronze]**.
- F. Pump Base: Cast iron or fabricated steel.
- G. Column Pipe: ASTM A53/A53M, Schedule 40, galvanized-steel pipe with threaded ends and cast-iron or steel threaded couplings.
- H. Capacities and Characteristics:
1. Capacity: **<Insert gpm (L/s)>**.
 2. Discharge Head: **<Insert psig (kPa)>**.
 3. Discharge Size: **<Insert NPS (DN)>**.
 4. Speed: **<Insert rpm>**.
 5. Motor Horsepower: **<Insert value>**.
 6. Lift: **<Insert feet (m)>**.
 7. Pressure Rating: **<Insert psig (kPa)>**.
 8. Volts: **<Insert value>**.
 9. Phases: **<Insert value>**.
 10. Hertz: **<Insert value>**.
 11. Full-Load Amperes: **<Insert value>**.
 12. Minimum Circuit Ampacity: **<Insert value>**.
 13. Maximum Overcurrent Protection: **<Insert amperage>**.

2.9 SUBMERSIBLE WELL PUMPS

- A. Description: Submersible, vertical-turbine well pump.
- B. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1. **[A.Y. McDonald Mfg. Co.]**
 - 2. **[Aermotor]**
 - 3. **[American Turbine Pump Co]**
 - 4. **[Crane Pumps & Systems]**
 - 5. **[Goulds Pumps; a brand of Xylem, Inc.]**
 - 6. **[GRUNDFOS CBS Inc.]**
 - 7. **[Jacuzzi Inc.]**
 - 8. **[Myers, F.E.; Pentair Ltd]**
 - 9. **[Peerless Pump Company]**
 - 10. **[Pentair Pump Group; Layne/Verti-Line]**
 - 11. **[Reda Productions Services; Schlumberger Limited]**
 - 12. **[Sta-Rite Industries, Inc.; Pentair Ltd.]**
 - 13. **[Sulzer Pumps Inc.]**
 - 14. **[Weber Industries, Inc]**
 - 15. **[Wilo USA LLC]**
 - 16. **<Insert manufacturer's name>**
- C. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - 1. **[A.Y. McDonald Mfg. Co.]**
 - 2. **[Aermotor]**
 - 3. **[American Turbine Pump Co]**
 - 4. **[Crane Pumps & Systems]**
 - 5. **[Goulds Pumps; a brand of Xylem, Inc.]**
 - 6. **[GRUNDFOS CBS Inc.]**
 - 7. **[Jacuzzi Inc.]**
 - 8. **[Myers, F.E.; Pentair Ltd]**
 - 9. **[Peerless Pump Company]**
 - 10. **[Pentair Pump Group; Layne/Verti-Line]**
 - 11. **[Reda Productions Services; Schlumberger Limited]**
 - 12. **[Sta-Rite Industries, Inc.; Pentair Ltd.]**
 - 13. **[Sulzer Pumps Inc.]**
 - 14. **[Weber Industries, Inc]**
 - 15. **[Wilo USA LLC]**
 - 16. **<Insert manufacturer's name>**
- D. Standards: HI 2.1-2.2 and HI 2.3.
- E. Impeller Material: **[Stainless steel][Silicon bronze]**.
- F. Motor: Capable of continuous operation under water, with protected submersible power cable.
- G. Column Pipe: ASTM A53/A53M, Schedule 40, galvanized-steel pipe with threaded ends and cast-iron or steel threaded couplings.
- H. Discharge Piping: ASTM D2239, SDR Numbers 5.3, 7, or 9 PE pipe; made with PE compound number required to give pressure rating not less than **[160 psig (1100 kPa)][200 psig (1380 kPa)]**. Include NSF

listing mark "NSF pw."

1. Insert Fittings for PE Pipe: ASTM D2609, made of PA, PP, or PVC with serrated, male insert ends matching inside of pipe. Include bands or crimp rings.

I. Capacities and Characteristics:

1. Capacity: **<Insert gpm (L/s)>**.
2. Discharge Head: **<Insert psig (kPa)>**.
3. Discharge Size: **<Insert NPS (DN)>**.
4. Speed: **<Insert rpm>**.
5. Motor Horsepower: **<Insert value>**.
6. Lift: **<Insert feet (m)>**.
7. Pressure Rating: **<Insert psig (kPa)>**.
8. Volts: **<Insert value>**.
9. Phases: **<Insert value>**.
10. Hertz: **<Insert value>**.
11. Full-Load Amperes: **<Insert value>**.
12. Minimum Circuit Ampacity: **<Insert value>**.
13. Maximum Overcurrent Protection: **<Insert amperage>**.

2.10 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 220500 "Common Work Results for Plumbing."
 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 2. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in electrical Sections.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Pilot-Hole Data: Review pilot-hole test analysis furnished by Owner.
- B. Neighborhood Well Data: Review operating and test analyses.

3.2 INSTALLATION OF WELLS

- A. Construct well using **[cable-tool][rotary drilling][reverse-rotary drilling][driven]** method.
- B. Take samples of substrata formation at **10-foot (3-m)** intervals and at changes in formation throughout entire depth of each water supply well. Carefully preserve samples on-site in glass jars properly labeled for identification.
- C. Excavate for mud pit or provide aboveground structure, acceptable to authorities having jurisdiction, to allow settlement of cuttings and circulation of drill fluids back to well without discharging to on-site waterways.

- D. Enlarge pilot hole and install permanent casing, screen, and grout. Install first section of casing with hardened steel driving shoe of an OD slightly larger than casing couplings if threaded couplings are used.
- E. Set casing and liners round, plumb, and true to line.
- F. Join casing pipe as follows:
 - 1. Ream ends of pipe and remove burrs.
 - 2. Remove scale, slag, dirt, and debris from inside and outside casing before installation.
 - 3. Cut bevel in ends of casing pipe and make threaded joints.
 - 4. Clean and make solvent-cemented joints.
- G. Mix grout in proportions of **1 cu. ft. (0.03 cu. m)** or a **94-lb (42.6-kg)** sack of cement with **5 to 6 gal. (19 to 23 L)** of water. Bentonite clay may be added in amounts of **3 to 5 lb/cu. ft. (1.4 to 2.3 kg/0.03 cu. m)** for a **94-lb (42.6-kg)** sack of cement. If bentonite clay is added, water may be increased to **6.5 gal./cu. ft. (25 L/0.03 cu. m)** of cement.
- H. Place grout continuously, from bottom to top surface, to ensure filling of annular space in one operation. Do not perform other operations in well within 72 hours after grouting of casing. When quick-setting cement is used, this period may be reduced to 24 hours.
- I. Provide permanent casing with temporary well cap. Install with top of casing **36 inches (910 mm)** above finished grade.
- J. Develop wells to maximum yield per **foot (meter)** of drawdown.
 - 1. Extract maximum practical quantity of sand, drill fluid, and other fine materials from water-bearing formation.
 - 2. Avoid settlement and disturbance of strata above water-bearing formation.
 - 3. Do not disturb sealing around well casings.
 - 4. Continue developing wells until water contains no more than 2 ppm of sand by weight when pumped at maximum testing rate.
- K. Install jet well pumps with ejector in or attached to pump housing. Place check valve on suction line to prevent drainage of compression tank.
- L. Install jet well pumps and pressure and suction lines. Install ejector where pressure and suction lines connect above well screen. Install check valve in suction line, or install foot valve below ejector, to prevent drainage of compression tank.
- M. Install **[line-shaft][submersible]** well pumps according to HI 2.4 and provide access for periodic maintenance.
 - 1. Before lowering permanent pump into well, lower a dummy pump that is slightly longer and wider than permanent pump to determine that permanent pump can be installed. Correct alignment problems.
 - 2. Before lowering permanent pump into well, start pump to verify correct rotation.
 - 3. Securely tighten discharge piping joints.
 - 4. Locate line-shaft well pump near well bottom; locate motor above grade. Install driver plate to correctly align motor and pump.
 - 5. Connect motor to submersible pump and locate near well bottom.
 - a. Connect power cable while connection points are dry and undamaged.
 - b. Do not damage power cable during installation; use cable clamps that do not have sharp edges.

- c. Install water-sealed surface plate that will support pump and piping.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in Section 331415 "Site Water Distribution Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
 - 1. Connect piping between well pump and water piping.
 - 2. Connect water distribution system in trench to well pipe at pitless **[adapter][unit]**.
 - 3. Connect building water distribution to well pipe inside well house.
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 WELL ABANDONMENT

- A. Comply with AWWA A100 when abandoning water supply wells. Fill and seal holes and casings, and restore ground surface to finished grade.
- B. Follow well-abandonment procedures of authorities having jurisdiction. Restore ground surface to finished grade.

3.5 FIELD QUALITY CONTROL

- A. Test Preparation: Clean water supply wells of foreign substances. Swab casings using alkalis, if necessary, to remove foreign substances.
- B. Testing Agency: **[Owner will engage][Engage]** a qualified testing agency to perform tests and inspections.
- C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- D. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
 - 1. Plumbness and Alignment Testing: Comply with AWWA A100.
 - 2. Furnish samples of water-bearing formation to testing laboratory and well-screen manufacturer for mechanical sieve analysis.
 - 3. Prepare reports on static level of ground water, level of water for various pumping rates, and depth to water-bearing strata.
 - 4. Performance Test Preparation: Start well pump and adjust controls and pressure setting. Replace damaged and malfunctioning controls and equipment.
 - 5. Performance Testing: Conduct final pumping tests after wells have been constructed, cleaned, and tested for plumbness and alignment.
 - a. Arrange to conduct tests, with seven days' advance notice, after test pump and auxiliary equipment have been installed. Note water-level elevations referred to for each assigned datum in wells.
 - b. Provide discharge piping to conduct water to locations where disposal will not create a

- nuisance or endanger adjacent property. Comply with requirements of authorities having jurisdiction.
 - c. Provide and maintain equipment of adequate size and type for measuring flow of water, such as weir box, orifice, or water meter.
 - d. Measure elevation to water level in wells.
 - e. Perform two bailer or air-ejection tests to determine expected yield. Test at depths with sufficient quantity of water to satisfy desired yields.
 - f. Test Pump: Variable capacity test pump with capacity equal to maximum expected yields at pressure equal to drawdown in wells, plus losses in pump columns and discharge pipes.
 - g. Start and adjust test pumps and equipment to required pumping rates.
 - h. Record readings of water levels in wells and pumping rates at [30]<Insert number>-minute maximum intervals throughout 24-hour minimum period.
 - i. Record maximum yields when drawdown is [60 inches (1500 mm)]<Insert dimension> above top of suction screens after designated times.
 - j. Operate pumping units continuously for [eight]<Insert number> hours after maximum drawdown is reached.
 - k. Record returning water levels in wells and plot curves of well recovery rates.
 - l. Remove sand, stones, and other foreign materials that may become deposited in wells after completing final tests.
 - E. Water supply well will be considered defective if it does not pass tests and inspections.
 - F. Prepare test and inspection reports.
 - G. Water Analysis Testing:
 - 1. [Owner will engage][Engage] a qualified testing agency to make bacteriological, physical, and chemical analyses of water from each finished well and report the results. Make analyses according to requirements of authorities having jurisdiction.
 - 2. Analyze water sample from each finished well for bacteriological, physical, and chemical quality and report the results. Make analyses according to requirements of authorities having jurisdiction.
- 3.6 CLEANING
- A. Disinfect water supply wells according to AWWA A100 and AWWA C654 before testing well pumps.
 - B. Follow water supply well disinfection procedures required by authorities having jurisdiction before testing well pumps.
- 3.7 PROTECTION
- A. Water Quality Protection: Prevent well contamination, including undesirable physical and chemical characteristics.
 - B. Ensure that mud pit will not leak or overflow into streams or wetlands. When well is accepted, remove mud and solids in mud pit from Project site and restore site to finished grade.
 - C. Provide casings, seals, sterilizing agents, and other materials to eliminate contamination; shut off contaminated water.
 - D. Exercise care to prevent breakdown or collapse of strata overlaying that from which water is to be drawn.
 - E. Protect water supply wells to prevent tampering and introducing foreign matter. Retain temporary well



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cap until installation is complete.

END OF SECTION 33 11 13 00A

SECTION 33 14 00 00 - SITE WATER DISTRIBUTION PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Copper tube and fittings.
2. Ductile-iron pipe and fittings.
3. PE pipe and fittings.
4. PVC pipe and fittings.
5. Fiberglass pipe and fittings.
6. Special pipe fittings.
7. Piping joining materials.
8. Piping specialties.
9. Encasement for piping.
10. Gate valves.
11. Gate valve accessories and specialties.
12. Check valves.
13. Detector check valves.
14. Butterfly valves.
15. Corporation valves, curb valves, and meter valves.
16. Water meters.
17. Water meter boxes.
18. Pressure-reducing valves.
19. Relief valves.
20. Vacuum breakers.
21. Backflow preventers.
22. Concrete vaults.
23. Protective enclosures.
24. Fire hydrants.
25. Flushing hydrants.
26. Sampling stations.
27. Fire department connections.
28. Alarm devices.

B. Related Requirements:

1. Section 031000 "Concrete Forming and Accessories."
2. Section 032000 "Concrete Reinforcing."
3. Section 211000 "Water-Based Fire-Suppression Systems."
4. Section 221216 "Facility Elevated, Potable-Water Storage Tanks."
5. Section 221219 "Facility Ground-Mounted, Potable-Water Storage Tanks."
6. Section 221223.11 "Facility Indoor Potable-Water Storage Tanks."
7. Section 315000 "Excavation Support and Protection."

1.2 DEFINITIONS

- A. CDA: Copper Development Association.
- B. EPDM: Ethylene-propylene-diene terpolymer rubber.

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- C. PA: Polyamide (nylon) plastic.
- D. PE: Polyethylene plastic.
- E. PP: Polypropylene plastic.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings:
 - 1. Detail precast concrete vault assemblies and indicate dimensions, method of field assembly, and components.
 - 2. Include diagrams for power, signal, and control wiring for alarms.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: For piping and specialties including relation to other services in same area, drawn to scale. Show piping and specialty sizes and valves, meter and specialty locations, and elevations.
- B. Field Quality-Control Submittals:
 - 1. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each type of product indicated.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Preparation for Transport: Prepare piping, valves, meters, backflow prevention devices, and fire hydrants according to the following:
 - 1. Ensure that piping, valves, meters, backflow prevention devices, and fire hydrants are dry and internally protected against rust and corrosion.
 - 2. Protect threaded ends and flange faces against damage.
 - 3. Set piping, valves, meters, backflow prevention devices, and fire hydrants in best position for handling and to prevent rattling.
- B. During Storage: Use precautions for piping, valves, meters, backflow prevention devices, and fire hydrants according to the following:
 - 1. Do not remove end protectors unless necessary for inspection; then reinstall for storage.
 - 2. Protect from weather. Store indoors and maintain temperature higher than ambient dew point temperature. Support off the ground or pavement in watertight enclosures when outdoor storage is necessary.
- C. Handling: Use sling to handle products if size requires handling by crane or lift. Rig products to avoid

damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

- D. Deliver piping with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe-end damage and to prevent entrance of dirt, debris, and moisture.
- E. Protect stored piping from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor when storing inside.
- F. Protect flanges, fittings, and specialties from moisture and dirt.
- G. Store plastic piping protected from direct sunlight. Support to prevent sagging and bending.

1.7 PROJECT CONDITIONS

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

1.8 COORDINATION

- A. Coordinate connection to water main with utility company.
- B. Content includes water-distribution piping and related components outside the building for **[domestic water service][fire-suppression water service][combined domestic water service and fire-suppression water service][and terminated 5 ft. (1.5 m) from building][and service entrance piping to a point 1 ft. (0.3 m) above finished floor][and service entrance piping to a point 1 ft. (0.3 m) inside finished wall]**. Terminate water-service piping with appropriate fitting for extension by **[Division 21][Division 22][Divisions 21 and 22]**.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Comply with requirements of utility company supplying water. Include tapping of water mains and backflow prevention.
- B. Comply with standards of authorities having jurisdiction for domestic water-service piping, including materials, installation, testing, and disinfection.
- C. Comply with standards of authorities having jurisdiction for fire-suppression water-service piping, including materials, hose threads, installation, and testing.
- D. Piping materials to bear label, stamp, or other markings of specified testing agency.
- E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended location and

application.

- F. Comply with ASTM F645 for selection, design, and installation of thermoplastic water piping.
- G. Comply with FM Approvals' "Approval Guide" and/or UL's "Fire Protection Equipment Directory" for fire-suppression water-service products.
- H. Comply with NFPA 24 for materials, installations, tests, flushing, and valve and hydrant supervision for fire-suppression water-service piping.
- I. All piping and appurtenances intended to convey or dispense water for human consumption are to comply with the U.S. Safe Drinking Water Act (SDWA), with requirements of the Authority Having Jurisdiction (AHJ), and with NSF 61/NSF 372 or are certified in compliance with NSF 61/NSF 372 by an ANSI-accredited third-party certification body, that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.

2.2 PIPING MATERIALS

- A. Comply with requirements in "Piping Applications" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and service sizes.
- B. Potable-water piping and components comply with NSF 14, NSF 61, and NSF 372. **[Include marking "NSF-pw" on piping.]**

2.3 COPPER TUBE AND FITTINGS

- A. Drawn-Temper Copper Tube: **[ASTM B88, Type K (ASTM B88M, Type A)][and][ASTM B88, Type L (ASTM B88M, Type B)].**
- B. Annealed-Temper Copper Tube: **[ASTM B88, Type K (ASTM B88M, Type A)][and][ASTM B88, Type L (ASTM B88M, Type B)].**
- C. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.
- D. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, pressure fittings.
- E. Copper Tube, Pressure-Seal-Joint Fittings:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[Elkhart Products Corporation; a part of Aalberts Integrated Piping Systems]**
 - c. **[Mueller Co. LLC; Mueller Water Products, Inc.]**
 - d. **[Mueller Streamline Co.; a company of Mueller Industries]**
 - e. **[NIBCO INC.]**
 - f. **[Viega LLC]**
 - g. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert**

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

- a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[Elkhart Products Corporation; a part of Aalberts Integrated Piping Systems]**
 - c. **[Mueller Co. LLC; Mueller Water Products, Inc.]**
 - d. **[Mueller Streamline Co.; a company of Mueller Industries]**
 - e. **[NIBCO INC.]**
 - f. **[Viega LLC]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Obtain copper tube, pressure-seal-joint fittings from single manufacturer.
 4. Standard: UL 213.
 5. Fittings: Cast brass, cast bronze, or wrought copper with EPDM O-ring seal in each end. **NPS 2-1/2 (DN 65)** and larger with stainless steel grip ring and EPDM O-ring seal.
 6. Minimum **200 psig (1379 kPa)** working-pressure rating at **250 deg F (121 deg C)**.
- F. Bronze Flanges: ASME B16.24, Class 150, with solder-joint end. Furnish Class 300 flanges if required to match piping.
- G. Cast-Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock-body, ball-and-socket, metal-to-metal seating surfaces; and solder-joint or threaded ends.
- H. Wrought-Copper Unions: ASME B16.22.

2.4 DUCTILE-IRON PIPE AND FITTINGS

A. Mechanical-Joint, Ductile-Iron Pipe:

1. AWWA C151/A21.51, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.
2. AWWA C104/A21.4 cement mortar-lined.

B. Mechanical-Joint, Ductile-Iron Fittings:

1. AWWA C110, ductile- or gray-iron standard pattern or AWWA C153/A21.53, ductile-iron compact pattern.
2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.
3. AWWA C104/A21.4 cement mortar-lined.

C. Push-on-Joint, Ductile-Iron Pipe:

1. AWWA C151/A21.51, with push-on-joint bell and plain spigot end unless grooved or flanged ends are indicated.
2. AWWA C104/A21.4 cement mortar-lined.

D. Push-on-Joint, Ductile-Iron Fittings:

1. AWWA C110, ductile- or gray-iron standard pattern or AWWA C153/A21.53, ductile-iron compact pattern.
2. Gaskets: AWWA C111/A21.11, rubber.
3. AWWA C104/A21.4 cement mortar-lined.

E. Grooved-End, Ductile-Iron Pipe:

1. AWWA C151/A21.51, with cut, rounded-grooved ends.
2. AWWA C104/A21.4 cement mortar-lined.

F. Grooved-End, Ductile-Iron Pipe Appurtenances:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Anvil; an ASC Engineered Solution]**
 - b. **[GroovJoint]**
 - c. **[Shurjoint; a part of Aalberts Integrated Piping Systems]**
 - d. **[Smith-Cooper International]**
 - e. **[Star Pipe Products]**
 - f. **[Victaulic Company]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Anvil; an ASC Engineered Solution]**
 - b. **[GroovJoint]**
 - c. **[Shurjoint; a part of Aalberts Integrated Piping Systems]**
 - d. **[Smith-Cooper International]**
 - e. **[Star Pipe Products]**
 - f. **[Victaulic Company]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Obtain grooved-end, ductile-iron pipe appurtenances from single manufacturer.
4. Grooved-End, Ductile-Iron Fittings:
 - a. ASTM A536, ductile-iron castings with dimensions matching pipe.
 - b. AWWA C104/A21.4 cement mortar-lined.
5. Grooved-End, Ductile-Iron-Piping Mechanical Couplings:
 - a. AWWA C606, for ductile-iron-pipe dimensions. Include ferrous housing sections, gasket suitable for water, and bolts and nuts.

G. Flanges: ASME 16.1, Class 125, cast iron.

2.5 PE PIPE AND FITTINGS

- A. PE, ASTM Pipe: ASTM D2239, SIDR No. 5.3, 7, or 9; with PE compound number required to give pressure rating not less than **[160 psig (1100 kPa)][200 psig (1380 kPa)]**.
 1. Insert Fittings for PE Pipe: ASTM D2609, made of PA, PP, or PVC with serrated male insert ends matching inside of pipe. Include bands or crimp rings.
 2. Molded PE Fittings: ASTM D3350, PE resin, socket- or butt-fusion type, made to match PE pipe dimensions and class.

- B. PE, AWWA Pipe: AWWA C906, DR No. 7.3, 9, or 9.3; with PE compound number required to give pressure rating not less than **[160 psig (1100 kPa)][200 psig (1380 kPa)]**.
- 1. PE, AWWA Fittings: AWWA C906, socket- or butt-fusion type, with DR number matching pipe and PE compound number required to give pressure rating not less than **[160 psig (1100 kPa)][200 psig (1380 kPa)]**.
- C. PE, Fire-Service Pipe: ASTM F714, AWWA C906, or equivalent for PE water pipe; FM Global approved, with minimum thickness equivalent to FM Global **[Class 150][and][Class 200]**.
- 1. Molded PE Fittings: ASTM D3350, PE resin, socket- or butt-fusion type, and made to match PE pipe dimensions and class.

2.6 PVC PIPE AND FITTINGS

- A. PVC, Schedule 40 Pipe: ASTM D1785.
- 1. PVC, Schedule 40 Socket Fittings: ASTM D2466.
- B. PVC, Schedule 80 Pipe: ASTM D1785.
- 1. PVC, Schedule 80 Socket Fittings: ASTM D2467.
- 2. PVC, Schedule 80 Threaded Fittings: ASTM D2464.
- C. PVC Pipe: **[AWWA C900][UL 1285]**, **[Class 150][and][Class 200]**, with bell end with gasket, and with spigot end.
- 1. Comply with UL 1285 for fire-suppression water service.
- 2. PVC Fabricated Fittings: AWWA C900, **[Class 150][and][Class 200]**, with bell-and-spigot or double-bell ends. Include elastomeric gasket in each bell.
- 3. PVC Molded Fittings: AWWA C907, Class 150, with bell-and-spigot or double-bell ends. Include elastomeric gasket in each bell.

2.7 FIBERGLASS PIPE AND FITTINGS

- A. RTRP Pipe: AWWA C950, **[Class 150][Class 200][and][Class 250]**, Type I[or II], **[Grade 1, epoxy][or][Grade 2, polyester]**, with bell-and-spigot ends **[for bonded][with gasket or seal for gasketed]** joints. Liner is optional unless otherwise indicated. **[Include FM Global approval if used for fire-service mains.]**
- B. Fittings, RTRF, AWWA C950: Similar to pipe in material, pressure class, and joining method.
- C. Fittings: Compatible with pipe size, pressure class, and joining method.

2.8 SPECIAL PIPE FITTINGS

- A. Ductile-Iron Rigid Expansion Joints: Three-piece, ductile-iron assembly consisting of telescoping sleeve with gaskets and restrained-type, ductile-iron, end sections.
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the**

following]:

- a. **[EBAA Iron Sales, Inc.]**
- b. **[U.S. Pipe]**
- c. **<Insert manufacturer's name>**

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

- a. **[EBAA Iron Sales, Inc.]**
- b. **[U.S. Pipe]**
- c. **<Insert manufacturer's name>**

- 3. Source Limitations: Obtain ductile-iron rigid expansion joints from single manufacturer.
- 4. Standards: AWWA C110 or AWWA C153/A21.53; AWWA C111/A21.11.
- 5. Pressure Rating: **250 psig (1725 kPa)** minimum.

- B. Ductile-Iron Flexible Expansion Joints: Compound, ductile-iron fitting with combination of flanged and mechanical-joint ends. Include two gasketed ball-joint sections and one or more gasketed sleeve sections.

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

- a. **[EBAA Iron Sales, Inc.]**
- b. **[Star Pipe Products]**
- c. **<Insert manufacturer's name>**

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

- a. **[EBAA Iron Sales, Inc.]**
- b. **[Star Pipe Products]**
- c. **<Insert manufacturer's name>**

- 3. Source Limitations: Obtain ductile-iron flexible expansion joints from single manufacturer.
- 4. Standards: AWWA C110 or AWWA C153/A21.53; AWWA C111/A21.11.
- 5. Pressure Rating: **250 psig (1725 kPa)** minimum.
- 6. Offset: **<Insert inches (mm)>**.
- 7. Expansion Required: **<Insert inches (mm)>**.

- C. Ductile-Iron Deflection Fittings, Lead Free: Compound, ductile-iron coupling fitting with sleeve and one or two flexing sections for up to 15-degree deflection, gaskets, and restrained-joint ends.

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

- a. **[EBAA Iron Sales, Inc.]**
- b. **[U.S. Pipe]**

- c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[EBAA Iron Sales, Inc.]**
 - b. **[U.S. Pipe]**
 - c. **<Insert manufacturer's name>**
3. Source Limitations: Obtain ductile-iron deflection fittings from single manufacturer.
4. Standards: AWWA C110 or AWWA C153/A21.53; AWWA C111/A21.11.
5. Pressure Rating: **250 psig (1725 kPa)** minimum.

2.9 PIPING JOINING MATERIALS

- A. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series.
- B. Bonding Adhesive for Fiberglass Piping: As recommended by fiberglass piping manufacturer.
- C. Gaskets for Ferrous Piping and Copper-Alloy Tubing: ASME B16.21, asbestos free.
- D. Plastic Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

2.10 PIPING SPECIALTIES

- A. Transition Fittings: Manufactured fitting or coupling same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.
- B. Tubular-Sleeve Pipe Couplings: Metal, bolted, sleeve-type, reducing or transition coupling, with center sleeve, gaskets, end rings, and bolt fasteners and with ends of same sizes as piping to be joined.
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Cascade Waterworks Mfg. Co.]**
 - b. **[Ford Meter Box Company, Inc. (The)]**
 - c. **[JCM Industries, Inc]**
 - d. **[Smith-Blair, a Xylem brand.]**
 - e. **[United Water Products]**
 - f. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Cascade Waterworks Mfg. Co.]**
 - b. **[Ford Meter Box Company, Inc. (The)]**
 - c. **[JCM Industries, Inc]**
 - d. **[Smith-Blair, a Xylem brand.]**

- e. **[United Water Products]**
 - f. **<Insert manufacturer's name>**
3. Source Limitations: Obtain tubular-sleeve pipe couplings from single manufacturer.
 4. Standard: AWWA C219.
 5. Center-Sleeve Material: **[Manufacturer's standard][Carbon steel][Stainless steel][Ductile iron][Malleable iron]**.
 6. Gasket Material: Natural or synthetic rubber.
 7. Pressure Rating: **[150 psig (1035 kPa)][200 psig (1380 kPa)]<Insert pressure>** minimum.
 8. Metal Component Finish: Corrosion-resistant coating or material.
- C. Split-Sleeve Pipe Couplings: Metal, bolted, split-sleeve-type, reducing or transition coupling with sealing pad and closure plates, O-ring gaskets, and bolt fasteners.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Victaulic Company]**
 - b. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Victaulic Company]**
 - b. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain split-sleeve pipe couplings from single manufacturer.
 4. Standard: AWWA C227.
 5. Sleeve Material: **[Manufacturer's standard][Carbon steel][Stainless steel]**.
 6. Sleeve Dimensions: Of thickness and width required to provide pressure rating.
 7. Gasket Material: O-rings made of EPDM rubber unless otherwise indicated.
 8. Pressure Rating: **[150 psig (1035 kPa)][200 psig (1380 kPa)]<Insert pressure>** minimum.
 9. Metal Component Finish: Corrosion-resistant coating or material.
- D. Flexible Connectors:
1. Nonferrous-Metal Piping: Bronze hose covered with bronze wire braid; with copper-tube, pressure-type, solder-joint ends or bronze flanged ends brazed to hose.
 2. Ferrous-Metal Piping: Stainless steel hose covered with stainless steel wire braid; with ASME B1.20.1, threaded steel pipe nipples or ASME B16.5, steel pipe flanges welded to hose.
- E. Dielectric Fittings: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
1. Dielectric Unions:
 - a. Standard: ASSE 1079.
 - b. Pressure Rating: **[125 psig (860 kPa) minimum at 180 deg F (82 deg C)][150 psig (1035 kPa)][250 psig (1725 kPa)]<Insert pressure rating and temperature>**.
 - c. End Connections: Solder-joint copper alloy and threaded ferrous.
 2. Dielectric Flanges:

- a. Standard: ASSE 1079.
 - b. Factory-fabricated, bolted, companion-flange assembly.
 - c. Pressure Rating: **[125 psig (860 kPa) minimum at 180 deg F (82 deg C)][150 psig (1035 kPa)][175 psig (1200 kPa)][300 psig (2070 kPa)]<Insert pressure rating and temperature>**.
 - d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.
3. Dielectric-Flange Insulating Kits: Nonconducting materials for field assembly of companion flanges.
- a. Pressure Rating: **[150 psig (1035 kPa)]<Insert pressure rating>**.
 - b. Gasket: Neoprene or phenolic.
 - c. Bolt Sleeves: Phenolic or PE.
 - d. Washers: Phenolic with steel backing washers.
4. Dielectric Nipples:
- a. Standard: IAPMO PS 66.
 - b. Electroplated steel nipple complying with ASTM F1545.
 - c. Pressure Rating: **[300 psig (2070 kPa) at 225 deg F (107 deg C)]<Insert pressure rating and temperature>**.
 - d. End Connections: Male threaded or grooved.
 - e. Lining: Inert and noncorrosive, PP.

2.11 ENCASEMENT FOR PIPING

- A. Standards: ASTM A674 or AWWA C105/A21.5.
- B. Form: **[Sheet][or][tube]**.
- C. Material: **[Linear low-density PE film of 0.008-inch (0.20-mm) minimum thickness][or][high-density, cross-laminated PE film of 0.004-inch (0.10-mm) minimum thickness]**.
- D. Color: **[Black][or][natural]<Insert color>**.

2.12 GATE VALVES

- A. Gate Valves - AWWA, Cast Iron:
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American AVK Co.]**
 - b. **[American Cast Iron Pipe Company]**
 - c. **[Clow Valve Company; a subsidiary of McWane, Inc.]**
 - d. **[EJ Group, Inc.]**
 - e. **[Flomatic Valves; Flomatic Corporation]**
 - f. **[M & H Valve Company; a division of McWane, Inc.]**
 - g. **[Mueller Co. LLC; Mueller Water Products, Inc.]**
 - h. **[NIBCO INC.]**
 - i. **[Zurn Industries, LLC]**

- j. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [American AVK Co.]
 - b. [American Cast Iron Pipe Company]
 - c. [Clow Valve Company; a subsidiary of McWane, Inc.]
 - d. [EJ Group, Inc.]
 - e. [Flomatic Valves; Flomatic Corporation]
 - f. [M & H Valve Company; a division of McWane, Inc.]
 - g. [Mueller Co. LLC; Mueller Water Products, Inc.]
 - h. [NIBCO INC.]
 - i. [Zurn Industries, LLC]
 - j. <Insert manufacturer's name>
3. Source Limitations: Obtain gate valves - AWWA, cast iron, from single manufacturer.
4. Gate Valves - Nonrising Stem, Resilient Seated: Cast- or ductile-iron body and bonnet, with bronze or cast- or ductile-iron gate, resilient seats, bronze stem, and stem nut.
 - a. Standards: AWWA C509 or AWWA C515.
 - b. Minimum Pressure Rating: **200 psig (1380 kPa)**.
 - c. End Connections: Mechanical joint, flanged, threaded, or push on.
 - d. Interior Coating: Complying with AWWA C550.
5. Gate Valves - OS&Y, Rising Stem, Resilient Seated: Cast- or ductile-iron body and bonnet, with bronze or cast- or ductile-iron gate, resilient seats, and bronze stem.
 - a. Standard: AWWA C509 or AWWA C515.
 - b. Minimum Pressure Rating: **200 psig (1380 kPa)**.
 - c. End Connections: Mechanical joint, flanged, threaded, or push on.
- B. Gate Valves - UL/FM Global, Cast Iron:
 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [American AVK Co.]
 - b. [American Cast Iron Pipe Company]
 - c. [Clow Valve Company; a subsidiary of McWane, Inc.]
 - d. [Kennedy Valve Company; a division of McWane, Inc.]
 - e. [M & H Valve Company; a division of McWane, Inc.]
 - f. [Mueller Co. LLC; Mueller Water Products, Inc.]
 - g. [NIBCO INC.]
 - h. [Zurn Industries, LLC]
 - i. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [American AVK Co.]

- b. **[American Cast Iron Pipe Company]**
 - c. **[Clow Valve Company; a subsidiary of McWane, Inc.]**
 - d. **[Kennedy Valve Company; a division of McWane, Inc.]**
 - e. **[M & H Valve Company; a division of McWane, Inc.]**
 - f. **[Mueller Co. LLC; Mueller Water Products, Inc.]**
 - g. **[NIBCO INC.]**
 - h. **[Zurn Industries, LLC]**
 - i. **<Insert manufacturer's name>**
 - 3. Source Limitations: Obtain gate valves - UL/FM Global, cast iron, from single manufacturer.
 - 4. Gate Valves - UL/FM Global, Nonrising Stem, Resilient Seated: Cast- or ductile-iron body and bonnet, with flange for indicator post, bronze seating material, and inside screw.
 - a. Standards: AWWA C509 or AWWA C515, UL listed and FM Global approved.
 - b. Minimum Pressure Rating: **175 psig (1207 kPa)**.
 - c. End Connections: Mechanical joint or flanged.
 - d. Interior Coating: Complying with AWWA C550.
 - 5. Gate Valves - OS&Y, Rising Stem, Resilient Seated: Cast- or ductile-iron body and bonnet and bronze seating material.
 - a. Standards: AWWA C509 or AWWA C515, UL listed and FM Global approved.
 - b. Minimum Pressure Rating: **175 psig (1207 kPa)**.
 - c. End Connections: Mechanical joint or flanged.
 - d. Interior Coating: Complying with AWWA C550.
- C. Gate Valves - Bronze:
- 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Crane Fluid Systems; Crane Co.]**
 - b. **[Hammond Valve]**
 - c. **[Jenkins Valves; a Crane Co. brand]**
 - d. **[Milwaukee Valve Company]**
 - e. **[NIBCO INC.]**
 - f. **[Red-White Valve Corp.]**
 - g. **[Stockham; a Crane Co. brand]**
 - h. **<Insert manufacturer's name>**
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Crane Fluid Systems; Crane Co.]**
 - b. **[Hammond Valve]**
 - c. **[Jenkins Valves; a Crane Co. brand]**
 - d. **[Milwaukee Valve Company]**
 - e. **[NIBCO INC.]**
 - f. **[Red-White Valve Corp.]**
 - g. **[Stockham; a Crane Co. brand]**
 - h. **<Insert manufacturer's name>**
 - 3. Source Limitations: Obtain gate valves - bronze, from single manufacturer.

4. Gate Valves - OS&Y, Rising Stem: Bronze body and bonnet and bronze stem.

- a. Standards: UL listed and FM Global approved.
- b. Minimum Pressure Rating: **175 psig (1207 kPa)**.
- c. End Connections: Threaded.

5. Gate Valves - Nonrising Stem: Class 125, bronze with solid wedge.

- a. Standard: MSS SP-80.
- b. End Connections: Threaded or solder.
- c. Handwheel: Malleable iron.

2.13 GATE VALVE ACCESSORIES AND SPECIALTIES

A. Tapping-Sleeve Assemblies: Sleeve and valve compatible with drilling machine.

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

- a. **[American Cast Iron Pipe Company]**
- b. **[Kennedy Valve Company; a division of McWane, Inc.]**
- c. **[U.S. Pipe]**
- d. **<Insert manufacturer's name>**

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

- a. **[American Cast Iron Pipe Company]**
- b. **[Kennedy Valve Company; a division of McWane, Inc.]**
- c. **[U.S. Pipe]**
- d. **<Insert manufacturer's name>**

3. Source Limitations: Obtain tapping-sleeve assemblies from single manufacturer.

4. Standard: MSS SP-60.

5. Tapping Sleeve: Cast- or ductile-iron or stainless steel, two-piece bolted sleeve with flanged outlet for new branch connection. Include sleeve matching size and type of pipe material being tapped and with recessed flange for branch valve.

6. Valve: AWWA, cast-iron, nonrising-stem, **[metal][resilient]**-seated gate valve with one raised face flange mating tapping-sleeve flange.

B. Valve Boxes: Comply with AWWA M44 for cast-iron valve boxes. Include top section, adjustable extension of length required for depth of burial of valve, plug with lettering "WATER," and bottom section with base that fits over valve and with a barrel approximately **5 inches (125 mm)** in diameter.

1. Operating Wrenches: Steel, tee-handle with one pointed end, stem of length to operate deepest buried valve, and socket matching valve operating nut.

C. Indicator Posts: UL 789, FM Global approved, vertical-type, cast-iron body with operating wrench, extension rod, and adjustable cast-iron barrel of length required for depth of burial of valve.

2.14 CHECK VALVES

- A. Check Valves - AWWA: Swing-check type with resilient seat with ends to match piping.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[American AVK Co.]**
 - b. **[American Cast Iron Pipe Company]**
 - c. **[Clow Valve Company; a subsidiary of McWane, Inc.]**
 - d. **[DeZURIK]**
 - e. **[Flomatic Valves; Flomatic Corporation]**
 - f. **[M & H Valve Company; a division of McWane, Inc.]**
 - g. **[Mueller Co. LLC; Mueller Water Products, Inc.]**
 - h. **[NIBCO INC.]**
 - i. **[Stockham; a Crane Co. brand]**
 - j. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American AVK Co.]**
 - b. **[American Cast Iron Pipe Company]**
 - c. **[Clow Valve Company; a subsidiary of McWane, Inc.]**
 - d. **[DeZURIK]**
 - e. **[Flomatic Valves; Flomatic Corporation]**
 - f. **[M & H Valve Company; a division of McWane, Inc.]**
 - g. **[Mueller Co. LLC; Mueller Water Products, Inc.]**
 - h. **[NIBCO INC.]**
 - i. **[Stockham; a Crane Co. brand]**
 - j. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain check valves, AWWA, from single manufacturer.
 4. Standards:
 - a. AWWA C508.
 - b. Interior coating in accordance with AWWA C550.
 5. Pressure Rating: **175 psig (1207 kPa).**
- B. Check Valves - UL/FM Global: Swing-check type with pressure rating, rubber-face checks unless otherwise indicated, and ends matching piping.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[American Cast Iron Pipe Company]**
 - b. **[Matco-Norca]**
 - c. **[Mueller Co. LLC; Mueller Water Products, Inc.]**
 - d. **[NIBCO INC.]**
 - e. **[Reliable Automatic Sprinkler Co., Inc. (The)]**



- f. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [American Cast Iron Pipe Company]
 - b. [Matco-Norca]
 - c. [Mueller Co. LLC; Mueller Water Products, Inc.]
 - d. [NIBCO INC.]
 - e. [Reliable Automatic Sprinkler Co., Inc. (The)]
 - f. <Insert manufacturer's name>
3. Source Limitations: Obtain check valves - UL/FM Global, from single manufacturer.
4. Standards: UL listed and FM Global approved.
5. Pressure Rating: [175 psig (1207 kPa)][250 psig (1725 kPa)].

2.15 DETECTOR CHECK VALVES

A. Detector Check Valves:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Ames Fire & Waterworks; A Watts Water Technologies Company]
 - b. [FEBCO; A WATTS Brand]
 - c. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Ames Fire & Waterworks; A Watts Water Technologies Company]
 - b. [FEBCO; A WATTS Brand]
 - c. <Insert manufacturer's name>
3. Source Limitations: Obtain detector check valves from single manufacturer.

B. Description: Include threaded bypass taps in inlet and outlet for bypass meter connection. Set valve to allow minimal water flow through bypass meter when major water flow is required.

1. Standards: UL listed and FM Global approved.
2. Pressure Rating: 175 psig (1207 kPa).

C. Water Meter: AWWA C700, disc type, at least one-fourth size of detector check valve. Include meter, bypass piping, gate valves, check valve, and connections to detector check valve.

2.16 BUTTERFLY VALVES

A. Butterfly Valves - AWWA:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[DeZURIK]**
 - b. **[Flomatic Valves; Flomatic Corporation]**
 - c. **[Henry Pratt Company; a Mueller brand]**
 - d. **[Homestead Valve: a division of Olson Technologies, Inc.]**
 - e. **[Milliken Valve Company; a Mueller brand.]**
 - f. **[Mueller Co. LLC; Mueller Water Products, Inc.]**
 - g. **[Val-Matic Valve & Manufacturing Corp.]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[DeZURIK]**
 - b. **[Flomatic Valves; Flomatic Corporation]**
 - c. **[Henry Pratt Company; a Mueller brand]**
 - d. **[Homestead Valve: a division of Olson Technologies, Inc.]**
 - e. **[Milliken Valve Company; a Mueller brand.]**
 - f. **[Mueller Co. LLC; Mueller Water Products, Inc.]**
 - g. **[Val-Matic Valve & Manufacturing Corp.]**
 - h. **<Insert manufacturer's name>**
3. Source Limitations: Obtain butterfly valves - AWWA, from single manufacturer.
4. Standard: AWWA C504.
5. Body: Cast or ductile iron.
6. Body Type: **[Wafer][or][flanged]<Insert type>**.
7. Seat: Rubber.
8. Pressure Rating: **150 psig (1035 kPa)**.

B. Butterfly Valves - UL:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Henry Pratt Company; a Mueller brand]**
 - b. **[NIBCO INC.]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Henry Pratt Company; a Mueller brand]**
 - b. **[NIBCO INC.]**
 - c. **<Insert manufacturer's name>**
3. Source Limitations: Obtain butterfly valves - UL, from single manufacturer.
4. Standards: UL 1091 and FM Global approved.
5. Body: Cast or ductile iron.

6. Body Type: **[Wafer][or][flanged]<Insert type>**.
7. Seat: Metal or resilient material.
8. Pressure Rating: **175 psig (1207 kPa)**.

2.17 CORPORATION VALVES, CURB VALVES, AND METER VALVES

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 1. **[A.Y. McDonald Mfg. Co.]**
 2. **[Ford Meter Box Company, Inc. (The)]**
 3. **[James Jones Company, LLC; a Mueller brand]**
 4. **[Red Hed Manufacturing Company; a division of Everett J. Prescott, Inc.]**
 5. **<Insert manufacturer's name>**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 1. **[A.Y. McDonald Mfg. Co.]**
 2. **[Ford Meter Box Company, Inc. (The)]**
 3. **[James Jones Company, LLC; a Mueller brand]**
 4. **[Red Hed Manufacturing Company; a division of Everett J. Prescott, Inc.]**
 5. **<Insert manufacturer's name>**
- C. Source Limitations: Obtain corporation valves, curb valves, and meter valves from single manufacturer.
- D. Corporation Valves: Comply with AWWA C800. Include saddle and valve compatible with tapping machine.
 1. Service Saddle: Copper alloy with seal and AWWA C800, threaded outlet for corporation valve.
 2. Corporation Valve: Bronze body, ground-key plug or ball, with AWWA C800, threaded inlet and outlet matching service piping material.
 3. Manifold: Copper fitting with two to four inlets as required, with ends matching corporation valves and outlet matching service piping material.
- E. Curb Valves: Comply with AWWA C800. Include bronze body, ground-key plug or ball, and wide tee head, with inlet and outlet matching service piping material.
 1. Service Boxes for Curb Valves: ASTM A48/A48M, Class 25 cast-iron valve boxes. Include cast-iron telescoping top section of length required for depth of burial of valve, plug with lettering "WATER," and bottom section with base that fits over curb valve and with a barrel approximately **3 inches (75 mm)** in diameter.
 - a. Shutoff Rods: Steel, tee-handle with one pointed end, stem of length to operate deepest buried valve, and slotted end matching curb valve.
- F. Meter Valves: Comply with AWWA C800 for high-pressure, service-line valves. Include angle or straight-through-pattern bronze body, ground-key plug or ball, wide tee head, with inlet and outlet matching service piping material.

2.18 WATER METERS

A. Water Meter - Utility Company Furnished:

1. Utility Company: **<Insert name>**.

B. Water Meters - Displacement Type:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Badger Meter, Inc.]**
 - b. **[Carlson Meter]**
 - c. **[Master Meter, Inc]**
 - d. **[Mueller Systems, LLC; a subsidiary of Mueller Water Products, Inc.]**
 - e. **[Neptune Technology Group Inc.]**
 - f. **[Niagara Meters]**
 - g. **[Sensus; a Xylem brand]**
 - h. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Badger Meter, Inc.]**
 - b. **[Carlson Meter]**
 - c. **[Master Meter, Inc]**
 - d. **[Mueller Systems, LLC; a subsidiary of Mueller Water Products, Inc.]**
 - e. **[Neptune Technology Group Inc.]**
 - f. **[Niagara Meters]**
 - g. **[Sensus; a Xylem brand]**
 - h. **<Insert manufacturer's name>**
3. Source Limitations: Obtain water meters - displacement type, from single manufacturer.
4. Standard: AWWA C700.
5. Pressure Rating: **150 psig (1035 kPa)** working pressure.
6. Body Design: Nutating disc; totalization meter.
7. Registration: Flow in **[gal. (L)][cu. ft. (cu. m)]** as required by utility company.
8. Case: **[Bronze][Stainless steel]**.
9. End Connections: Threaded or flanged **<Insert connection>**.

C. Water Meters - Turbine Type:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Badger Meter, Inc.]**
 - b. **[Carlson Meter]**
 - c. **[Mueller Systems, LLC; a subsidiary of Mueller Water Products, Inc.]**
 - d. **[Neptune Technology Group Inc.]**
 - e. **[Niagara Meters]**
 - f. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Badger Meter, Inc.]**
 - b. **[Carlson Meter]**
 - c. **[Mueller Systems, LLC; a subsidiary of Mueller Water Products, Inc.]**
 - d. **[Neptune Technology Group Inc.]**
 - e. **[Niagara Meters]**
 - f. **<Insert manufacturer's name>**
3. Source Limitations: Obtain water meters - turbine type, from single manufacturer.
4. Standard: AWWA C701.
5. Pressure Rating: **150 psig (1035 kPa)** working pressure.
6. Body Design: Turbine; totalization meter.
7. Registration: Flow in **[gal. (L)][cu. ft. (cu. m)]** as required by utility company.
8. Case: **[Bronze][Epoxy-coated cast iron]**.
9. End Connections: Threaded or flanged **<Insert connection>**.

D. Water Meters - Compound Type:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Badger Meter, Inc.]**
 - b. **[Mueller Systems, LLC; a subsidiary of Mueller Water Products, Inc.]**
 - c. **[Neptune Technology Group Inc.]**
 - d. **[Sensus; a Xylem brand]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Badger Meter, Inc.]**
 - b. **[Mueller Systems, LLC; a subsidiary of Mueller Water Products, Inc.]**
 - c. **[Neptune Technology Group Inc.]**
 - d. **[Sensus; a Xylem brand]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain water meters - compound type, from single manufacturer.
4. Standard: AWWA C702.
5. Pressure Rating: **150 psig (1035 kPa)** working pressure.
6. Body Design: With integral mainline and bypass meters; totalization meter.
7. Registration: Flow in **[gal. (L)][cu. ft. (cu. m)]** as required by utility company.
8. Case: **[Bronze][Coated ductile iron]**.
9. End connections: Flanged **<Insert connection>**.

E. Water Meters - Ultrasonic Type:

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

following]:

- a. [Badger Meter, Inc.]
 - b. [Master Meter, Inc]
 - c. [Neptune Technology Group Inc.]
 - d. <Insert manufacturer's name>
2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
- a. [Badger Meter, Inc.]
 - b. [Master Meter, Inc]
 - c. [Neptune Technology Group Inc.]
 - d. <Insert manufacturer's name>
3. Source Limitations: Obtain water meters - ultrasonic type, from single manufacturer.
4. Standard: AWWA C715.
5. Pressure Rating: **150 psig (1035 kPa)** working pressure.
6. Body Design: Ultrasonic open flow tube; totalization meter.
7. Registration: Flow in [gal. (L)][cu. ft. (cu. m)] as required by utility company.
8. Case: [Bronze][Stainless steel][Engineered polymer][Epoxy-coated ductile iron]<Insert type>.
9. End Connections: Threaded or flanged <Insert connection>.
- F. Ultrasonic Type Water Meter, Remote Registration System, Direct-Reading Type: Utility company standard. Include meter modified with signal-transmitting assembly, low-voltage connecting wiring, and remote register assembly.
1. Registration: Flow in [gal. (L)][cu. ft. (cu. m)].
- G. Ultrasonic Type Water Meter, Remote Registration System, Encoder Type: Utility company standard. Include meter modified with signal-transmitting assembly, low-voltage connecting wiring, and remote register assembly.
1. Standard: AWWA C707.
 2. Registration: Flow in [gal. (L)][cu. ft. (cu. m)].
 3. Data-Acquisition Units: Comply with utility company requirements for type and quantity.
 4. Visible Display Units: Comply with utility company requirements for type and quantity.
- H. Water Meters - Detector Type:
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Badger Meter, Inc.]
 - b. [Mueller Systems, LLC; a subsidiary of Mueller Water Products, Inc.]
 - c. [Neptune Technology Group Inc.]
 - d. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

- a. **[Badger Meter, Inc.]**
 - b. **[Mueller Systems, LLC; a subsidiary of Mueller Water Products, Inc.]**
 - c. **[Neptune Technology Group Inc.]**
 - d. **<Insert manufacturer's name>**
- 3. Source Limitations: Obtain water meters - detector type, from single manufacturer.
 - 4. Standards: AWWA C703, and UL listed or FM Global approved.
 - 5. Pressure Rating: **175 psig (1207 kPa)**.
 - 6. Registration: Flow in **[gal. (L)][cu. ft. (cu. m)]**.
 - 7. Bypass Meter: **[AWWA C700, disc][AWWA C701, turbine][AWWA C702, compound]-type, bronze case.**
- I. Detector Type Water Meter, Remote Registration System, Direct-Reading Type: Utility company standard. Include meter modified with signal-transmitting assembly, low-voltage connecting wiring, and remote register assembly.
 - 1. Registration: Flow in **[gal. (L)][cu. ft. (cu. m)]**.
 - J. Detector Type Water Meter, Remote Registration System, Encoder Type: Utility company standard. Include meter modified with signal-transmitting assembly, low-voltage connecting wiring, and remote register assembly.
 - 1. Standard: AWWA C707.
 - 2. Registration: Flow in **[gal. (L)][cu. ft. (cu. m)]**.
 - 3. Data-Acquisition Units: Comply with utility company requirements for type and quantity.
 - 4. Visible Display Units: Comply with utility company requirements for type and quantity.

2.19 WATER METER BOXES

- A. Water Meter Boxes:
 - 1. Cast-iron body and cover for disc-type water meter, with lettering "WATER METER" in cover; and with slotted, open-bottom base section of length to fit over service piping.
 - a. Option: Base section may be cast-iron, PVC, clay, or other pipe.
 - 2. Cast-iron body and double cover for disc-type water meter, with lettering "WATER METER" in top cover; and with separate inner cover; air space between covers; and slotted, open-bottom base section of length to fit over service piping.
 - 3. Water Meter Boxes: Polymer-concrete body and cover for disc-type water meter, with lettering "WATER METER" in cover; and with slotted, open-bottom base section of length to fit over service piping. Include vertical and lateral design loadings of **15,000 lb minimum over 10 by 10 inches (6800 kg minimum over 254 by 254 mm)** square.

2.20 PRESSURE-REDUCING VALVES

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

- a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - b. [Cash Acme Plumbing Products; an RWC brand]
 - c. [Flomatic Valves; Flomatic Corporation]
 - d. [WATTS; A Watts Water Technologies Company]
 - e. [Zurn Industries, LLC]
 - f. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - b. [Cash Acme Plumbing Products; an RWC brand]
 - c. [Flomatic Valves; Flomatic Corporation]
 - d. [WATTS; A Watts Water Technologies Company]
 - e. [Zurn Industries, LLC]
 - f. <Insert manufacturer's name>
 3. Source Limitations: Obtain pressure-reducing valves - direct acting, from single manufacturer.
 4. Standard: ASSE 1003.
 5. Pressure Rating: Initial pressure of **150 psig (1035 kPa)**.
 6. Size: <Insert NPS (DN)>.
 7. Design Flow Rate: <Insert gpm (L/s)>.
 8. Design Inlet Pressure: <Insert psig (kPa)>.
 9. Design Outlet Pressure Setting: <Insert psig (kPa)>.
 10. Body: Bronze[**with chrome-plated finish**].
 11. End Connections: Threaded for **NPS 2 (DN 50)** and smaller; flanged for **NPS 2-1/2 and NPS 3 (DN 65 and DN 80)**.
- B. Pressure-Reducing Valves - Pilot Operated: Pilot-operation, diaphragm-type, single-seated main water control valve with interior epoxy coating. Include small pilot control valve, restrictor device, specialty fittings, and sensor piping.
1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - b. [CLA-VAL]
 - c. [Dorot Control Valves Inc.]
 - d. [Flomatic Valves; Flomatic Corporation]
 - e. [OCV Control Valves]
 - f. [Zurn Industries, LLC]
 - g. <Insert manufacturer's name>
 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Apollo Valves; a part of Aalberts Integrated Piping Systems]
 - b. [CLA-VAL]
 - c. [Dorot Control Valves Inc.]
 - d. [Flomatic Valves; Flomatic Corporation]
 - e. [OCV Control Valves]
 - f. [Zurn Industries, LLC]

g. **<Insert manufacturer's name>**

3. Source Limitations: Obtain pressure-reducing valves - pilot operated, from single manufacturer.
4. Pressure Rating: Initial pressure of **150 psig (1035 kPa)** minimum.
5. Main Valve Body: Cast- or ductile-iron, or stainless steel body.
6. Size: **<Insert NPS (DN)>**.
7. Pattern: **[Angle][Globe]**-valve design.
8. Design Flow Rate: **<Insert gpm (L/s)>**.
9. Design Inlet Pressure: **<Insert psig (kPa)>**.
10. Design Outlet Pressure Setting: **<Insert psig (kPa)>**.
11. End Connections: **[Threaded][or][grooved][or][flanged]**.

2.21 RELIEF VALVES

A. Air-Release Valves:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Crispin Valve]**
 - b. **[Flomatic Valves; Flomatic Corporation]**
 - c. **[GA Industries, Inc]**
 - d. **[Val-Matic Valve & Manufacturing Corp.]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Crispin Valve]**
 - b. **[Flomatic Valves; Flomatic Corporation]**
 - c. **[GA Industries, Inc]**
 - d. **[Val-Matic Valve & Manufacturing Corp.]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain air-release valves from single manufacturer.
4. Standard: AWWA C512.
5. Pressure Rating: **[300 psig (2070 kPa)]<Insert pressure>**.
6. Body Material: **[Cast iron]<Insert material>**.
7. Trim Material: Stainless steel[, **brass, or bronze**].
8. Water Inlet Size: **<Insert NPS (DN)>**.
9. Air Outlet Size: **<Insert NPS (DN)>**.
10. Orifice Size: **<Insert inches (mm)>**.
11. Design Air-Release Capacity: **<Insert cfm (L/s)>** at **<Insert psig (kPa)>** pipeline pressure.

B. Air/Vacuum Valves: Direct-acting, float-operated, hydromechanical device with large orifice to automatically release accumulated air or to admit air during filling of piping.

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

- a. **[Crispin Valve]**
 - b. **[Flomatic Valves; Flomatic Corporation]**
 - c. **[GA Industries, Inc]**
 - d. **[Val-Matic Valve & Manufacturing Corp.]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Crispin Valve]**
 - b. **[Flomatic Valves; Flomatic Corporation]**
 - c. **[GA Industries, Inc]**
 - d. **[Val-Matic Valve & Manufacturing Corp.]**
 - e. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain air/vacuum valves from single manufacturer.
 4. Standard: AWWA C512.
 5. Pressure Rating: **[300 psig (2070 kPa)]<Insert pressure>**.
 6. Body Material: **[Cast iron]<Insert material>**.
 7. Trim Material: Stainless steel[, **brass, or bronze**].
 8. Inlet and Outlet Size: **<Insert NPS (DN)>**.
 9. Orifice Size: **<Insert inches (mm)>**.
 10. Design Air Capacity: **<Insert cfm (L/s)>** at **<Insert psig (kPa)>** differential pressure.
- C. Combination Air Valves: Float-operated, hydromechanical device to automatically release accumulated air or to admit air.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Crispin Valve]**
 - b. **[Flomatic Valves; Flomatic Corporation]**
 - c. **[GA Industries, Inc]**
 - d. **[Val-Matic Valve & Manufacturing Corp.]**
 - e. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Crispin Valve]**
 - b. **[Flomatic Valves; Flomatic Corporation]**
 - c. **[GA Industries, Inc]**
 - d. **[Val-Matic Valve & Manufacturing Corp.]**
 - e. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain combination air valves from single manufacturer.
 4. Standard: AWWA C512.
 5. Pressure Rating: **[300 psig (2070 kPa)]<Insert pressure>**.
 6. Body Material: **[Cast iron]<Insert material>**.
 7. Trim Material: Stainless steel[, **brass, or bronze**].
 8. Inlet and Outlet Size: **<Insert NPS (DN)>**.
 9. Orifice Size: **<Insert inches (mm)>**.

10. Design Air Capacity: **<Insert cfm (L/s)>** at **<Insert psig (kPa)>** differential pressure.

2.22 VACUUM BREAKERS

A. Pressure Vacuum Breaker Assembly:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[FEBCO; A WATTS Brand]**
 - c. **[WATTS; A Watts Water Technologies Company]**
 - d. **[Zurn Industries, LLC]**
 - e. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[FEBCO; A WATTS Brand]**
 - c. **[WATTS; A Watts Water Technologies Company]**
 - d. **[Zurn Industries, LLC]**
 - e. **<Insert manufacturer's name>**
3. Source Limitations: Obtain pressure vacuum breaker assembly from single manufacturer.
4. Standard: ASSE 1020.
5. Operation: Continuous-pressure applications.
6. Pressure Loss: **[5 psig (35 kPa)]<Insert pressure>** maximum, through middle one-third of flow range.
7. Size: **<Insert NPS (DN)>**.
8. Design Flow Rate: **<Insert gpm (L/s)>**.
9. Selected Unit Flow Range Limits: **<Insert gpm (L/s)>**.
10. Pressure Loss at Design Flow Rate: **<Insert psig (kPa)>**.
11. Accessories: Ball valves on inlet and outlet.

2.23 BACKFLOW PREVENTERS

A. Backflow Preventers - Reduced-Pressure Principle:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Ames Fire & Waterworks; A Watts Water Technologies Company]**
 - b. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - c. **[FEBCO; A WATTS Brand]**
 - d. **[WATTS; A Watts Water Technologies Company]**
 - e. **[Zurn Industries, LLC]**
 - f. **<Insert manufacturer's name>**

2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Ames Fire & Waterworks; A Watts Water Technologies Company]**
 - b. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - c. **[FEBCO; A WATTS Brand]**
 - d. **[WATTS; A Watts Water Technologies Company]**
 - e. **[Zurn Industries, LLC]**
 - f. **<Insert manufacturer's name>**
3. Source Limitations: Obtain backflow preventers - reduced-pressure principle, from single manufacturer.
4. Standard: **[ASSE 1013][or][AWWA C511]**.
5. Operation: Continuous-pressure applications.
6. Pressure Loss: **[12 psig (83 kPa)]<Insert pressure>** maximum, through middle one-third of flow range.
7. Size: **<Insert NPS (DN)>**.
8. Design Flow Rate: **<Insert gpm (L/s)>**.
9. Selected Unit Flow Range Limits: **<Insert gpm (L/s)>**.
10. Pressure Loss at Design Flow Rate: **<Insert psig (kPa)>** for **NPS 2 (DN 50)** and smaller; **<Insert psig (kPa)>** for **NPS 2-1/2 (DN 65)** and larger.
11. Body: Bronze for **NPS 2 (DN 50)** and smaller; **[cast iron with interior lining complying with AWWA C550 or that is FDA approved][steel with interior lining complying with AWWA C550 or that is FDA approved][stainless steel]** for **NPS 2-1/2 (DN 65)** and larger.
12. End Connections: Threaded for **NPS 2 (DN 50)** and smaller; **[flanged]<Insert type>** for **NPS 2-1/2 (DN 65)** and larger.
13. Configuration: Designed for **[horizontal, straight through][vertical inlet, horizontal center section, and vertical outlet][vertical]<Insert configuration>** flow.
14. Accessories:
 - a. Valves: Ball type with threaded ends on inlet and outlet of **NPS 2 (DN 50)** and smaller; OS&Y gate type with flanged ends on inlet and outlet of **NPS 2-1/2 (DN 65)** and larger.
 - b. Air-Gap Fitting: ASME A112.1.2, matching backflow preventer connection.

B. Backflow Preventers - Double-Check Assembly:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Ames Fire & Waterworks; A Watts Water Technologies Company]**
 - b. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - c. **[FEBCO; A WATTS Brand]**
 - d. **[WATTS; A Watts Water Technologies Company]**
 - e. **[Zurn Industries, LLC]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Ames Fire & Waterworks; A Watts Water Technologies Company]**
 - b. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - c. **[FEBCO; A WATTS Brand]**

- d. **[WATTS; A Watts Water Technologies Company]**
 - e. **[Zurn Industries, LLC]**
 - f. **<Insert manufacturer's name>**
3. Source Limitations: Obtain backflow preventers - double-check assembly, from single manufacturer.
 4. Standard: **[ASSE 1015][or][AWWA C510]**.
 5. Operation: Continuous-pressure applications unless otherwise indicated.
 6. Pressure Loss: **[5 psig (35 kPa)]<Insert pressure>** maximum, through middle one-third of flow range.
 7. Size: **<Insert NPS (DN)>**.
 8. Design Flow Rate: **<Insert gpm (L/s)>**.
 9. Selected Unit Flow Range Limits: **<Insert gpm (L/s)>**.
 10. Pressure Loss at Design Flow Rate: **<Insert psig (kPa)>** for **NPS 2 (DN 50)** and smaller; **<Insert psig (kPa)>** for **NPS 2-1/2 (DN 65)** and larger.
 11. Body: Bronze for **NPS 2 (DN 50)** and smaller; **[cast iron with interior lining complying with AWWA C550 or that is FDA approved][steel with interior lining complying with AWWA C550 or that is FDA approved][stainless steel]** for **NPS 2-1/2 (DN 65)** and larger.
 12. End Connections: Threaded for **NPS 2 (DN 50)** and smaller; **[flanged]<Insert type>** for **NPS 2-1/2 (DN 65)** and larger.
 13. Configuration: Designed for **[horizontal, straight through]<Insert configuration>** flow.
 14. Accessories: Ball valves with threaded ends on inlet and outlet of **NPS 2 (DN 50)** and smaller; OS&Y gate valves with flanged ends on inlet and outlet of **NPS 2-1/2 (DN 65)** and larger.

C. Backflow Preventers - Reduced-Pressure-Detector, Fire-Protection Assembly:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Ames Fire & Waterworks; A Watts Water Technologies Company]**
 - b. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - c. **[FEBCO; A WATTS Brand]**
 - d. **[WATTS; A Watts Water Technologies Company]**
 - e. **[Zurn Industries, LLC]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Ames Fire & Waterworks; A Watts Water Technologies Company]**
 - b. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - c. **[FEBCO; A WATTS Brand]**
 - d. **[WATTS; A Watts Water Technologies Company]**
 - e. **[Zurn Industries, LLC]**
 - f. **<Insert manufacturer's name>**
3. Source Limitations: Obtain backflow preventers - reduced-pressure-detector, fire-protection assembly, from single manufacturer.
4. Standards: ASSE 1047, and UL listed or FM Global approved.
5. Operation: Continuous-pressure applications.
6. Pressure Loss: **[12 psig (83 kPa)]<Insert pressure>** maximum, through middle one-third of flow range.

7. Size: **<Insert NPS (DN)>**.
8. Design Flow Rate: **<Insert gpm (L/s)>**.
9. Selected Unit Flow Range Limits: **<Insert gpm (L/s)>**.
10. Pressure Loss at Design Flow Rate: **<Insert psig (kPa)>**.
11. Body: **[Cast iron with interior lining complying with AWWA C550 or that is FDA approved][Steel with interior lining complying with AWWA C550 or that is FDA approved][Stainless steel]**.
12. End Connections: Flanged.
13. Configuration: Designed for **[horizontal, straight through][vertical inlet, horizontal center section, and vertical outlet][vertical]<Insert configuration>** flow.
14. Accessories:
 - a. Valves: UL 262, FM Global approved, OS&Y gate type with flanged ends on inlet and outlet.
 - b. Air-Gap Fitting: ASME A112.1.2, matching backflow preventer connection.
 - c. Bypass: With displacement-type water meter, shutoff valves, and reduced-pressure backflow preventer.

D. Backflow Preventers - Double-Check, Detector Assembly:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Ames Fire & Waterworks; A Watts Water Technologies Company]**
 - b. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - c. **[FEBCO; A WATTS Brand]**
 - d. **[WATTS; A Watts Water Technologies Company]**
 - e. **[Zurn Industries, LLC]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Ames Fire & Waterworks; A Watts Water Technologies Company]**
 - b. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - c. **[FEBCO; A WATTS Brand]**
 - d. **[WATTS; A Watts Water Technologies Company]**
 - e. **[Zurn Industries, LLC]**
 - f. **<Insert manufacturer's name>**
3. Source Limitations: Obtain backflow preventers - double-check, detector-assembly, from single manufacturer.
4. Standards: ASSE 1048, and UL listed or FM Global approved.
5. Operation: Continuous-pressure applications.
6. Pressure Loss: **[5 psig (35 kPa)]<Insert pressure>** maximum, through middle one-third of flow range.
7. Size: **<Insert NPS (DN)>**.
8. Design Flow Rate: **<Insert gpm (L/s)>**.
9. Selected Unit Flow Range Limits: **<Insert gpm (L/s)>**.
10. Pressure Loss at Design Flow Rate: **<Insert psig (kPa)>**.
11. Body: **[Cast iron with interior lining complying with AWWA C550 or that is FDA approved][Steel with interior lining complying with AWWA C550 or that is FDA approved][Stainless steel]**.

12. End Connections: Flanged.
13. Configuration: Designed for **[horizontal, straight through][vertical inlet, horizontal center section, and vertical outlet][vertical]<Insert configuration>** flow.
14. Accessories:
 - a. Valves: UL 262, FM Global approved, OS&Y gate type with flanged ends on inlet and outlet.
 - b. Bypass: With displacement-type water meter, shutoff valves, and reduced-pressure backflow preventer.

E. Backflow Preventer Test Kits: Factory calibrated, with gages, fittings, hoses, and carrying case with test-procedure instructions.

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Ames Fire & Waterworks; A Watts Water Technologies Company]**
 - b. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - c. **[FEBCO; A WATTS Brand]**
 - d. **[WATTS; A Watts Water Technologies Company]**
 - e. **[Zurn Industries, LLC]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Ames Fire & Waterworks; A Watts Water Technologies Company]**
 - b. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - c. **[FEBCO; A WATTS Brand]**
 - d. **[WATTS; A Watts Water Technologies Company]**
 - e. **[Zurn Industries, LLC]**
 - f. **<Insert manufacturer's name>**
3. Source Limitations: Obtain backflow preventer test kits from single manufacturer.

2.24 CONCRETE VAULTS

- A. Concrete Vault - Precast, Reinforced Concrete: Designed for A-16 load designation in accordance with ASTM C857 and made in accordance with ASTM C858.
 1. Ladder: ASTM A36/A36M, steel or PE-encased steel steps.
 2. Manhole:
 - a. ASTM A48/A48M Class No. 35A minimum tensile strength, gray-iron traffic frame and cover; **24-inch (610-mm)** minimum diameter unless otherwise indicated.
 - b. ASTM A536, Grade 60-40-18, ductile-iron traffic frame and cover: **24-inch (610-mm)** minimum diameter unless otherwise indicated.
 3. Drain: ASME A112.6.3, cast-iron floor drain with outlet of size indicated. Include body anchor flange, light-duty cast-iron grate, bottom outlet, and integral or field-installed bronze ball or clapper-type backwater valve.

2.25 PROTECTIVE ENCLOSURES

- A. Freeze-Protection Enclosures: Insulated enclosure designed to protect aboveground water piping, equipment, or specialties from freezing and damage, with heat source to maintain minimum internal temperature of **40 deg F (4 deg C)** when external temperatures reach as low as **minus 30 deg F (minus 34 deg C)**.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[AquaSHIELD]**
 - c. **[BF Products Inc.]**
 - d. **[DekoRRa Products LLC]**
 - e. **[G&C Enclosures]**
 - f. **[Hot Box; brand of Hubbell Utility Solutions; Hubbell Incorporated]**
 - g. **[HydroCowl, Inc]**
 - h. **[WATTS; A Watts Water Technologies Company]**
 - i. **<Insert manufacturer's name>**
 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Apollo Valves; a part of Aalberts Integrated Piping Systems]**
 - b. **[AquaSHIELD]**
 - c. **[BF Products Inc.]**
 - d. **[DekoRRa Products LLC]**
 - e. **[G&C Enclosures]**
 - f. **[Hot Box; brand of Hubbell Utility Solutions; Hubbell Incorporated]**
 - g. **[HydroCowl, Inc]**
 - h. **[WATTS; A Watts Water Technologies Company]**
 - i. **<Insert manufacturer's name>**
 3. Source Limitations: Obtain freeze-protection enclosures from single manufacturer.
 4. Standard: ASSE 1060.
 5. Class I: For equipment or devices other than pressure or atmospheric vacuum breakers.
 6. Class I-V: For pressure or atmospheric vacuum breaker equipment or devices. Include drain opening in housing.
 7. Housing: Reinforced**[-aluminum][or][-fiberglass]<Insert housing>** construction.
 - a. Size: Of dimensions indicated, but not less than those required for access and service of protected unit.
 - b. Drain opening for units with drain connection.
 - c. Access doors with locking devices.
 - d. Insulation inside housing.
 - e. Anchoring devices for attaching housing to concrete base.
 8. Electric heating cable or heater with self-limiting temperature control.
- B. Freeze-Retardant Enclosures: Insulated enclosure designed to protect aboveground water piping, equipment, or specialties from weather and damage with minimum external temperatures of **33 deg F (0.5 deg C)**.

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[AquaSHIELD]**
 - b. **[BF Products Inc.]**
 - c. **[DekoRRa Products LLC]**
 - d. **[G&C Enclosures]**
 - e. **[Hot Box; brand of Hubbell Utility Solutions; Hubbell Incorporated]**
 - f. **[HydroCowl, Inc]**
 - g. **[WATTS; A Watts Water Technologies Company]**
 - h. **<Insert manufacturer's name>**

 2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[AquaSHIELD]**
 - b. **[BF Products Inc.]**
 - c. **[DekoRRa Products LLC]**
 - d. **[G&C Enclosures]**
 - e. **[Hot Box; brand of Hubbell Utility Solutions; Hubbell Incorporated]**
 - f. **[HydroCowl, Inc]**
 - g. **[WATTS; A Watts Water Technologies Company]**
 - h. **<Insert manufacturer's name>**

 3. Source Limitations: Obtain freeze-retardant enclosures from single manufacturer.
 4. Standard: ASSE 1060.
 5. Class II: For equipment or devices other than pressure or atmospheric vacuum breakers.
 6. Class II-V: For pressure or atmospheric vacuum breaker equipment or devices. Include drain opening in housing.
 7. Housing: Reinforced**[-aluminum][or][-fiberglass]<Insert housing>** construction.
 - a. Size: Of dimensions indicated, but not less than those required for access and service of protected unit.
 - b. Drain opening for units with drain connection.
 - c. Access doors with locking devices.
 - d. Anchoring devices for attaching housing to concrete base.
- C. Non-Freeze Protection Enclosures: Uninsulated enclosure designed to protect aboveground water piping, equipment, or specialties from weather and damage.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[AquaSHIELD]**
 - b. **[BF Products Inc.]**
 - c. **[DekoRRa Products LLC]**
 - d. **[G&C Enclosures]**
 - e. **[Hot Box; brand of Hubbell Utility Solutions; Hubbell Incorporated]**
 - f. **[HydroCowl, Inc]**
 - g. **[WATTS; A Watts Water Technologies Company]**

- h. <Insert manufacturer's name>
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [AquaSHIELD]
 - b. [BF Products Inc.]
 - c. [DekoRRa Products LLC]
 - d. [G&C Enclosures]
 - e. [Hot Box; brand of Hubbell Utility Solutions; Hubbell Incorporated]
 - f. [HydroCowl, Inc]
 - g. [WATTS; A Watts Water Technologies Company]
 - h. <Insert manufacturer's name>
 - 3. Source Limitations: Obtain non-freeze protection enclosures from single manufacturer.
 - 4. Standard: ASSE 1060.
 - 5. Class III: For equipment or devices other than pressure or atmospheric vacuum breakers.
 - 6. Class III-V: For pressure or atmospheric vacuum breaker equipment or devices. Include drain opening in housing.
 - 7. Housing: Reinforced[-aluminum][or][-fiberglass]<Insert housing> construction.
 - a. Size: Of dimensions indicated, but not less than those required for access and service of protected unit.
 - b. Drain opening for units with drain connection.
 - c. Access doors with locking devices.
 - d. Anchoring devices for attaching housing to concrete base.
- D. Expanded-Metal Enclosures: Enclosure designed to protect aboveground water piping, equipment, or specialties from damage.
 - 1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. [Cross Brothers Inc.]
 - b. <Insert manufacturer's name>
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. [Cross Brothers Inc.]
 - b. <Insert manufacturer's name>
 - 3. Source Limitations: Obtain expanded-metal enclosures from single manufacturer.
 - 4. Standard: ASTM F1267.
 - 5. Material: Expanded metal side and top panels, of weight and with reinforcement of same metal at edges as required for rigidity.
 - 6. Type: [I, expanded][II, expanded and flattened].
 - 7. Class: [1, uncoated carbon steel][2, hot-dip, zinc-coated carbon steel][3, corrosion-resistant steel].
 - 8. Finish: Manufacturer's enamel paint.
 - 9. Size: Of dimensions indicated, but not less than those required for access and service of protected unit.

10. Locking device.
11. Lugs or devices for securing enclosure to base.

- E. Enclosure Bases: **[4-inch- (100-mm-)][6-inch- (150-mm-)]** minimum thickness precast concrete, of dimensions required to extend at least **6 inches (150 mm)** beyond edges of enclosure housings. Include openings for piping.

2.26 FIRE HYDRANTS

A. Fire Hydrants - Dry Barrel:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **[American AVK Co.]**
 - b. **[American Cast Iron Pipe Company]**
 - c. **[Clow Valve Company; a subsidiary of McWane, Inc.]**
 - d. **[EJ Group, Inc.]**
 - e. **[M & H Valve Company; a division of McWane, Inc.]**
 - f. **[Mueller Co. LLC; Mueller Water Products, Inc.]**
 - g. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American AVK Co.]**
 - b. **[American Cast Iron Pipe Company]**
 - c. **[Clow Valve Company; a subsidiary of McWane, Inc.]**
 - d. **[EJ Group, Inc.]**
 - e. **[M & H Valve Company; a division of McWane, Inc.]**
 - f. **[Mueller Co. LLC; Mueller Water Products, Inc.]**
 - g. **<Insert manufacturer's name>**
3. Source Limitations: Obtain fire hydrants - dry barrel, from single manufacturer.
4. Pressure Rating: **[150 psig (1035 kPa) minimum][250 psig (1725 kPa)]**.
5. Standard: AWWA C502.
6. Freestanding configuration, with one **NPS 4-1/2 (DN 115)** and two **NPS 2-1/2 (DN 65)** outlets, **5-1/4-inch (133-mm)** main valve, drain valve, and **NPS 6 (DN 150)** mechanical-joint inlet. Include interior coating in accordance with AWWA C550. Hydrant to have cast-iron body, compression-type valve opening against pressure and closing with pressure.
7. Standards: UL 246, and FM Global approved.
8. Freestanding configuration, with one **NPS 4-1/2 (DN 115)** and two **NPS 2-1/2 (DN 65)** outlets, **5-1/4-inch (133-mm)** main valve, drain valve, and **NPS 6 (DN 150)** mechanical-joint inlet. Hydrant to have cast-iron body, compression-type valve opening against pressure and closing with pressure.
 - a. Outlet Threads: NFPA 1963, with external hose thread used by local fire department. Include cast-iron caps with steel chains.
 - b. Operating and Cap Nuts: Pentagon, **1-1/2 inches (38 mm)** point to flat.
 - c. Direction of Opening: Open hydrant valve by turning operating nut to left or counterclockwise.

d. Exterior Finish: Red alkyd-gloss enamel paint unless otherwise indicated.

B. Fire Hydrants - Wet Barrel:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[American AVK Co.]**
 - b. **[Clow Valve Company; a subsidiary of McWane, Inc.]**
 - c. **[James Jones Company, LLC; a Mueller brand]**
 - d. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[American AVK Co.]**
 - b. **[Clow Valve Company; a subsidiary of McWane, Inc.]**
 - c. **[James Jones Company, LLC; a Mueller brand]**
 - d. **<Insert manufacturer's name>**
3. Source Limitations: Obtain fire hydrants - wet barrel, from single manufacturer.
4. Pressure Rating: **150 psig (1035 kPa)** minimum.
5. Standard: AWWA C503.
6. Freestanding configuration, with one **NPS 4-1/2 (DN 115)** and two **NPS 2-1/2 (DN 65)** outlets, **NPS 6 (DN 150)** threaded or flanged inlet, and base section with **NPS 6 (DN 150)** mechanical-joint inlet. Include interior coating in accordance with AWWA C550.
7. Standards: UL 246, and FM Global approved.
8. Freestanding configuration, with one **NPS 4-1/2 (DN 115)** and two **NPS 2-1/2 (DN 65)** outlets, **NPS 6 (DN 150)** threaded or flanged inlet, and base section with **NPS 6 (DN 150)** mechanical-joint inlet.
 - a. Outlet Threads: NFPA 1963, with external hose thread used by local fire department. Include cast-iron caps with steel chains.
 - b. Operating and Cap Nuts: Pentagon, **1-1/2 inches (38 mm)** point to flat.
 - c. Direction of Opening: Open hydrant valves by turning operating nut to left or counterclockwise.
 - d. Exterior Finish: Red alkyd-gloss enamel paint unless otherwise indicated.

2.27 FLUSHING HYDRANTS

- A. Flushing Hydrants - Post Type: Nonfreeze and drainable, of length required for shutoff valve installation below frost line.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[GIL Industries, Inc]**
 - b. **[Kupferle Foundry Co. (The)]**
 - c. **<Insert manufacturer's name>**

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

- a. **[GIL Industries, Inc]**
- b. **[Kupferle Foundry Co. (The)]**
- c. **<Insert manufacturer's name>**

3. Source Limitations: Obtain flushing hydrants - post type, from single manufacturer.
4. Pressure Rating: **150 psig (1035 kPa)** minimum.
5. Outlet: One, with horizontal discharge.
6. Hose Thread: **NPS 2-1/2 (DN 65)**, with NFPA 1963 external hose thread for use by local fire department, and with cast-iron cap with brass chain.
7. Barrel: Cast-iron or steel pipe with breakaway feature.
8. Valve: Bronze body with bronze-ball or plunger closure, and automatic draining.
9. Security: Locking device for padlock.
10. Exterior Finish: Red alkyd-gloss enamel paint unless otherwise indicated.
11. Inlet: **NPS 2 (DN 50)** minimum.
12. Operating Wrench: One for each unit.

- B. Flushing Hydrants - Ground Type: Nonfreeze and drainable, of length required for shutoff valve installation below frost line.

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

- a. **[GIL Industries, Inc]**
- b. **[Kupferle Foundry Co. (The)]**
- c. **<Insert manufacturer's name>**

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

- a. **[GIL Industries, Inc]**
- b. **[Kupferle Foundry Co. (The)]**
- c. **<Insert manufacturer's name>**

3. Source Limitations: Obtain flushing hydrants - ground type, from single manufacturer.
4. Pressure Rating: **150 psig (1035 kPa)** minimum.
5. Outlet: One, with **[vertical][angle]** discharge.
6. Hose Thread: **NPS 2-1/2 (DN 65)**, with NFPA 1963 external hose thread for use by local fire department, and with cast-iron cap with brass chain.
7. Barrel: Cast-iron or steel pipe.
8. Valve: Bronze body with bronze-ball or plunger closure, and automatic draining.
9. Inlet: **NPS 2 (DN 50)** minimum.
10. Hydrant Box: Cast iron with cover, for ground mounting.
11. Operating Wrench: One for each unit.

2.28 SAMPLING STATIONS

- A. Sampling Station - Post Type: Nonfreeze and drainable, of length required for shutoff valve installation

below frost line.

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[GIL Industries, Inc]**
 - b. **[Kupferle Foundry Co. (The)]**
 - c. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[GIL Industries, Inc]**
 - b. **[Kupferle Foundry Co. (The)]**
 - c. **<Insert manufacturer's name>**
3. Source Limitations: Obtain sampling stations - post type, from single manufacturer.
4. Pressure Rating: **100 psig (690 kPa)** minimum.
5. Sampling Outlet: One unthreaded nozzle with handle.
6. Valve: Bronze body with bronze-ball or plunger closure. Include operating handle.
7. Drain: Tubing with separate manual vacuum pump.
8. Inlet: **NPS 3/4 (DN 20)** minimum.
9. Housing: Weatherproof material with locking device. Include anchor device.
10. Operating Wrench: One for each unit.

2.29 FIRE DEPARTMENT CONNECTIONS

A. Fire Department Connections:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. **[Croker; a Division of Morris Group International]**
 - b. **[Elkhart Brass Mfg. Co., Inc]**
 - c. **[Guardian Fire Equipment, Inc]**
 - d. **[Kidde; Carrier Global Corporation]**
 - e. **[Potter Roemer LLC; a Division of Morris Group International]**
 - f. **<Insert manufacturer's name>**
2. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
 - a. **[Croker; a Division of Morris Group International]**
 - b. **[Elkhart Brass Mfg. Co., Inc]**
 - c. **[Guardian Fire Equipment, Inc]**
 - d. **[Kidde; Carrier Global Corporation]**
 - e. **[Potter Roemer LLC; a Division of Morris Group International]**
 - f. **<Insert manufacturer's name>**

3. Source Limitations: Obtain fire department connections from single manufacturer.
4. Standard: UL 405.
5. Configuration: Freestanding, with cast-bronze body, thread inlets in accordance with NFPA 1963 and matching local fire department hose threads, and threaded bottom outlet. Include lugged caps, gaskets, and chains; lugged swivel connection and drop clapper for each hose-connection inlet; **18-inch- (460-mm-)** high, brass sleeve; and round escutcheon plate.
6. Connections:
 - a. **[Two][Three] NPS 2-1/2 (DN 65)** inlets and one **[NPS 4 (DN 100)][NPS 6 (DN 150)]** outlet.
 - b. Two **NPS 3 (DN 80)** inlets and one **[NPS 4 (DN 100)][NPS 6 (DN 150)]** outlet.
 - c. **[Three][Four] NPS 2-1/2 (DN 65)** inlets and one **NPS 6 (DN 150)** outlet.
 - d. Six **NPS 2-1/2 (DN 65)** inlets and one **[NPS 6 (DN 150)][NPS 8 (DN 200)]** outlet.
7. Inlet Alignment: **[Inline, horizontal][Square]**.
8. Finish Including Sleeve: **[Polished chrome-plated][Rough chrome-plated][Polished bronze]**.
9. Escutcheon Plate Marking: **"[AUTO SPKR][&][STANDPIPE]."**

2.30 ALARM DEVICES

- A. Alarm Devices: UL 753 and FM Global approved, of types and sizes to mate and match piping and equipment.
- B. Water-Flow Indicators: Vane-type water-flow detector, rated for **250 psig (1725 kPa)** working pressure; designed for horizontal or vertical installation; with 2 SPDT circuit switches to provide isolated alarm and auxiliary contacts, 7 A, 125 V ac and 0.25 A, 24 V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal when cover is removed.
- C. Supervisory Switches: SPDT; designed to signal valve in other than fully open position.
- D. Pressure Switches: SPDT; designed to signal increase in pressure.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Comply with excavating, trenching, and backfilling requirements in Section 312000 "Earth Moving."

3.2 PIPING APPLICATIONS

- A. Transition couplings and special fittings with pressure ratings at least equal to piping pressure rating may be used unless otherwise indicated.
- B. Do not use flanges or unions for underground piping.
- C. Flanges, unions, grooved-end-pipe couplings, and special fittings may be used, instead of joints indicated, on aboveground piping and piping in vaults.
- D. Underground water-service piping **[NPS 3/4 to NPS 3 (DN 20 to DN 80)]<Insert pipe size range>** to be **[any of]** the following:

1. Soft copper tube, [ASTM B88, Type K (ASTM B88M, Type A)][ASTM B88, Type L (ASTM B88M, Type B)]; [wrought-copper, solder-joint fittings; and brazed][copper, pressure-seal fittings; and pressure-sealed] joints.
 2. PE, ASTM pipe; [insert fittings for PE pipe; and clamped][molded PE fittings; and heat-fusion] joints.
 3. PVC, Schedule [40 pipe; PVC, Schedule 40][80 pipe; PVC, Schedule 80] socket fittings; and solvent-cemented joints.
 4. NPS 1 to NPS 3 (DN 25 to DN 80) fiberglass, RTRP, AWWA pipe, [Class 150][Class 200][Class 250]; RTRF, AWWA pipe; and bonded joints.
 5. Fiberglass, RTRP, AWWA pipe [Class 150][Class 200][Class 250]; RTRF; and bonded joints.
- E. Underground water-service piping [NPS 4 to NPS 8 (DN 100 to DN 200)]<Insert pipe size range> to be[any of] the following:
1. Soft copper tube, [ASTM B88, Type K (ASTM B88M, Type A)][ASTM B88, Type L (ASTM B88M, Type B)]; wrought-copper, solder-joint fittings; and brazed joints.
 2. Ductile-iron, [push-on-joint pipe; ductile-iron, push-on-joint fittings; and gasketed][mechanical-joint pipe; ductile-iron, mechanical-joint fittings; and mechanical][grooved-end pipe; ductile-iron-pipe appurtenances; and grooved] joints.
 3. PE, AWWA pipe; PE, AWWA fittings; and heat-fusion joints.
 4. PVC, Schedule [40 pipe; PVC, Schedule 40][80 pipe; PVC, Schedule 80] socket fittings; and solvent-cemented joints.
 5. NPS 4 and NPS 6 (DN 100 and DN 150): NPS 6 (DN 150) PVC, AWWA Class 150 pipe; PVC, AWWA Class 150 [fabricated][or][molded] fittings; and gasketed joints.
 6. NPS 8 (DN 200): PVC, AWWA Class 200 pipe; [PVC, AWWA Class 200 fabricated][push-on-joint, ductile-iron][mechanical-joint, ductile-iron] fittings; and gasketed joints.
 7. Fiberglass, RTRP, AWWA pipe [Class 150][Class 200][Class 250]; RTRF, AWWA pipe; and bonded joints.
- F. Water Meter Box Water-Service Piping: [NPS 3/4 to NPS 2 (DN 20 to DN 50)]<Insert pipe size range> to be same as underground water-service piping.
- G. Aboveground[and vault] water-service piping [NPS 3/4 to NPS 3 (DN 20 to DN 80)]<Insert pipe size range> to be[any of] the following:
1. Hard copper tube, [ASTM B88, Type K (ASTM B88M, Type A)][ASTM B88, Type L (ASTM B88M, Type B)]; [wrought-copper, solder-joint fittings; and brazed][copper, pressure-seal fittings; and pressure-sealed] joints.
 2. PVC, Schedule 80 pipe; PVC, Schedule 80 [socket fittings; and solvent-cemented][threaded fittings; and threaded] joints.
 3. NPS 1 to NPS 2 (DN 25 to DN 50) fiberglass, RTRP, AWWA pipe [Class 150][Class 200][Class 250]; RTRF, AWWA pipe; and bonded joints.
- H. Aboveground [and vault]water-service piping [NPS 4 to NPS 8 (DN 100 to DN 200)]<Insert pipe size range> to be[any of] the following:
1. Hard copper tube, [ASTM B88, Type K (ASTM B88M, Type A)][ASTM B88, Type L (ASTM B88M, Type B)]; wrought-copper, solder-joint fittings; and brazed joints.
 2. Ductile-iron, grooved-end pipe; ductile-iron, grooved-end appurtenances; and grooved joints.
 3. PVC, Schedule 80 pipe; PVC, Schedule 80 [socket fittings; and solvent-cemented][threaded fittings; and threaded] joints.
 4. Fiberglass, RTRP, AWWA pipe [Class 150][Class 200][Class 250]; RTRF, AWWA pipe; and bonded joints.
- I. Underground fire-service-main piping [NPS 4 to NPS 12 (DN 100 to DN 300)]<Insert pipe size range> to be[any of] the following:

1. Ductile-iron, **[push-on-joint pipe; ductile-iron, push-on-joint fittings; and gasketed][mechanical-joint pipe; ductile-iron, mechanical-joint fittings; and mechanical][grooved-end pipe; ductile-iron-pipe appurtenances; and grooved]** joints.
 2. PE, **[Class 150][Class 200]**, fire-service pipe; molded PE fittings; and heat-fusion joints.
 3. PVC, AWWA Class 150 pipe listed for fire-protection service; PVC Class 150 fabricated or molded fittings; and gasketed joints.
 4. PVC, AWWA Class 200 pipe listed for fire-protection service; PVC Class 200 fabricated fittings; and gasketed joints.
 5. Fiberglass, AWWA, FM Global approved RTRP, **[Class 150][Class 200]**; RTRF; and gasketed joints.
- J. Aboveground[**and vault**] fire-service-main piping **[NPS 4 to NPS 12 (DN 100 to DN 300)]<Insert pipe size range>** to be ductile-iron, grooved-end pipe; ductile-iron-pipe appurtenances; and grooved joints.
- K. Underground Combined Water-Service and Fire-Service-Main Piping **[NPS 6 to NPS 12 (DN 150 to DN 300)]<Insert pipe size range>** to be[**any of**] the following:
1. Ductile-iron, **[push-on-joint pipe; ductile-iron, push-on-joint fittings; and gasketed][mechanical-joint pipe; ductile-iron, mechanical-joint fittings; and mechanical][grooved-end pipe; ductile-iron-pipe appurtenances; and grooved]** joints.
 2. PVC, AWWA **[Class 150][Class 200]** pipe listed for fire-protection service; PVC fabricated or molded fittings of same class as pipe; and gasketed joints.
 3. Fiberglass, AWWA, FM Global approved RTRP, **[Class 150][Class 200]**; RTRF; and gasketed joints.
- L. Aboveground[**and vault**] combined water service and fire-service-main piping **[NPS 6 to NPS 12 (DN 150 to DN 300)]<Insert pipe size range>** to be ductile-iron, grooved-end pipe; ductile-iron-pipe appurtenances; and grooved joints.

3.3 VALVE APPLICATIONS

- A. General Application: Use mechanical-joint-end valves for **NPS 3 (DN 80)** and larger underground installation. Use threaded- or flanged-end valves for installation in vaults. Use UL/FM Global, nonrising-stem gate valves for installation with indicator posts. Use corporation valves and curb valves with ends compatible with piping, for **NPS 2 (DN 50)** and smaller installation.
- B. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
1. Underground Valves, NPS 3 (DN 80) and Larger: AWWA, cast-iron, nonrising-stem, **[metal][resilient][high-pressure, resilient]**-seated gate valves with valve box.
 2. Underground Valves, NPS 4 (DN 100) and Larger, for Indicator Posts: UL/FM Global, cast-iron, nonrising-stem gate valves with indicator post.
 3. Use the following for valves in vaults and aboveground:
 - a. Gate Valves, NPS 2 (DN 50) and Smaller: Bronze, **[nonrising][rising]** stem.
 - b. Gate Valves, NPS 3 (DN 80) and Larger: **[AWWA, cast iron, OS&Y rising stem, metal seated][AWWA, cast iron, OS&Y rising stem, resilient seated][UL/FM Global, cast iron, OS&Y rising stem]**.
 - c. Check Valves: **[AWWA C508][UL/FM Global]**, swing type.
 4. Pressure-Reducing Valves: Use for water-service piping in vaults and aboveground to control water pressure.
 5. Relief Valves: Use for water-service piping in vaults and aboveground.

- a. Air-Release Valves: To release accumulated air.
 - b. Air/Vacuum Valves: To release or admit large volume of air during filling of piping.
 - c. Combination Air Valves: To release or admit air.
6. Detector Check Valves: Use for water-service piping in vaults and aboveground to detect unauthorized use of water.

3.4 PIPING SYSTEMS - COMMON REQUIREMENTS

- A. Comply with Section 330500 "Common Work Results for Utilities" for piping-system common requirements.
- B. Provide a continuous bare copper or aluminum tracer wire not less than **0.10 inch (2.5 mm)** in diameter in sufficient length over each separate run of nonmetallic pipe.

3.5 INSTALLATION OF PIPING

- A. Water-Main Connection:
 - 1. Arrange with utility company for tap of size and in location indicated in water main.
 - 2. Tap water main in accordance with requirements of water utility company and of size and in location indicated.
- B. Make connections larger than **NPS 2 (DN 50)** with tapping machine according to the following:
 - 1. Install tapping sleeve and tapping valve in accordance with MSS SP-60.
 - 2. Install tapping sleeve on pipe to be tapped. Position flanged outlet for gate valve.
 - 3. Use tapping machine compatible with valve and tapping sleeve; cut hole in main. Remove tapping machine and connect water-service piping.
 - 4. Install gate valve onto tapping sleeve. Comply with MSS SP-60. Install valve with stem pointing up and with valve box.
- C. Make connections **NPS 2 (DN 50)** and smaller with drilling machine according to the following:
 - 1. Install service-saddle assemblies and corporation valves in size, quantity, and arrangement required by utility company standards.
 - 2. Install service-saddle assemblies on water-service pipe to be tapped. Position outlets for corporation valves.
 - 3. Use drilling machine compatible with service-saddle assemblies and corporation valves. Drill hole in main. Remove drilling machine and connect water-service piping.
 - 4. Install corporation valves into service-saddle assemblies.
 - 5. Install manifold for multiple taps in water main.
 - 6. Install curb valve in water-service piping with head pointing up and with service box.
- D. Comply with NFPA 24 for fire-service-main piping materials and installation.
 - 1. Install PE corrosion-protection encasement in accordance with ASTM A674 or AWWA C105/A21.5.
 - 2. Install copper tube and fittings in accordance with CDA's "Copper Tube Handbook."
- E. Install ductile-iron, water-service piping in accordance with AWWA C600 and AWWA M41.
 - 1. Install PE corrosion-protection encasement in accordance with ASTM A674 or AWWA

C105/A21.5.

- F. Install PE pipe in accordance with ASTM D2774 and ASTM F645.
 - G. Install PVC, AWWA pipe in accordance with ASTM F645 and AWWA M23.
 - H. Install fiberglass AWWA pipe in accordance with AWWA M45.
 - I. Bury piping with depth of cover over top at least **[30 inches (750 mm)]<Insert dimension>**, with top at least **[12 inches (300 mm)]<Insert dimension>** below level of maximum frost penetration, and according to the following:
 - 1. Under Driveways: With at least **[36 inches (910 mm)]<Insert dimension>** of cover over top.
 - 2. Under Railroad Tracks: With at least **[48 inches (1220 mm)]<Insert dimension>** of cover over top.
 - 3. In Loose Gravelly Soil and Rock: With at least **[12 inches (300 mm)]<Insert dimension>** of additional cover.
 - J. Install piping by tunneling or jacking, or combination of both, under streets and other obstructions that cannot be disturbed.
 - K. Extend **[water-service][and][fire-suppression water-service]** piping and connect to water-supply source and building **[water-piping][and][fire-suppression piping]** systems at outside face of building wall in locations and pipe sizes indicated.
 - 1. Terminate **[water-service][and][fire-suppression water-service]** piping at building wall until building **[water-piping][and][fire-suppression piping]** systems are installed. Terminate piping with caps, plugs, or flanges as required for piping material. Make connections to building **[water-piping][and][fire-suppression piping]** systems when those systems are installed.
 - L. Sleeves are specified in **[Section 210500 "Common Work Results for Fire Suppression"]****[and]****[Section 220500 "Common Work Results for Plumbing."]**
 - M. Mechanical sleeve seals are specified in **[Section 210500 "Common Work Results for Fire Suppression"]****[and]****[Section 220500 "Common Work Results for Plumbing."]**
 - N. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in **[Section 210500 "Common Work Results for Fire Suppression"]****[and]****[Section 220500 "Common Work Results for Plumbing."]**
 - O. Install underground piping with restrained joints at horizontal and vertical changes in direction. Use restrained-joint piping, thrust blocks, anchors, tie-rods and clamps, and other supports.
 - P. Comply with Section 211000 "Water-Based Fire-Suppression Systems" for fire-suppression-water piping inside the building.
 - Q. Comply with Section 221116 "Domestic Water Piping" for potable-water piping inside the building.
- 3.6 INSTALLATION OF HANGERS AND SUPPORTS
- A. Comply with requirements for seismic-restraint devices specified in **[Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment"]****[and]****[Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."]**